Rifles, Swords and Water Pistols: Circumstances in Which Action Becomes Influential in an Action–Irrelevant Categorisation Task

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Published Work

Some of the material presented in this thesis has been published previously. Experiments 2, 4 and 6 have been presented at 2014 and 2016 annual conference of the Cognitive Science Society, and published in the conference proceedings. Experiments 1, 2 and 5 have also been presented at other conferences and are listed below.

Publications

Shipp, N. J., Vallée-Tourangeau, F., & Anthony, S. H. (2014). The context-dependent nature of action knowledge. In P. Bello, M. Guarani, M. McShane, & B. Scassellati (Eds.), *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 2925-2930). Austin, TX: Cognitive Science Society. [Experiment 2, Chapter 2]

Shipp, N. J., Vallée-Tourangeau, F., & Anthony, S. H. (2016a). Priming categorical choices through physical object interaction. In A. Papafragou, D. Grodner, D. Mirman, & J.C. Trueswell, (Eds.), *Proceedings of the 38th Annual Conference of the Cognitive Science Society* (pp. 2153-2158). Austin, TX: Cognitive Science Society. [Experiment 6, Chapter 4]

Shipp, N. J., Vallée-Tourangeau, F., & Anthony, S. H. (2016b). Shakers and maracas: Action-based categorisation choices in triads are influenced by task instructions. In A. Papafragou, D. Grodner, D. Mirman, & J.C. Trueswell, (Eds.), *Proceedings of the 38th Annual Conference of the Cognitive Science Society* (pp. 2153-2158). Austin, TX: Cognitive Science Society. [Experiment 4, Chapter 2]

Conference Presentations

Shakers and maracas: Action-based categorisation choices in triads are influenced by task instructions. Presentation given at the 38th Annual Conference of the Cognitive Science Society, Philadelphia, PA, USA, 10th – 13th August 2016. [Experiment 4, Chapter 2]

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Influencing categorical choices through physical object interaction. Presentation given at the 3rd International Conference on Interactivity, Language and Cognition, Kingston-upon-Thames, London, England, 29th June – 1st July 2016. [Experiment 6, Chapter 4]

Looking at hands, objects or words? Tracking eye movements on an action based categorisation task. Poster presented at the 31st BPS Cognitive Psychology Section Conference, Nottingham, England, 3rd – 5th September 2014. [Experiment 5, Chapter 3]

The context-dependent nature of action knowledge. Poster presented at the 36th Annual Conference of the Cognitive Science Society, Quebec City, Canada, 23rd – 26th July 2014. [Experiment 2, Chapter 2]

Rifles, swords and water pistols: The role of action over taxonomic information in conceptual knowledge. Presentation given at the 1st International Conference on Interactivity, Language and Cognition, Odense, Denmark, 12th-14th September 2012. [Experiments 1 and 2, Chapter 2]

Abstract

An assumption in Cognitive Psychology, which has been challenged in recent years, is that the systems responsible for action and perception work independently of one another. These systems work together during conceptual tasks and research has demonstrated that action knowledge can influence performance even when the task is 'action-irrelevant' (Borghi, 2004; Borghi, Flumini, Natraj & Wheaton, 2012; Creem & Proffitt, 2001; Tucker & Ellis, 1998, 2001). However, participants in such tasks are often only asked to make simple category judgements, such as *natural* versus *man made*. The research reported in this thesis has shown that, under certain conditions, participants use action knowledge to make 'complex' category choices in an action-irrelevant task. The experimental work has predominantly used the forced-choice triad task to assess the circumstances under which participants categorise objects based on shared actions. The triads were designed with a target object and two choice objects matching on either shared actions (*rifle* + *water pistol*), shared taxonomic relations (*rifle* + *sword*), or both (*orange* + *banana*). The context in which the objects were presented was also manipulated so that the objects were either presented on a white background (context-lean) or being used by an agent (context-rich). Participants were most likely to select the choice object that shared both a taxonomic and an action demonstrating that action has an 'additive' effect in categorical decisions. Presenting the objects being used by an agent in a functional scenario increased the saliency of the shared actions between the stimuli, and participants were more likely to select the action choice. The subsequent experimental work reported in the thesis sought to eliminate potential confounding variables including perceptual features, object typicality and task instructions. What the experimental work presented here has demonstrated is that action can influence decisions on more complex categories, and judgments of similarity. The research has identified three main circumstances under which knowledge of action becomes influential in the triad task designed for the purpose of this research as follows: (i) when it is presented in conjunction with taxonomic information, (ii) when it is presented with a context, and (iii) when participants are first asked to physically interact with the objects.

Chapter 1

The Role of Action in Cognition

Cognitive Psychology has traditionally taken the view that the systems responsible for perception and action act independently of one another. Recent research has shown that the two systems are not independent, but work together such that perception can have a direct influence on action responses (Creem & Proffitt, 2001; Ellis & Tucker, 2000; Tucker & Ellis, 1998, 2001, 2004). This has been shown to be the case in experiments where participants are asked to perform physical actions, as well as 'action-irrelevant' tasks in which action is not required for task performance (Borghi, 2004; Bub & Masson, 2006, 2010, 2012; Campanella & Shallice, 2011; Chao & Martin, 2000; Helbig, Graf & Keifer, 2006; Myung, Blumstein & Sedivy, 2006). While action has been shown to influence performance in a variety of cognitive tasks, the reported thesis is primarily aimed at how action influences categorical decisions. In categorising objects together, various sources can be drawn upon such as perceptual, taxonomic and thematic information. It has been further argued that concepts are developed around potential actions and that such information should represent an integral aspect of conceptual knowledge (Barsalou, 2008, 2016b; Franks & Braisby, 1997). It has been further argued that concepts are embedded within the modalities in which they were originally experienced, and as such are 'grounded' (Barsalou, 1999, 2003, 2008, 2016a, 2016b; Martin, 2016). In the case of artefacts, this directly refers to concepts represented within the motor cortex. While research has shown that action is influential in task performance, action has not previously been considered as a source of information used in categorical decisions. The thesis reports experimental evidence using the forced-choice triad task demonstrating (some of) the circumstances under which action is used as a source of commonality in categorising objects together.

Chapter 1 outlines the previous literature that has informed the experimental work of the thesis, including experimental evidence demonstrating how action information influences performance across a variety of cognitive tasks. In addition, Chapter 1 outlines the theoretical framework in which the experimental results here are discussed (Simulation theory, Barsalou, 1999, 2003, 2008, 2016b). Chapter 2 reports the initial experimental work using the triad task to demonstrate the circumstances under which action is used to categorise objects. In particular, the experimental work tested the relative influence of action and taxonomic information; the effect of context and how the results are influenced by task instructions and object typicality. The experimental work reported in Chapter 2 showed how action is influential, and used, within an action-irrelevant task to group objects together. In Chapter 3, eye-tracking software was used to determine which elements within the context-rich images used were most influential in selecting the action related choice item. In Chapter 4, the triad task was amended in order to test if action influence could be increased through using physical actions. Chapter 5 describes the analysis of the stimuli used in the experimental work. This is because the experimental work through the previous chapters shows that the influence of action is not consistent, and some of the triads are more likely to lead to action-based responses than others. In order to assess this, protocol analysis was used to investigate the strategies employed by participants in the triad task. Chapter 6 outlines the close theoretical relationship between categorisation and similarity (Rips, 1989), and how research has shown that there is a dissociation between the two processes (Braisby, 2004; Rips, 1989; Smith & Sloman, 1994). The aim of the work reported in Chapter 6 was to see if action showed the same pattern of influence on the evaluation of similarity using the same stimuli developed in Chapter 2, re-designed in the form of a similarity judgement task. Chapter 7 draws the thesis to a close and discusses the results from this programme of work within the framework of simulation theory (Barsalou, 1999, 2003, 2008).

1. Background Review Of Literature That Stimulated And Informed The New Work Reported In This Thesis.

Chapter 1 outlines the experimental and theoretical research that has informed the work reported in this thesis. This includes research on categorisation, embodied cognition, context, and the role of action in experimental cognitive psychology. The literature discussed here has been broken down into the following sections:

(i). The Relationship Between Action and Perception
(ii). Physical Action Responses
(iii). Action-Irrelevant Tasks
(iv). Is Action Knowledge Automatic or Task Dependent?
(v). Neurological Findings
(vi). Volumetric and Functional Actions
(vii). Actions in Object Recognition
(viii). When is Action not Activated?
(ix). The Role of Context
(x). Actions in Context
(xi). Actions as Features?
(xii). Simulation Theory
(xiii). Evidence for Simulation Theory
(xiv). Extensions to Simulation Theory
(xv). The Current research
(xvi). The Task

1.1 The Relationship Between Action and Perception

Traditional information-processing models (Massaro & Cowan, 1993; Simon, 1979) suggest that a visual stimulus is transduced into a series of representations that can serve a number of psychological functions forming the basis of physical actions. This assumes that stimuli are interpreted by the visual system before being analysed separately by the motor cortex in order to execute an action. Such a view assumes that concept knowledge is abstracted from real-world encounters and stored as amodal symbols, whereby the mechanisms involved in concept representations differ to those used in perception and action (Hampton, 1995; Machery, 2016; Mahon & Caramazza, 2008; Rosch, 1975; Rosch & Mervis, 1975). However, this does not allow for the interaction that takes place between the visual and action systems. It has been argued that these systems do not act independently of one another, and that this distinction has been greatly exaggerated by information-processing models (Ellis & Tucker, 2000). For example, our concept of *orange* includes not only the typical visual information present (that it is orange in colour) but that it also includes the physical properties (that it is round, smooth to the touch and requires peeling in order to eat). In an early position that arguably laid the ground for more current perspectives, Gibson (1979) proposed that the vision and motor systems are entwined in such a way that all objects in the environment have *affordances*. These affordances are properties of an object that allow for potential actions to be made. A flat, sturdy surface could afford support and could even be walked upon affording locomotion. In contrast, a water surface would not afford either. Gibson posits that objects are perceived in terms of their potential affordances and how we interact with them rather than their properties. Potential actions, and the affordances offered by an object, are derived upon perceiving an object, before functional properties. Such a view might suggest that the human brain shows a predisposition for action over function. Gibson argued that the affordances of objects show a great deal of variation between different items and are manufactured in order to be manipulated such as lifting, carrying and grasping. This is partly because objects themselves vary on many dimensions such as size, shape, texture and weight. For example, a small ball would allow for a person to pick it up with one hand where a larger ball would not and would need to be picked up with both hands. Such affordances are directly perceived and can be established from the visual system without the need for abstract processing (Greeno, 1994).

However, not all affordances are derived from the perceptual system. For example, fire can afford heat, which can be derived from the senses but is not a visually perceivable property. Objects that have a handle afford the action of being grasped by the handle. The context in which someone views an object can also influence the affordances derived from such. For example, if someone saw a frying pan with the handle pointing towards them they might be inclined to pick it up by grasping the handle in a use-appropriate manner in which case the grasp could lead to a potential action. In contrast, if someone saw the frying pan with the handle pointing away from they might be more inclined to grasp it by the pan rather than reach over and grasp it by the handle (see Creem & Proffitt, 2001).

In summary, the theory of affordances provides a way of combining both the visual and motor system in a dynamic manner allowing for the interaction between the two systems. Gibson distinguished between affordances and categorisation in that an object does not need to be categorised in order for affordances to be derived. A small, round object does not need to be categorised in order for it to be judged as 'graspable'. This supports the view that the visual and action systems work in tandem rather than separately.

1.2 Physical Action Responses

In line with the views of Gibson (1979), further research has also concurred that the distinction between the visual and motor/action system has been overstated and that the two systems have more of a reciprocal role (Ellis & Tucker, 2000; Grèzes, Tucker, Armony, Ellis & Passingham, 2003; Tucker & Ellis, 1998, 2001, 2004). Ellis and Tucker (2000) argued that as well as objects having affordances, they also contain *micro-affordances*. The difference between the two lies in the specificity of the action that the visual object can facilitate. For example, a mug with a handle can facilitate the action of grasping and picking up (affordance). A micro-affordance would be the mug facilitating a specific type of grasp. For example if the handle of the mug were pointing to the right it would facilitate a right-handed grasp and vice-versa. As Ellis and Tucker (2000) put it, "features of the object such as its location, shape and orientation will lead to activation of specific components of a reaching and grasping action" (p. 453). As objects can afford a wide range of possible actions both functional and volumetric (Bub & Masson, 2006; Bub, Masson & Cree, 2008), it follows that objects possess a variety of micro-affordances to suit such situations.

Tucker and Ellis (1998) showed that objects have micro-affordances through experiments demonstrating Stimulus Response Compatibility (SRC) effects on how grasp actions are made. Such effects are similar to the Simon effect (Simon & Ruddel, 1967), which describes the way in which the spatial position of a target stimulus significantly slows down response times when the response apparatus is not within the same (compatible) spatial position. What is particularly significant about such effects is that they are found even when spatial position is irrelevant to the task.

In Experiment 1 of Tucker and Ellis (1998), participants were shown images of household objects such as a knife, teapot and a frying pan in either an upright or inverted position and participants were asked to respond to the orientation of the object (left-hand inverted/right-hand upright or vice versa). The experimenters manipulated the direction of the handle in each image so that the handle either pointed to the left or to the right. The results showed a significant interaction between handle direction and response hand. When the handle of the objects pointed to the right participants were faster and more accurate to respond with the right hand; conversely, when the handle pointed to the left participants were faster to respond with the left hand over the right. This would show that the orientation of the object was able to potentiate possible actions and hence participants were faster to respond with the stimulus compatible hand.

Tucker and Ellis (1998) suggested that one possibility when considering these results was that rather than the orientation of the stimuli potentiating a grasp response to the compatible hand, participants were rather assigning an abstract left-right coding to the object based on its orientation. As such, they would be attuning to the location of the object rather than the potential action that could be carried out. Therefore, responses were faster with the right hand when the object was orientated to the right because it had simply been coded ‘right’ by the participant (and vice versa for the left hand/left orientation).

In order to test this, Experiment 2 aimed to replicate the procedure with a different response mode. To do this, the same experiment was repeated but participants responded only with the index and middle finger of the right hand. If abstract coding of left and right were responsible for the compatibility effect seen in Experiment 1, then the same compatibility effects would be replicated. If, however, seeing the orientation of the objects does potentiate possible actions then using only one hand to respond should fail to replicate the findings of Experiment 1. The results of only using one hand failed to replicate the response compatibility effect suggesting that the previous effects found were due to the specific potential actions (micro-affordances) activated and not due to the location of the items.

Experiment 3 was similar to Experiment 1 but presented objects whose use demanded that a person rotates their wrist to a vertical or horizontal orientation, turning the wrist either clockwise or anti-clockwise. The SRC effects found in Experiment 1 were not replicated in Experiment 3. Tucker and Ellis suggest that this might be due to one of two reasons; (a) as wrist movements take longer to make compared to button presses used in Experiments 1 and 2, it might be the case that any potentiation effects may have decayed before response onset, or (b) the planning of wrist movements is not made prior to the action being made, but is made “online” while the action is being performed. The former explanation is less likely given research which shows that action effects are relatively long lasting across experimental techniques (Binkofski & Buxbaum, 2013; Buxbaum & Kalénine, 2010; Campanella & Shallice, 2011; Jax & Buxbaum, 2010). Overall, the authors argue that the data demonstrate the link between action and cognition, i.e. that the visual system does not process information separately from the motor system but that the two systems interact in a dynamic manner. Viewing specific object stimuli had the effect of potentiating specific action and an object with the handle on the right/left side lead to faster and more accurate responses with the right hand/left hand respectively.

What is most interesting about the SRC effects found in Tucker and Ellis (1998) is that the potentiation of possible actions were brought about despite the action not being relevant for the task. This would imply that actions are automatically potentiated from visual information and would be in line with the account of affordances suggested by Gibson (1979)[1].

Tucker and Ellis (2001) have shown further compatibility effects when the actions are mimicked as the task response. Experiment 1 of Tucker and Ellis (2001) followed a similar task paradigm to that of Tucker and Ellis (1998) but, rather than participants responding to the orientation of the object, participants judged whether the object was natural or man-made. The experiment used a variety of natural and man-made stimuli which were further sub-divided into small objects that would normally be picked up with a precision grip (a pinch between the index finger and thumb) or a large object picked up with a power grasp (clasping of the whole palm and fingers).

Participants were provided with a response device consisting of two buttons, one between the index finger and thumb and the other along the side of the object operated with a clenched fist (see Fig 1.1). These buttons resembled the general pinch and power grasps and would be operated in one hand with both buttons accessible. The response pattern itself was counterbalanced between participants with half making the precision grip to the natural objects and the power grip to the man-made objects and vice versa. In addition, the authors sought to test if object distance had

[1] The suggestion that action is automatically recruited has been debated in recent literature and is discussed in more detail in Section 1.4.

any effect on the compatibility effects. The objects were either presented close to the participants (15cm – peri-personal) or further away (200cm – extra-personal) and the authors predicted that an enhanced compatibility effect would be found in the close condition. A correct response was made if the participants correctly identified the objects as either natural or man-made.

The results demonstrated strong evidence for compatibility effects with larger objects responded to faster with power grips and smaller objects responded to faster with precision grips. These effects were found despite object size being irrelevant to the task at hand. Interestingly, no difference in response times was found between the peri-personal and extra-personal space manipulation. These results further demonstrate that viewing objects automatically potentiates possible actions leading to faster response times when the response function was compatible with the general grip associated with use of the object.

The remaining experiments (Experiments 2 to 5) used a slightly different task of a go-no go paradigm where participants were trained to respond to tones rather than the images using the same response apparatus as in Experiment 1. In Experiment 2 participants were trained to prepare the index finger/thumb response if they heard a high pitched tone, or to prepare the squeeze on the cylinder if they heard a low pitched tone. After the tone they saw an image of an object and were told to make the prepared response only if the object they saw was natural. The results showed no compatibility effects, suggesting that the action compatibility effect generated from seeing the object was blocked by the previous action planning.

Using this go-no go paradigm the compatibility effect was only seen when the object denoting a go or no go response was presented 300ms before onset of the tone (Experiment 3) and when the object disappeared immediately before onset of the tone (Experiment 4a). The effect was not found when the object disappeared 300ms before onset of the tone (Experiment 4b). Finally, Experiment 5 was the same as Experiment 1 only participants used both hands to make a response with mapping counterbalanced between the left and right hand making precision and power grasps. The results once again showed a significant compatibility effect with potential actions not limited to the dominant hand of response.

Overall, the results of the experimental work showed that actions relevant to the use of objects can be potentiated from visual information despite the object properties in question being task-irrelevant. What the data further shows (using the terminology of Tucker & Ellis, 2001) is that the potentiation effect is *transient*. Looking at the difference between Experiments 4a and 4b it can be seen that introducing a delay negated the potentiation effect with no significant interaction found. Tucker and Ellis suggest that the mechanisms of the dorsal stream that represent the visual stimuli are not static, but are continually refreshed. If the prime were kept in continual view, then the dorsal stream would remain refreshed and the potentiation effect would remain consistent. In contrast, when the prime is removed the dorsal stream cannot refresh the same information and as such any potentiation effect would decay. Where the presented object is removed from view immediately before the onset of the tone (Experiment 4a) the dorsal stream is still influenced by the stimuli and hence the potentiation effects are still seen. In such a view, the potentiation effect only occurs while the stimulus is kept in constant view. However, this is in contrast to other research suggesting that action effects can be relatively long lasting (Binkofski & Buxbaum, 2013; Buxbaum & Kalénine, 2010; Campanella & Shallice, 2011; Jax & Buxbaum, 2010). Similar effects were found in Experiment 1 of Ellis and Tucker (2000) where participants responded with a power or precision grip to a low or high-pitched tone. However, the compatibility effects here were confined to the high-pitched/precision grip mapping response.

Grèzes et al. (2003) have since sought to identify the brain areas activated whilst conducting such behavioural experiments. Their experiment followed the same basic paradigm of Experiment 1 of Tucker and Ellis (2001) where participants responded with a power or a precision grip if an object was natural or man-made. Participants made these choices with two manipulanda, one of a precision and one of a power grasp (similar to that used in Tucker & Ellis, 2001, and seen in Figure 1.1). The experiment was a replication of Tucker and Ellis (2001), except MRI scans were taken while participants engaged in the task.

The experiment found that participants were significantly faster to make precision grips to those objects normally picked up with a precision grip than they were to make power grips to the same objects. However, no difference was found between the time it took participants to make power grips over precision grips to objects normally picked up with a power grip. The MRI scans found a high level of activation in the parietal, premotor and inferior cortex. In particular, it was found that the greater the difference between the reaction times of the congruent and incongruent trials, the greater the activity that was found in such areas. The authors explain this as a competition effect that occurs between the affordances potentiated from seeing the objects and the response to be generated. During congruent trials there is little competition effect and the activation of the prefrontal cortex is small. However, when the affordances and the response to be made differ the, competition effect is greater leading to higher activation in the prefrontal cortex and longer response times. Grèzes et al. (2003) take this as further evidence for the activation of affordances and the automatic nature of potentiated actions.

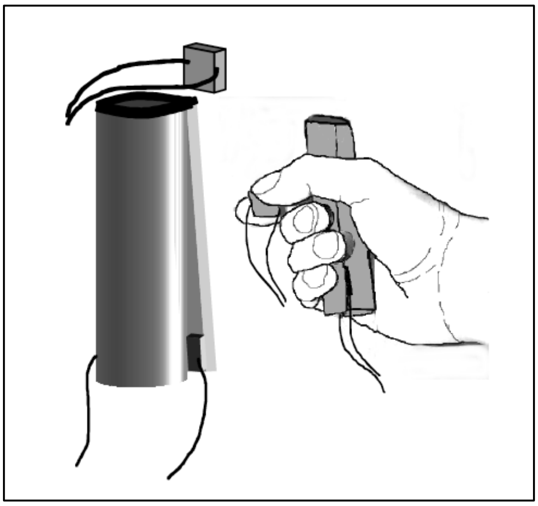

Figure 1.1. Response device used in Tucker and Ellis (2001) consisting of a grasp and a pinch button.

1.3 Action-Irrelevant Tasks

It seems then that participants are influenced by instantiated action knowledge in tasks where they are required to make action-based responses, i.e. in ‘action required’ tasks (Ellis & Tucker, 2000; Tucker & Ellis, 1998, 2001, 2004). Further research for the intrinsic activation of action knowledge has shown that even in tasks where participants are not required to access action-based semantic information (‘action-irrelevant’ tasks) such knowledge still has a strong influence on task performance and is activated ‘automatically’.

Myung et al. (2006) demonstrated this using a lexical decision task (Experiment 1) and a speech-to-picture matching task (Experiment 2). While the definition of action does vary across research (Tucker and Ellis, 1998, 2001, define action as the precision or power grip used to pick up the item), Myung et al. (2006) take the view that objects share an action based on hand positions and body movements for the intention of using the objects for their functional purpose. For example, *piano* and *typewriter* share an action because of the finger movements required to play the keys or type. In the lexical decision task, participants were aurally played word-word and word-nonword pairs where the relation between the target and prime was manipulated for the congruency of action. For example, the target of *typewriter* followed the prime of either *piano* (action related) or *blanket* (non-related). Participants were faster to correctly identify the target as a word when the prime shared an action compared to the unrelated prime.

This was followed-up in their second experiment using a speech-to-picture matching task where the results were recorded using eye-tracking software. Four objects were shown on a screen consisting of the target, two un-related objects and an object that was either related to the target by action, as in Experiment 1, or shared perceptual characteristics (i.e., they looked similar). Participants listened to the name of the target played aurally and were instructed to touch the correct matching object on the screen in front of them. Participants spent more time looking at, and were more distracted by, the object that shared an action with the target compared to the object that looked similar. These results show that activation of action knowledge is implicit in such a task, and particularly important given that this is an action-irrelevant task in which no physical action is required to respond.

Borghi (2004) has provided further evidence that action knowledge influences task performance in action-irrelevant tasks. Borghi showed that during property generation tasks, participants were more likely to generate properties of objects directly related to action when they were thought of in the context of direct physical interaction. In other words, thinking of using an object brings to mind directly the object parts that afford actions. Borghi (Experiment 1, 2004) gave participants, in a between-subjects design, a series of objects and asked if they could imagine either using/acting, building or seeing the objects. On seven critical objects participants were then given a property generation task and asked to list relevant parts of the objects. The protocols were analysed according to the context in which participants were asked to think of the objects and it was found that properties relevant to physical interaction were produced earlier when participants were asked to think about using the objects compared to building or seeing.

In Experiment 2 the imagery decision task was removed and a neutral condition was introduced whereby participants were simply asked to perform the property generation task. No differences were found between the neutral and the action/use condition where participants still gave action-based properties earlier and with more frequency. The lowest action-based properties were generated in the building and seeing condition. This might indicate that within a general context, concepts are intricately linked to actions given that no difference was found between the action and neutral condition. Borghi further demonstrated the "irrelevant" influence of action in Experiments 3-5 where a property verification task was used. Participants were given a sentence followed by an object part that was either affording "the child divided the orange – slice" or was not affording "the child divided the orange – pulp". Across the experiments participants were faster, and produced fewer errors, on artefacts when the object part afforded the action in the sentence. Therefore, the results support the notion that concepts are intricately linked with physical actions and such information is 'automatically' evoked.

Campanella and Shallice (2011) have shown further evidence that action is automatically activated in action-irrelevant tasks, and that such effects are long lasting. In their first experiment, Campanella and Shallice employed a word-to-picture matching task where participants were shown a word (denoting an object) followed by two object images and they had to identify if an object matching the word was seen on the left or the right and to answer as quickly as possible. The distractor item was manipulated in how it was related to the target item such that it either shared no relation (pincers + candle), a visual relation (pincers + compass) or an action relation such that the pairs were manipulated in the same manner (pincers + nutcracker). Participants showed a very high level of accuracy when the distractor shared no relation to the target. Most interestingly, accuracy significantly decreased with a visual distractor, and decreased even more so with a manipulability distractor.

In Experiment 2, Campanella and Shallice not only replicated the effects of Experiment 1, showing that a manipulability distractor impacts on performance, but also showed that such distractors continue to have a detrimental effect on performance. Participants repeated the same task as in Experiment 1, only this time images were repeated so that participants saw each pair three times. The results showed that, as expected, a learning effect was seen on the visual distractor pairs such that after three presentations accuracy had significantly improved from the initial presentation. However, the opposite was shown for the manipulability distractor pairs in that a negative serial position effect was seen. After three presentations the accuracy had significantly decreased compared to the initial presentation.

These results could be explained by the activation of the motor system. When reading the target word, the motor system becomes active (following a simulation of the object[2]) and distractor pairs that share the same action (and therefore the same motor pattern) cause interference in selecting the correct item as they also activate the motor system at the same time. Over repeated exposure, this motor simulation becomes strengthened resulting in a long-term use-on-grasp effect (Jax & Buxbaum, 2010), causing stronger interference effects and hence a negative serial position effect occurs. This effect does not occur on the visual distractor pairs as no action knowledge is activated to cause an interference effect. However, what complicates the results here and this interpretation is that items that share an action will invariably share visual characteristics due to ergonomic constraints and how they are designed to work with the human body. Therefore, it is possible that the manipulability distractors had a stronger interference effect than the visual pairs because of sharing multiple sources of commonality rather than only sharing a single source of communality. The issue of ergonomics in selecting items that share actions is problematic for research in this area, and will be further explored in Chapter 2).

1.4 Is Action Knowledge Automatic or Task Dependent?

Claims concerning the automaticity of potentiated actions when viewing objects, such as those of Tucker and Ellis (1998, 2001, 2004), Ellis and Tucker (2000) and Myung et al. (2006), have since been moderated by further research showing potentiated actions to be task dependent (Bub & Masson, 2006; Bub, Masson & Bukach, 2003; Bub et al., 2008). Bub and Masson (and colleagues) have shown differences in passive viewing of objects and how this is insufficient in activating gestural knowledge (the gesture used in interacting with an object). Bub et al. (2003) designed an experimental task based on the Stroop paradigm (Stroop, 1935). In their task, participants were trained to associate a specific gesture (pinch, poke, closed grasp, open grasp) with a colour. After the training phase, participants were shown a series of coloured objects functionally operated with either a pinch, poke, open or closed grasp and instructed to mimic the gesture to the colour that they had previously learnt. In congruent trials the gesture associated with the colour matched the functional gesture of the object. In incongruent trials, the gesture associated with the

[2] According to simulation theory (Barsalou, 1999, 2003).

colour was different to the functional gesture of the object. The premise behind this is that if gesture knowledge is automatically recruited by looking at an object, then participants should be faster to respond on the congruent trials. The activation of the gesture on incongruent trials should cause an interference effect and hence increase response latencies.

In Experiment 1, participants were shown these congruent and incongruent trials along with coloured squares containing no object and asked to mimic the associated gesture previously learnt. Whilst response latencies were quickest overall on the coloured squares containing no object, there was no significant difference between the congruent and incongruent object trials. This was taken to show that simple passive viewing of objects does not recruit gesture knowledge associated with the functional use of it (an effect replicated in other experimental work, Bub & Masson, 2006, Experiment 1). The second experiment further examined this to see if a congruency effect could be found if participants had increased attention levels to the stimuli used in a task-switching paradigm.

In Experiment 2 a cue presented at the beginning of each trial indicated to participants whether to gesture to the colour (using the same training phase as in Experiment 1) or gesture to the object. The gesture to the object was to mimic the gesture normally associated with using it. Here the results showed a significant congruency effect in both the gesture to colour and object tasks. In both cases the response latencies on incongruent trials was significantly longer than on the congruent trials showing a direct interference from the activation of gestural knowledge of the object. It is not clear, however, if under any conditions participants made incorrect gestures (incompatible with the functional use) when they were asked to gesture to the objects rather than the colour. Therefore, the interference effect found on the gesture-to-object task is possibly caused not by the potential instantiation of the action to be made, but by errors in memory of what the colour represented in the training phase.

Experiment 3 examined whether or not gestural knowledge could be recruited in tasks where a physical action is not required. This is more closely linked to the work within the current thesis where an action-irrelevant task is used. Experiment 3 followed the same design as Experiment 2, but participants were either instructed to gesture to the colour (as in the previous experiments) or name the object. A significant congruency benefit was seen when participants gestured to the colour of the object, but no differences were found between the congruent and incongruent trials when participants were instructed to name the object. These results demonstrate that functional knowledge, particularly the action involved in physical interaction with the object, is recruited in tasks where a physical action is required but not when naming the objects or in passive viewing.

Bub and Masson (2006) followed up this line of research using a similar paradigm as Bub et al. (2003) to further investigate how gestural knowledge is automatically recruited in such tasks. In Experiments 1-3 participants were presented with an object prime, followed by an image of a hand gesture in which participants were asked to mimic the gesture shown. This followed the same design as the previous work whereby congruent trials were those in which the hand gesture shown matched that of the functional use of the object whereas these were different in the incongruent trials. Experiment 1 (where participants passively viewed the objects) showed no congruency effect between the congruent and incongruent trials (as found in Experiment 1 of Bub et al., 2003). However, in Experiment 2 participants were instructed to focus on the objects in more detail by running the same experiment, but asking participants to name the object shown in the prime at the end after mimicking the gesture. Using this paradigm participants showed an advantage with faster response latencies on the congruent than incongruent trials. It is possible in Experiment 1 that the task was not salient enough to activate semantic knowledge of the object, and that such action interference effects are only found when semantic knowledge is required for the task (as in Experiment 2, but in contrast to the previous research stated above showing action to be automatically instantiated, Borghi, 2004; Campanella & Shallice, 2011; Myung et al., 2006).

Experiment 3 increased the congruency advantage by presenting the prime and the gesture object simultaneously. In Experiments 4-6 the authors used the same Stroop-variant used in Bub et al. (2003) examining the differences in how different types of actions are evoked. The authors focused specifically on what they term functional and volumetric actions. Volumetric actions refer to any action involved with manipulating or moving an object, but are not the actions to interact with an object for its functional purpose. For example, the functional action of a calculator would be a ‘poke’ action of pushing the buttons where a volumetric action might be the ‘grasp’ of picking it up to carry it. All objects have both functional and volumetric actions with the potential that volumetric actions are numerous in comparison to functional actions. It should be noted here that there are some objects for which the functional and the volumetric actions can be the same (e.g. a drinking glass) and are termed as *non-conflict* objects in comparison to *conflict* objects (e.g. a calculator) and differences between such will be addressed in Section 1.6 (Jax & Buxbaum, 2010; Osuirak, Roche, Ramone & Chainay, 2013).

Bub and Masson (2006) gave participants a training phase to associate specific colours with both functional and volumetric gestures. In the same manner as previously, participants in the test phase were shown the objects in varying colours and asked to make the gesture associated to the colour in the training phase. Across Experiment's 4 and 5 (varying the proportion of congruent to incongruent trials) it was shown that participants were slower to make the gestures in the incongruent trails than the congruent trials. This effect was found for both the functional and the volumetric actions. This would suggest that both forms of actions are conceptually stored and can be primed to have an interference effect. What is particularly important here is that increasing attention to the objects (rather than passive viewing) evokes action knowledge associated with both the functional use of the objects as well as knowledge of general interaction with the same objects.

1.5 Neurological Findings

The notion that action information is incorporated into conceptual knowledge is supported not only by behavioural research but also by neurological research. Research has shown that areas of the brain related to action execution, namely areas of the premotor cortex, become active in both action-required and action-irrelevant tasks (Aziz-Zadeh & Damasio, 2008; Aziz-Zadeh, Wilson, Rizzolatti & Iacoboni, 2006; Canessa et al., 2008; Chao & Martin, 2000; Hauk, Johnsrude & Pulvermüller, 2004; Mahon & Caramazza, 2008; Martin, 2007, 2016; Martin, Haxby, Lalonde, Wiggs & Ungerleider, 1995; Tettamanti et al., 2005). The evidence supporting the claim that such effects are specific to the concept evoked and not just a general response to the task is that such areas only become active for specific concepts.

Chao and Martin (2000) conducted an fMRI study in which brain scans were taken while participants looked at images of faces, buildings, animals and tools. What was found was that the areas linked to action and the premotor cortex became active only when the participants viewed the images of the tools which carry a distinct level of interactive information such as *hammer* and *spanner* where buildings, animals and faces do not. Tettamanti et al. (2005) also showed that when participants listened to sentences containing actions involving the mouth, hands and feet, such as "I bite an apple" and "I kick the ball", there was activation of the fronto-parieto-temporal network in the left hemisphere. This was in direct contrast to participants listening to abstract sentences where no activation of the premotor cortex was seen.

Canessa et al. (2008) further showed differences in brain activation based on both action and functional knowledge. Participants were presented with pairs of objects and asked whether or not they shared the same manipulation pattern, or the same context of use. The results showed that while areas of the brain were activated simultaneously, activation of the left fronto-parietal areas including the dorsal premotor cortex were significantly stronger when participants were asked to identify which of the two objects shared the same manipulation pattern. Overall, the research here shows that areas of the brain devoted to planning and executions of actions are evoked even in passive tasks and that such information is incorporated into concept knowledge (Aziz-Zadeh & Damasio, 2008; Caramazza & Mahon, 2006; Grèzes & Decety, 2001; Tranel, Kemmerer, Adolphs, Damasio & Damasio, 2003). It should be noted that the programme of work reported in this thesis is not based within neurological research. However, such supporting findings from that perspective will be alluded to throughout the thesis.

1.6 Volumetric and Functional Actions

Bub et al. (2008) further tested the notion of differences in functional and volumetric actions through physical actions rather than pantomimed gestures (as used in their previous work – see section 1.4). Subsequent research has shown that participants perform differently in task conditions when required to perform physical actions on objects (Jax & Buxbaum, 2010; Osuirak et al., 2013). Bub et al. designed a response element known as the 'graspasaurus' (see Fig 1.2). This consisted of a three-dimensional, curved base with four response elements to allow participants to make a grasp, pinch or poke response (two grasp elements with a horizontal cylinder to allow a grasp and a vertical cylinder with a 'trigger' to resemble a spray bottle). Two graspasaurus were designed to allow for four functional and four volumetric actions (one for each gesture type).

Experiment 1 of Bub et al. (2008) used the same Stroop-variant task of Bub et al. (2003) and Bub and Masson (2006). Participants were trained to associate a specific colour to a gesture/response element and then saw objects in varying colours and were instructed to make the physical gesture on the correct element of the graspasaurus to the colour of the object. The results showed the same effect as in the previous work, i.e. that response latencies on congruent trials, where the appropriate gesture matched that of the object's natural functional gesture, were significantly shorter than on incongruent trials. In order to remove the possibility that participants would naturally gravitate towards the correct element on the congruent trials because of shared perceptual features (the response element looks like the object in the test trial), Experiment 2 repeated the procedure but instructed participants to simply point to the correct element rather than make the gesture. If perceptual information was playing a strong role here in the congruency effect then pointing at the correct response element should replicate the same patterns as in Experiment 1. However, this was not the case and no significant congruency effect was found demonstrating that gestural knowledge was evoked in Experiment 1 and that this interfered with the response to be made on incongruent trials. This would suggest that the effect found in Experiment 1 was not due to the perceptual characteristics of the object, but to the actions being potentiated upon viewing the target object.

The third and fourth experiments tested differences in using words (object names) as opposed to images to see if words alone can evoke gestural knowledge. Experiment 3 followed the same design as the previous (replacing the target objects with words) and participants again responded to the colour by making the associated gesture on the graspasaurus. Under these conditions, a significant congruency effect was not found demonstrating that passive viewing of words is ineffective in evoking gestural knowledge. However, in Experiment 4 a lexical decision task was added where participants first responded to the colour using the graspasaurus and then identified if the word was real or a non-word. Nonsense letter strings were added for this task but not analysed. This increase in attentional resources led to a significant congruency effect with shorter response latencies on the congruent than incongruent trials in both the functional and volumetric gestures. Therefore, passive viewing of words does not evoke gestural knowledge, however, when participants are forced to attend to the meaning of the words (as in the lexical decision task) gestural knowledge is recruited despite not being necessary for the task and this impacts on task performance.

What should be noted here is that in both Experiments 1 and 4, where significant congruency effects were found, there was no significant main effect of gesture type where subsequent research has found differences in how functional and volumetric information is recruited (Bub & Masson, 2010, 2012). Experiment 5 tested differences in functional and volumetric priming by using a combination of the lexical decision and gesture task to establish whether activation of functional and volumetric activation reflects a general 'action component' or if each can be recruited without the other. In this task, participants were shown a word (object, abstract or non-word) followed by a hand cue denoting either a functional or a volumetric gesture to mimic on the graspasaurus. After the response was made the participants verbally responded to the lexical decision task by stating yes or no. The gesture to be made matched that of the object in the word prime in the congruent trials whereas in incongruent trials these differed. Unlike the previous experiments, there was a trend for shorter response latencies in making functional over volumetric gestures and a significant interaction effect was found. Participants were significantly faster to make the gesture when it was functionally related to the object, but not when it was volumetrically related.

This has two important implications here. First, the finding that functional information can be recruited without volumetric information shows that the two are stored separately and do not share neural topography. This therefore suggests that activation of action knowledge is not a result of an overall 'action' component. Second, the rapid recruitment of functional information shows that functional information "holds a privileged place in the conceptual representations of objects" (Bub et al., 2008, p. 49) over volumetric information. This is supported by research demonstrating that functional information plays a central role in how objects are conceptualised (Barsalou, Sloman & Chaigneau, 2005; Barton & Komatsu, 1989; Chaigneau & Barsalou, 2008; Chaigneau, Barsalou & Sloman, 2004; Keil, 1989; Kemler-Nelson, Frankenfield, Morris & Blair, 2000; Masson, Bub & Newton-Taylor, 2008; Rips, 1989; for an opposing viewpoint see Malt & Johnson, 1992).

Masson, Bub and Warren (2008) supported these findings when participants were asked to read sentences containing an object, with no reference to a manual interaction, before seeing a hand gesture to respond to on the graspasaurus. A significant priming effect was seen on making functional hand gestures at both short (300ms) and long (750ms) priming intervals showing that functional information is quickly recruited in such tasks. However, no priming effect was seen for making volumetric gestures (though a borderline significant trend indicated a priming effect only at the long priming interval).

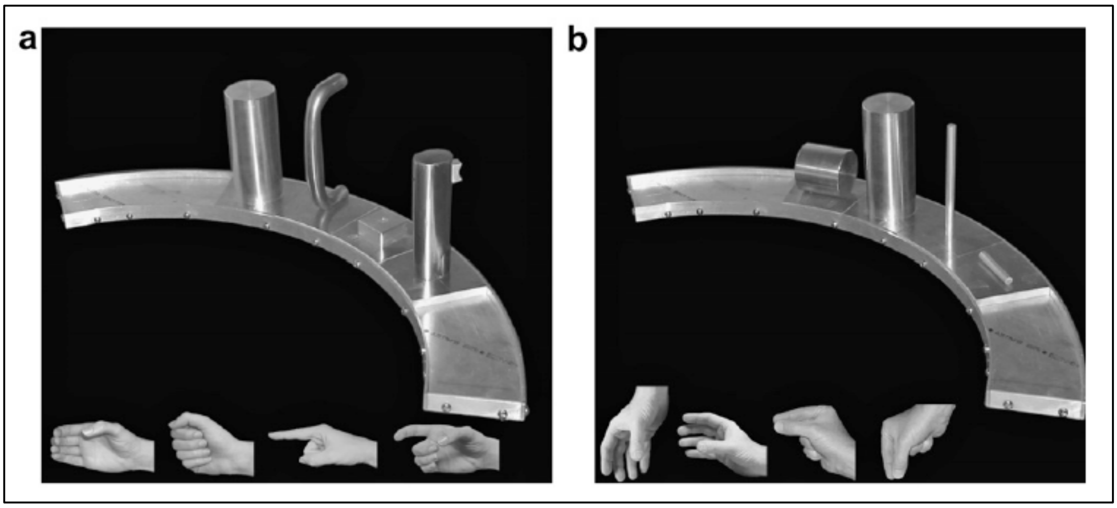

Figure 1.2. The response elements (Graspasaurus) used in Bub et al. (2008) for the functional gestures (A) and the volumetric gestures (B).

Bub and Masson (2012) have also supported differences between functional and volumetric actions in a primed response-to-gesture task. They designed an experiment where participants sat in front of the graspasaurus with three functional and three volumetric elements to grasp. Participants were shown a target cue on-screen depicting either a functional or a volumetric grasp and had to respond to the correct element. The onset of the cue was manipulated in conjunction with the name of an object played to the participant through headphones. The object itself was either congruent or incongruent to the cued hand gesture in terms of the associated action. The cue appeared on-screen either 150ms prior to onset of the word, at onset of the word, in the middle of the word or at the end. Reaction times for making functional and volumetric gestures were recorded for each level of the cue presentation. No effects were found for either grasp type when the cue was presented 150ms before onset of the word. However, strong priming effects were found for the functional grasps at onset, middle and end of the word where participants were faster for congruent than incongruent hand gestures to the object. As the onset of the cue increased in strength in relation to onset of the word, the priming advantage of congruent over incongruent trials also increased. This therefore shows that activation of functional knowledge of an object is relatively fast and has a strong effect which is maintained across the duration of the spoken word[3].

[3] However, what was not tested for here and remains unsure is the length of time for which this priming effect still exists after the word has been spoken.

In contrast to the functional grasps, the priming pattern of volumetric grasps is very different and not as consistent as that of the functional. For the volumetric grasps, no priming advantage for congruent over incongruent trials was seen for the cue 150ms before onset of the word nor at the point in which the cue appeared at the end of the word. At the onset of the word it appeared that the incongruent trials had a small but significant advantage over the congruent trials, which had a longer reaction time. This pattern was reversed when the cue appeared during the middle of the spoken word with the congruent trials having a shorter reaction time than incongruent (found in Experiment 1 and replicated in Experiment 2). This suggests that volumetric grasps are slower to activate, but quicker to dissipate. What is interesting here is that the prime initially resulted in a negative priming effect before quickly changing into a positive priming effect. Bub and Masson suggest that this is the result of the slow activation of volumetric information that begins relatively weak and develops in strength over time, in this case during the pronunciation of the spoken word. At the early stages the strength is weak and when a conflict occurs in an incongruent trial (between the action of the word and the action to generate) there is little competition in the cued action and evoked information. This results in the initial negative priming effect seen when the cue is presented at the onset of the spoken word. As the strength of the evoked volumetric information increases over time the competition effect also increases on the incongruent trials to the point where it slows down participant's reaction time. The result is a significantly longer reaction time on the incongruent than congruent trials. This information however quickly dissipates and there is no priming effect seen when the cue is presented at the end of the spoken word.

The overall pattern in the volumetric grasps was reversed in Experiment 3 where a verb was added to the spoken word. For example, participants heard "Lift up the pencil". The cue was presented either at the onset, middle, or end of the object in the sentence and a significant positive priming effect was seen at all three presentation intervals. Participants were consistently quicker on the congruent trials than they were on the incongruent trials. Overall, the results here show that both functional and volumetric information are evoked in cognitive tasks, but not at the same rate of instantiation. Functional information is stronger and more important as it is evoked quickly and is long lasting. In comparison, volumetric information is generated slowly and is quick to dissipate afterwards. However, the addition of a verb denoting the action can strengthen the volumetric information to have a consistently positive priming effect.

While it has been shown that functional information is stronger, research has also shown that interacting with an object in order to use it for its functional purpose impacts on later volumetric actions for grasping (Jax & Buxbaum, 2010, 2013). However, the reverse is not true and volumetric actions do not impact on functional actions. Jax and Buxbaum (2010) designed an experiment in which participants were presented with both conflict and non-conflict items and instructed to put their hand on the object as though they would either use the object (use action), or pick it up to pass to the experimenter (grasp action). The task order was manipulated and included into the analyses as a factor as either grasp-then-use or use-then-grasp conditions. Analysis of participants' initiation times to make use actions were significantly slower than to make grasp actions. Initiation times were also significantly slower for the conflict items than for the non-conflict items.

This is theoretically in line with the previous research as the conflict items would instantiate multiple motor patterns for actions which should slow down performance, whereas the non-conflict items would instantiate only a single motor pattern for both using and grasping an object. Therefore, the conflict items should be slower to act upon given the competition between those motor patterns activated. The latter finding has been supported by Jax and Buxbaum (2013) where using the same experimental technique two patients with ideomotor apraxia showed the same response pattern to the conflict and non-conflict items, which was more markedly pronounced compared to control subjects. In addition to these findings, Jax and Buxbaum (2010) also found a significant three-way interaction between task, object and order. When participants were asked to put their hand on the objects to use them they were significantly slower to do so for the conflict objects than the non-conflict. This pattern did not differ depending on which of the tasks was performed first, either use-then-grasp or grasp-then-use. When participants were asked to put their hand on the object to grasp and pass them there was no difference between the objects when they were asked to perform the grasp task first. However, when they were asked to perform the use task first, they were then significantly slower to put their hands on the conflict objects than the non-conflict in the grasp phase.

This shows that understanding of the use of the objects and instantiating such knowledge interfered with the grasp task when such knowledge is irrelevant for the task. The authors define this as a 'long-term use-on-grasp interference' effect. This interference was found to exist at both the early and later stages of the grasp task and lasted for approximately 20 minutes (as was the length the experiment took to complete). The authors explain this as being part of the "race effect" (Jax & Buxbaum, 2010, p.354) between functional and structural information. Functional information is much stronger than structural (referred to as volumetric by Bub and Masson, 2010, 2012; Bub et al., 2008), but requires activation of semantic knowledge to do so, i.e. you must know how to use it in order to do so. Whereas structural knowledge does not require such and is quicker to instantiate and hence "wins the race".

However, such results are in contrast to that found by Bub and Masson (2012) who showed that volumetric/structural actions are slower to evoke than functional actions. This difference could be explained by the fact that in Bub and Masson's work the participants had to make a physical response on the graspasaurus whereas in Jax and Buxbaum's research participants did not have to physically pick up the objects or use them.

Osiurak et al. (2013) conducted two experiments designed to replicate the work of Jax and Buxbaum (2010) using only non-conflict items. Experiment 1 was a direct replication of Jax and Buxbaum (not including the conflict items) where as, in Experiment 2 participants were physically asked to pick up the object and pass it over to the experimenter or to pick up the object and use it to hit a ping pong ball hanging in front of them on a string. The purpose of this was to directly compare the differences between the intention to use and object compared to physically doing so. Experiment 1 replicated the results of Jax and Buxbaum in which participants were faster to make grasp movements to transport the object than they were to use them. However, the results of Experiment 2 were in direct contrast to this showing that the actions to use the objects were significantly faster than that to grasp and transport them. This is most likely caused by the fact that having to grasp an object does evoke semantic information related to such an object such as its weight and solidity, as well as information relating to the destination such as where the experimenter's hand was to receive the object. Such characteristics would not have been evoked in Experiment 1 since they were not needed. This therefore supports the notion put forward by Bub and Masson (2012) that functional information is strong where volumetric/structural information is slower to evoke hence leading to a use-on-grasp effect, but not a grasp-on-use effect.

1.7 Actions in Object Recognition

In addition to the experimental evidence outlined above, studies on object recognition have also shown that action information is recruited and used in aiding such processes (Bub, Masson & Lin, 2013; Helbig et al., 2006; Helbig, Steinwinder, Graf & Kiefer, 2010). Helbig et al. (Experiment 1, 2006) presented participants with a prime followed by a target object; they had to identify both objects. The prime and target either shared an action (e.g. pliers and nutcracker) or shared no action, but were somewhat similar in their perceptual looks (e.g. pliers and horseshoe). In identifying the objects the participants were significantly more accurate on congruent pairs that shared an action. The experiment was repeated in Experiment 2 using words rather than visual images given the research that words can activate the premotor cortex (Hauk et al., 2001; Pulvermüller & Hauk, 2006). However, the results were not replicated suggesting that words do not activate action knowledge in the context of object recognition.

Helbig et al. (2010) followed this up by designing an object recognition task using video primes. In Helbig et al. (Experiment 1, 2010) the prime consisted of a hand performing the action on an invisible object against a black background. The prime was shown to the participants followed by an image of the target object. The prime was either congruent or incongruent with the action that would normally be associated with the functional action of the object. After the target object was shown an object label appeared and participants were instructed to respond as quickly and as accurately as to whether or not the target image and the word label matched. Participants were significantly more accurate when the action in the prime was congruent with that associated with the target object. However, unlike in previous research there was no difference in the reaction times. Helbig et al. further replicated these results in Experiment 2 where the task was made more difficult in a backwards masking paradigm. Overall, the experimental results suggest that both static images and video primes can facilitate object recognition by instantiating action information whereas words (object names/labels) do not.

1.8 When is Action not Activated?

While action knowledge might be activated automatically, it does not necessarily mean that it would always influence performance in experimental tasks. The experimental research discussed above (Bub et al., 2003; Bub et al., 2008, Bub & Masson, 2006, 2012; Elis & Tucker, 2000; Grèzes et al., 2003; Tucker & Ellis, 1998, 2001, 2004) has demonstrated that evocation of action knowledge is automatic and influences task performance, even in action-irrelevant tasks where such knowledge is not needed. This makes the prediction that visual stimuli should invoke action knowledge which has been supported by the research outlined above (Bub et al, 2003; Bub et al, 2008, Bub & Masson, 2006, 2012; Elis & Tucker, 2000; Grèzes et al, 2003; Tucker & Elis, 1998, 2001, 2004). However, research has shown that the use of visual images is not always effective in inducing priming effects (Borghi, Bonfiglioli, Lugli, Ricciardelli, Rubichi & Nicoletti, 2007).

Borghi et al. (Experiment 1, 2007) showed primes to participants of either a precision grip, a power grip or an open hand followed by an object that the participant had to classify as either natural or man-made (with the open hand acting as a no-go trial). The objects were selected so that half were interacted with a precision grip, and half with a power grasp. As with the previous work using primes (Bub et al, 2003; Bub et al, 2008, Bub & Masson, 2006, 2012; Elis & Tucker, 2000; Grèzes et al., 2003; Tucker & Ellis, 1998, 2001, 2004), it was predicted that participants would be quicker on congruent trials where the prime matched the action of the object. However, no effect of priming was found with no advantage of congruent over incongruent trials. It was found that natural objects requiring interaction with a power grasp, were identified faster than all other objects. This might possibly be the case because artefacts are more strongly associated with both functional and volumetric knowledge than natural objects, therefore simulating artefacts might cause more of a cognitive demand than its counterpart (Borghi et al., 2007; Vainio, Symes, Ellis, Tucker & Ottoboni, 2008).

Experiment 2 was identical to the previous with the exception that participants performed a motor training phase prior to the experiment. The precision grip and power grasp images were shown in random order and the participant was to mimic the gesture shown. In replicating the experiment, the significant interaction between prime and object gesture was found where reaction times on congruent trials were faster than on incongruent trials. This can be explained by the results of Jax and Buxbaum (2010) who showed the long-term use-on-grasp effects. As the primes shown to the participants were of the functional grasp of the object, this should activate a long lasting representation that should then facilitate the mimicking of the gesture. The same would not be predicted if the primes were of a volumetric action since Jax and Buxbaum found no long term grasp-on-use effect. In addition, Borghi et al. replicated the same effect from Experiment 1 where participants were faster to respond to natural objects with a power grasp than any other objects.

The overall results here could be explained by two possibilities:

(i). The use of pictorial images as primes is insufficient to activate knowledge of action and no priming effect occurs.

(ii). The use of pictorial images can instantiate action knowledge but this does not mean that its activation is salient enough to influence the categorisation task used above.

Given the previous evidence using priming experiments from Tucker and Ellis (1998, 2001, 2004) and Ellis and Tucker (2000) the first explanation does not seem likely. Such experimental work has shown that using images of objects can activate action knowledge. This is further supported by Creem and Proffitt (2001) who showed that action knowledge is instantiated when participants were asked to pick up a physical object placed in front of them. When asked to simply pick up the object placed directly in front of them, participants nearly always reached for the handle of the object to perform an “appropriate” grasp. However, when participants engaged in a simultaneous semantic paired-associates task, the percentage of appropriate grasps significantly dropped showing that the concurrent task interrupted the depth of semantic knowledge of the object activated and blocked activation of physical interaction. This finding shows that action knowledge can be evoked from physical and pictorial stimuli and therefore the first explanation cannot be substantiated.

It is therefore more likely that the latter explanation is true of the results. Visual imagery can activate a wide range of information such as functional, thematic and autobiographical and while this may also include action information, this does not necessarily mean that such action information will override other features and always be used in the task at hand. There are other factors involved that increase the salience of the action information and make it more likely that it will be used in such tasks. In the case of Borghi et al. (2007), it is clear that action information may have been activated in Experiment 1, but such information only became task salient when participants performed a motor training phase before the experiment. This in turn has the obvious drawback of increasing the participants' attention to the 'action' aspect of the experimental work and potentially lead to participant demand characteristics.

Using a similar task to that of Borghi et al. (2007), Vanio et al. (2008) further investigated compatibility effects on natural/man-made categorical decision making. Vanio et al. (2008) modified the procedure used in Borghi et al. (2007) by presenting items in their actual size and by presenting a dynamic prime to the participants. The latter was introduced as a result of Borghi et al. having shown that action compatible effects were only seen following a motor training phase.

In Experiment 1, the authors presented eight images of a hand making a power grasp or a precision grasp in a sequential order so that participants saw a dynamic hand prime. At the end of the sequence an object was superimposed on top of the hand so that they were transparent, and the participant could see both. The participant was tasked with identifying if the object seen was either natural or man-made. Catch trials were also included where the end of the prime showed an amalgamation of a power and a precision grasp, on such trials participants were instructed not to respond. The objects themselves were either small or large in size (presented in a real-time visual appearance) and the hand gesture to pick up the object was either congruent or incongruent with the prime (power or precision). As with previous research it was predicted that participants would be faster on congruent trials.

The results showed that overall, participants were faster to respond to the objects denoting a power grasp, and faster to respond to natural rather than man-made objects (with the effect particularly strong for natural objects). In line with Borghi et al. this is most likely because artefacts have stronger functional information associated with them compared to natural objects, which do not possess such functional knowledge, for example, a hammer is designed with a specific function in mind where as an orange does not have a function. Since 'less' information is activated on the natural objects these are quicker to respond to. Most importantly a significant compatibility effect was observed. Participants were significantly faster to respond to the power grasp compatible objects after seeing a power grasp prime, and conversely were faster on the precision objects after seeing the precision prime. This would show that dynamic primes are sufficient in instantiating action knowledge to facilitate categorical decisions based on shared actions.

Vainio et al. (2008) extended these findings when participants were instructed to respond verbally (Experiment 2) and used response apparatus allowing them to respond with either a precision or a power grasp (Experiment 3). As the congruency effects found with the type of gesture (power grasps and precision grasp object responses facilitate by the congruency of the prime shown) were replicated using different responses, this shows that such effects are not simply the result of physically priming a hand response. Rather, the results imply that such action knowledge itself was instantiated resulting in action compatible results across various response mediums.

The research outlined above has demonstrated that action knowledge is automatically instantiated under certain task conditions. However, importantly for this thesis, the picture that seems to be emerging from this literature is that action knowledge is influential, but not in all cases. The question that arises is what are the possible factors that mediate this influence?

1.9 The Role of Context

The research described above makes a strong case for concluding that the evocation of action knowledge, whilst potentially automatic, only influences performance in experimental tasks under certain circumstances such as following motor training (Borghi et al., 2007). It could potentially be that such tasks 'activate' action knowledge only in the context of a goal made relevant by the task. A further factor which has been shown to influence the saliency of not only action knowledge, but other objects' features in general, is the presence (or absence) of context (for a review, see Yee & Thomson-Schill, 2016). Barsalou (1982) argued that concepts have properties that are both context-dependent, only arising under certain situations, and context-independent, which are activated regardless of the situation they occur. For example, the fact that a skunk smells is a context-independent property, regardless of the context, this should always come to mind when thinking about skunks. In contrast, the fact that a roof can be walked upon is a context-dependent property where this feature should only be activated in the context of needing to gain access to a roof.

Experiment 1 (of Barsalou, 1982) used a property-verification task (pilot work was conducted to generate a list of context-independent and dependent properties). Participants were presented with a sentence including an underlined noun that they read aloud before seeing a property that they had to verify if the property belonged to the noun in the sentence. The hypothesis here was that for context-independent items the property should come to mind just as quickly whether the property was related or unrelated to the context. For example, if "has a smell" is a context-independent property of skunk then participants should be just as quick to verify this in the related sentence of "the skunk stunk up the entire neighbourhood" as they are in the unrelated sentence of "the skunk was under a large willow". In contrast, for context-dependent items participants should be quicker to verify the properties when they are related to the sentence than when they are unrelated. For example, "can be walked upon" should be verified quicker after the related sentence of "the roof creaked under the weight of the repairman" than after the unrelated sentence of "the roof had been renovated prior to the rainy season". The results of Experiment 1 confirmed these hypotheses, no differences were found in response latencies between the related and unrelated contexts of the context-independent items. In contrast, the response latencies for the related context on the context-dependent items were significantly shorter than for the unrelated contexts.

Barsalou (1982) further confirmed this distinction in Experiment 2 using a similarity judgement task. Participants were given pairs of objects from both common categories (e.g. birds, furniture) and from ad hoc categories (e.g. plunder taken by conquerors, can be a pet) and asked to rate their similarity on a scale of 1 to 9. The context manipulated in this experiment was that half of the subjects were given the category name prior to seeing the pair (context condition) while the remaining half did not see such headings (no-context condition). The predictions were that as common categories are bound by contextually independent properties then similarity ratings between the pairs should not differ whether or not the participants are given contextual information. In contrast, as ad hoc categories are bound by the context in which they occur (Barsalou, 1982, 1983, 2002), then similarity between such pairs should be significantly higher when they are presented within context.

The results again confirmed these predictions with context having no effect on the common categories, whereas the similarity ratings were significantly higher for the ad hoc categories when presented with context than when they were presented without. The results of both experiments confirm that concepts contain both context-independent and dependent properties. However, while the items used were assessed to ensure that the context-dependent and independent items were equally related to the target nouns, it is possible that context-independent properties are lexically more common and therefore, more likely to occur frequently in language.

What is not clear is where the role of action knowledge lies on this spectrum. Research supports both the notion that action could be thought of as a context-independent "property" (Borghi, 2004; Bub et al, 2003; Bub et al., 2008, Bub & Masson, 2006, 2012; Chao & Martin, 2000; Elis & Tucker, 2000; Grèzes et al., 2003; Tucker & Elis, 1998, 2001, 2004) as well as being context-dependent (Borghi et al., 2007; Creem & Proffitt, 2001). However, it is clear that this depends upon the method used and whether semantic knowledge is recruited for task completion. It is possible that this is due to how context is operationalised for the experimental tasks used.

Despite this research, newer ways of thinking about concept formation such as simulation theory posit that there is no such thing as objects being 'context free' (Barsalou, 2003, 2008, 2016a, 2016b, Solomon & Barsalou, 2004; Wu & Barsalou, 2009; Yee & Thompson-Schill, 2016; Yeh & Barsalou, 2006). Under this view, the simulation of the generated concept generated will draw upon all modalities and as such will always be thought of in a contextualised manner (Barsalou, 2003). Therefore, the results of Barsalou (1982) could be explained in a different manner. The nouns in the sentences (skunk/roof) are the concepts to be simulated in the sentences. The notion that a skunk smells is quite common and would occur across a multitude of contexts. In contrast, the notion that a roof can be walked upon might be rare in terms the number of times a person has walked on a roof (unless that was a person's profession).

The simulation generated is influenced by its availability arising from both the recency of encountering the object in the real world, and the frequency with which such properties occur (Barsalou, 2003; Yeh & Barsalou, 2006). One is more likely to encounter a skunk that smells than one which does not. Furthermore, it is more likely that encounters with a roof are more likely to be based on the roof being above a persons head rather than walking upon one. Therefore, a skunk that smells is more likely to be simulated than a roof that can be walked upon. It is not the case that such properties are context-independent, but are more likely to be included within the simulation of the concept. The concept will be simulated with a given context and the occurrence of the properties within the context leads to faster identification of the context-independent sentences.

1.10 Actions in Context

Bub and Masson (2010) also found context effects on generated actions when participants read sentences and mimicked actions following a hand prime. In Experiment 1, participants responded using the 'graspasaurus' response element used in Bub et al. (2008, see Figure 1.2) and later Bub and Masson (2012). In the experiment, participants were presented with sentences which suggested either a functional or a volumetric action such as "David wrote with the pencil" (functional) or "Bert picked up the pencil" (volumetric) allowing for a simulation of the object based on using or manipulating the objects. Participants were instructed to read the sentence out loud and then after a delay of either 300ms or 750ms were shown a hand prime which they had to mimic on the response element. The actions they performed were either congruent or incongruent with the functional/volumetric action that would normally be associated with object and the action suggested by the context. The results showed that in line with previous research, response latencies were significantly shorter when the action mimicked was congruent with the context, and that overall latencies were shorter for functional than volumetric actions. The results also indicated a significant three-way interaction between the cue, the action type and the delay length. The analysis showed that at the shorter delay both functional and volumetric actions resulted in a small but significant priming effect. At the longer delay the volumetric actions did show a small priming effect, but this was not significantly different from the priming effect seen at the short delay. However, for the functional actions, the priming effect significantly increased in strength at the long delay compared to that seen at the short delay. Therefore, this shows that actions suggested by reading sentences prime the associated action but that this effect is stronger for functional than volumetric information.

This is in line with the results of Bub and Masson (2012) who later showed that functional information is strong and fast paced in its nature whereas volumetric information is weaker and slower to develop. Experiment 2 showed that the effects seen in Experiment 1 were heightened when participants were shown an image of the object during the delay. Functional and volumetric actions resulted in a priming effect at the short delay, but as with Experiment 1, this was a small priming effect. At the long delay both functional and volumetric actions showed a strong priming effect, but this was only seen when the context suggested the action performed. The context suggested by reading sentences does invoke specific action effects, but this effect is strengthened by incorporating visual information and seeing the referent object of the sentence.

Further evidence for action playing a context-dependent role in conceptual knowledge has come from Borghi, Flumini, Natraj and Wheaten (2012) who considered context in terms of how items are functionally used together, i.e. sharing a functional co-occurrence. Borghi et al. presented participants with images showing pairs of objects manipulating the relationship between the paired items as well as the presence of a hand in the photos. Objects were shown sharing either a functional (scissors – paper), spatial (scissors – stapler) or no context (scissors – bottle) relation. A functional context was defined as a pair of objects that are not only found together but also used together as well. A spatial context was defined as being found together but not used. The hand factor was manipulated in four conditions; no-hand, where the objects were presented on their own; still-hand, a hand was placed near the objects but not touching them; functional-hand, a hand was placed on one of the objects as though it would be used; and the manipulation-hand condition where a hand was placed on one of the objects as though to pick it up but not to use it. Participants saw all possible object pairs in a complete within-subjects design and were asked to decide if the objects are "usually seen/used together or not". A significant effect of context was found where participants were faster and made fewer errors in the functional context over the spatial context. The main effect of hand posture was also significant in that participants made fewer errors with the functional-hand images and reaction times were fastest with the no-hand images and slowest on the manipulation-hand images, the latter effect possibly found because the images contained less information and were easier to analyse visually.

Of principle interest, the interaction was significant between hand posture and context. Post hoc analysis showed that there was no difference on the functional and manipulation images in the spatial context condition. For example, no difference was found for *scissors-stapler* when the hand was either placed on one of the objects either to use it functionally or to pick it up. However, in the functional context reaction times on the functional-hand images were faster than on the spatial. For example, participants were faster to identify that *scissors* and *paper* are used together when a hand was shown on the objects as though they would use it. When the hand was shown on the objects as though they would pick it up, but not use it, participants were slower to identify that *scissors* and *paper* are used together. Therefore, a facilitation effect occurred whereby activation of the motor system through the functional-hand images speeded accuracy and response times on judging item pairs that are functionally related to each other.

The results could be explained in one of two ways, the first is in line with Situated Simulation theory (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006). Under this view, the results can be interpreted as showing that a motor simulation was activated which facilitated object identification and the correct responses in the functional-context, but hindered speed and accuracy in the spatial context as the motor system tried to interpret the scene in front of it. Since *scissors* and *paper* share more of a common occurrence between them (as they are used together), it is easier to simulate them in context than it is to simulate *scissors* and *stapler*. The second explanation is that faster responses on the functional-context objects reflects a semantic association between the two objects. Participants might therefore be faster because scissors are simply more strongly associated with paper than stapler.

To test for this the authors repeated the experiment (Experiment 2) though participants were instructed to respond using foot pedals rather than using their hands. Using this technique would be able to distinguish between the two possible explanations. If the results were due to a stronger association between the functional stimuli then the same effects would be replicated when using their feet. However, if the results were not replicated then this would support the notion that the visual stimuli activate a motor simulation of the scene presented and thus facilitating the functional-context. Experiment 2 did not replicate the interaction effect seen in Experiment 1. Participants were equally faster to respond in the functional-context over the spatial-context, which once again elicited slower overall responses. This supports the conclusion that visual imagery activates a motor simulation of the event that is response specific in facilitating responses on a decision task between using hands or feet.

This finding is further supported by both neurological evidence (Chao & Martin, 2000; Hauk et al., 2004) and behavioural evidence (Campanella & Shallice, 2011). For example, Hauk et al. (2004) used event-related fMRI while participants engaged in a passive reading task where action words were used that were particularly related with the mouth, hands and feet (e.g. lick, pick and kick). The analysis revealed that the action words activated areas of the premotor cortex in a “somatotopic” fashion. The action words activated the regions of the premotor cortex that were associated with movement of such areas. This supports the findings of Borghi et al. (2012) as the images used were associated with hand gestures and therefore would activate the dorsolateral regions of the premotor cortex facilitating decision responses. This effect would not be seen in Experiment 2 where participants used their feet to respond, though one might predict a facilitation effect with objects denoting a foot gesture.

What should be discussed at this point is what is meant by the term “context”. The term itself has a wide range of definitions and it is often difficult to establish a shared meaning between disciplines (Bazire & Brézillon, 2005). For example, Borghi et al. (2012) discuss objects sharing a context when they are used together or share a thematic/spatial relation. In contrast, Barsalou (1982, 1999, 2003) discusses context in a more ‘situation’ based manner. For example, the context of buying fruit might occur within the context of being in a supermarket. For the purpose of the current thesis, context will be discussed in a more situation based meaning similar to the work of Barsalou (1999, 2003; Yeh & Barsalou, 2006) and Palmer (1975) rather than objects sharing a context because they are used together (Borghi et al., 2012).

Palmer (1975) showed that objects are faster to be identified in a physical context when it matched objects in a meaningful way. For example, a toaster was recognised quicker in a kitchen than in a garage. In a similar manner Kalénine, Shapiro, Flumini, Borghi and Buxbaum (2014) showed that visual scenes denoting either a use or a move context can potentiate affording actions. Kalénine et al. showed participants a visual scene consisting of a variety of objects that were organised in such a way that it was suggested to either move or use the target item. For example, in the move context, kitchen items including a timer were arranged so that the timer was in a drawer and needed to be picked up out of the drawer and requiring a power grasp to do so. In the use condition the items were arranged so that everything was ready and the timer needed to be set requiring a pinch to do so. The overall task of the participant was a categorisation task. In each scene participants saw the objects and a red square appeared around one of the items. Participants then heard either ‘natural’ or ‘man-made’ and participants had to answer yes or no. To do so participants were given a response device consisting of a cylindrical tube placed in front of them and held down a response box key until they were ready to answer. What was recorded here was the initiation time to release the button. Participants were given reverse mapping instructions with half making a power grasp onto the device to answer yes and a pinch to answer no, or vice versa.

It was predicted that the move context, which suggested a grasp action, would potentiate grasp responses while the use condition would potentiate pinch responses. No differences were found in the move context where participants were just as fast to make grasp responses, as they were pinch. However, the results did find that in the use context participants were faster to respond with a pinch movement than they were with a grasp. This is in contrast with research that has found that pinch movements are slower in general to make as they require precision, time and finesse (Borghi, Bonfiglioli, Lugli, Ricciardelli, Rubichi & Nicoletti, 2005; Vanio et al., 2008). Therefore, the results of Kalénine et al. show that visual scene contexts can potentiate actions however this is not for all contexts, but only those that suggest using objects in a functional manner. This leads to the predictions that action responses are more likely given a visual context (particularly denoting a functional use between them) than situations that impose no visual context.

1.11 Actions as Features?

An important aspect of this thesis, is the question of how action is stored in relation to a concept. Traditional models of categorisation (Collins & Quillian, 1969; Rosch & Mervis, 1975) take the view that concept knowledge is stored as amodal representations with the different elements stored as abstract symbols from the modal system used to process the information. For example, the knowledge that a water pistol is a toy, is made of plastic and is lightweight, would all be stored as individual, and "arbitrary" (Barsalou, 2003), symbols transduced from the original experience. Under this view, the knowledge that is also operated with a trigger squeeze would be stored in exactly the same symbolic form.

Different features for objects are stored as individual symbols and the combination of these symbols form the concept. According to traditional feature list views, only intrinsic features of the object such as perceptual and function properties were counted as features. Therefore, even if the concepts *are* stored amodally, action was not considered to be one of these features. Despite the fact that action was never previously considered to be an intrinsic feature of an object, the amodal views of conceptual knowledge *could* predict that action knowledge is incorporated within concepts by suggesting that action is stored as a feature. However, what is questionable is the extent to which amodal feature-based theories of concept representation can be effectively extended to encompass action as a 'feature' of objects.

Intrinsic features, such as functional and perceptual properties, are often well defined. For example, a kettle either boils water or it does not, a bird can either fly or it cannot. Even when artefacts are not being used by an agent, these properties still 'exist'. Such property knowledge would be easy to store within an amodal list given that the features are intrinsic and possessed by many instances of the category. In contrast, actions are not clearly defined as multiple actions can be performed on the same object, and not all category instances share the same action mechanisms. Given that actions are dynamic and that the term 'action' is itself open to interpretation, the notion of representing action as a feature presents a clear problem.

Many researchers have identified that object concepts incorporate multiple types of actions such as functional (using an object for its intended purpose) and structural/volumetric (manipulating an object for the purpose of generic movement; Bub & Masson, 2010, 2012; Bub Masson & Cree, 2008; Buxbaum & Kalénine, 2010). The operationalisation of 'action' within research has varied across experimental work. For example, action could be considered as the grasp and motor movement required to use a function for its intended purpose (squeezing a trigger, pressing a button), the grasp required to pick up an object (power or precision), that two items are used together (corkscrew and wine bottle), or even the functional goal of the situation (the 'shooting' of a rifle). A strict view would suggest that the conceptual system would need to store each individual action as a potential feature.

Consider a mug for example. Under amodal views, the conceptual system would need to store multiple features including that it could be *picked up by the handle*, *picked up by the base*, *picked up by the top of the mug*, or even *picked up by the handle using a precision grip.* Tucker and Ellis (2001, 2004) have described how objects have micro-affordances; the action required for an object where current demands may alter how a person interacts with it (e.g., is the handle facing the left or the right, does it require grasping with the left or right hand). It is unlikely that separate features are stored based on grasping objects with either hand dependent on the position of the object, but that such micro-affordances are transient and developed 'in flight'. Therefore, it does not seem feasible, nor economical, for the conceptual system to store multiple features around such potential actions that would only serve to exhaust its demands.

The final point to make here is based on what constitute ‘features’. Traditional literature has always discussed features in terms of physical, functional and biological characteristics. They are properties of the object which are either clearly visible, allow certain functions or is inherent in the genetic makeup of the objects. While some researchers have described action knowledge as representing a feature of an object (Campanella & Shallice, 2012), this would not apply to all definitions of action.

Consider a property generation task where participants are asked to generate properties of a rifle. Participants will generate perceptual properties along with functional and thematic properties. It should be noted that, as with action, thematic information is technically not a feature or a property of objects themselves. However, Wu and Barsalou (2009) found that thematic properties were reported by participants during a property generation task which might have arisen based on the participants’ misunderstanding of the word ‘property’ during such tasks. Based on participants’ performance during property generation tasks, they may very well generate the *handle* and *trigger* as properties of a rifle. Borghi (2004) showed that participants were most likely to generate the features of objects that directly relate to the functional use of them. However, it is unlikely that participants will generate *grasp palm around the handle* or *squeeze the trigger* as being ‘properties’ of the object given that they represent something that can be done and not possessive of a specific quality.

Knowledge of how to interact with an object would not be considered as an intrinsic ‘feature’ of an object. Furthermore, objects can be interacted with in numerous different ways. The fact that a mug could be picked up by the handle using a precision grasp, might not necessarily be considered as a standard action, and therefore not a ‘feature’ of the object. The argument here is that this does not represent a featural aspect, and that an amodal system could not in fact achieve this given the wide complexity of the term ‘action’.

1.12 Simulation Theory

As outlined above in Section 1.11, amodal views cannot offer an economical view of concepts given the difficulties in defining ‘actions’ and the notion of ‘features’. Part of the difficulty in explaining action, is the separation of the perceptual and motor as posited by amodal theories. In contrast, an embodied approach (such as Simulation Theory; Barsalou, 1999, 2003; Yeh & Barsalou, 2006) would present a more parsimonious view by incorporating both the perceptual and motor systems. In such a view, potential actions are not stored within a list but are guided by the perceptual system and the affordances available.

Situated Simulation takes the view that conceptual representations are not modular, but are grounded within multi-modal representations, particularly involving the perceptual, affective and motor systems. Concept representations are stored across all modalities and thinking about the concepts recruit information from all domains to create a single mental representation. Simulation theory argues that, upon thinking of a concept, information derived from those modalities, and the neurons active upon the initial encounter, are partially reinstantiated and a mental simulation is created. In contrast to traditional amodal theories, simulation theory suggests that concept knowledge is highly contextualised (Borghi, 2004; Barsalou, 1999; 2003, 2008; Connell & Lynott, 2014).

Simulation theory suggests that knowledge of actions is incorporated directly into conceptual knowledge (Barsalou, 1999, 2003, 2008; Barsalou, Solomon & Wu, 1999; Wu & Barsalou, 2009; Yeh & Barsalou, 2006). The theory suggests that unlike traditional views of category knowledge (Brooks, 1978; Collins & Quillian, 1969; Collins & Loftus, 1975; Medin & Schaffer, 1978; Rosch & Mervis, 1975), concepts are not represented as abstract and decontextualised ‘feature lists’ but are stored within sensory-motor circuits used on the initial encounter with an object (Aziz-Zadeh & Damasio, 2008; Fernandino & Iacoboni, 2010; Martin, 2016).

Upon viewing an object, the conceptual system does not record a visual image, but rather registers the neurons that were activated at the time of the initial encounter (Barsalou, 1999). When thinking of, or re-instantiating, a concept the system partially reactivates those neurons that were active at the time in which we initially encountered the object. This includes neurons based within each of the brains sensory systems including neurons in the motor cortex. It is important here to note that this is only a partial, not full, re-instantiation, as a full instantiation of the visual cortex would result in physically seeing the object when it would not be there. As such our concepts are ‘modal’ being stored across such sensory systems. Re-instantiating a concept reactivates the motor neurons which in turn will influence performance in tasks where such information may not be necessary to complete the task, yet is already activated. This leads to the prediction that upon thinking about an object, information related to action should come readily to mind on tasks irrespective of whether it is necessary for the task.

The simulation involving the object can take a variety of forms and is dependent on various factors such as the type of experience with the object, the amount of experience with the object (objects that are more common to us are easier to simulate) and how recently we encountered the object. Certain features of the objects become more salient in the simulation based on our most recent experience. For example, if your most recent experience with a grapefruit was seeing it in a supermarket then the simulation would most likely be based around such a shopping experience. However, if your most recent experience was eating one, then the simulation might centre around such an event and the taste of the grapefruit would be included in such. What is important to note is that the brain does not work like a recording device which, upon simulating, would reinstantiate the whole event as it was originally perceived. Rather the simulations created are based on a partial reactivation of the original neurons involved, which leads to the simulation. Connell and Lynott (2014) further suggest that the simulation/representation will always be different upon each instantiation with the object because of a variety of factors including strategic attention, task demands, time and linguistic abilities and changes in language.

Yeh and Barsalou (2006) further propose that conceptual knowledge is 'situated' within physical contexts. As our concepts are dynamic and contextualised (Barsalou, 2003), simulations of concepts are embedded within a given context, and not 'abstracted'. For example, when thinking of a kettle the simulation system does not simulate a kettle in isolation, but generates a context in which the kettle would normally be seen. From a simulation perspective, there is no such thing as 'context free' (Barsalou, 2003, 2008, 2016a, 2016b). Yeh and Barsalou have proposed that the simulation (out of all the situations in which these items could have been encountered) will vary based on three factors;

(i). Grain size: The physical size of the situation will vary given the nature of the spatial and temporal dimensions of such. For example, being in a classroom would represent a small grain size in comparison to being at the beach, which would represent a large grain size. This can be likened to the aperture of a camera where the 'snapshot' could include either a wide or narrow field of view.

(ii). Meaningfulness: This refers to the relation between the concept object and the situation, which could be meaningful or simply reflect a co-occurrence. For example, blackboards and desks have a meaningful relation to a classroom and are highly predictable whereas coffee cup might be less predictable and not an integral aspect of the classroom.

(iii). Tangibility: This refers to whether or not the situation is imagined, further depending on a person's previous experiences, or physically re-instated. This often comes into play in research on context-dependent memory where physical reinstatement of the context leads to better memory recall (Brinegar, Lehman & Malmberg, 2013; Godden & Baddeley, 1975; Smith, 1979; Smith, Glenberg & Bjork, 1978; Smith & Vela, 2001).

1.13 Evidence for Simulation Theory

In support of the simulation view of concepts, evidence using property verification and feature listing tasks have shown how participants simulate objects during task performance (Kan, Barsalou, Solomon, Minor & Thompson-Schill, 2003; Santos, Chaigneau, Simons & Barsalou, 2011; Simmons, Hamann, Harenski, Hu & Barsalou, 2008; Solomon & Barsalou 2004; Wu & Barsalou, 2009). Solomon and Barsalou (2004) used a property verification task where they manipulated the relationship of the false trials to the target word along with the task instructions. Property verification tasks give participants the word of a concept followed by the word of a property. Participants are asked to respond *true* if the property is a part of the concept. For example, participants might be asked if *keys* is a property of PIANO (true condition) or if *keys* is a property of FLUTE (false condition). Participants who perform this task might use one of two strategies; either participants (as predicted by simulation theory) create a simulation of the object relying heavily on perceptual features, or they adopt a word association strategy. Dual-coding theory suggests that participants can use both linguistic and perceptual information depending on task conditions[4] (Glaser, 1992; Paivio, 1986, 1991). From such a view, participants might simply respond to property verification tasks by simply detecting an association between the object and property rather than accessing a conceptual representation of

[4] The Language And Situated Simulation (LASS) theory would also make this prediction. However, the results of Solomon and Barsalou (2004) strongly imply that participants are using the simulation system to verify properties rather than the linguistic system. See section 1.13 for details.

the object. In order to assess the strategies participants use on this task they designed two sets of false stimuli, unassociated (BICYCLE-*chin*) or associated (MONKEY-*banana*). If participants are simulating the objects then perceptual factors, rather than linguistic, should predict task response. The authors further manipulated the task instructions. If simulation theory holds true, then participants upon receiving the object concept should simulate the objects and hold a mental image of such during the task. In the imagery condition participants were asked to imagine the concept object and only respond true if the property was on the image. In the neutral condition no such explicit instructions were given and participants were simply asked to respond if the property belonged to the concept. If participants automatically simulate the objects then the same pattern of results should be found across both instructions[5].

A similar pattern of data was seen in both the imagery and neutral conditions, which would indicate that participants do use simulation as a standard strategy when thinking of concepts. In addition, differences were found in the results between the associated and unassociated false trials. Participants showed slower verification times and an increased amount of errors for the associated false trials showing that association between the concept and property, despite being incorrect, interfered with task performance. This in itself would indicate that participants used different strategies for completing each set. In addition, it was found that linguistic variables (including associative strength) best predicted performance on the unassociated false trials indicating that participants responded to such trials not by recruiting conceptual knowledge for the task, but by adopting a word association strategy. For the associated false trials the results were best predicted by perceptual factors indicating that participants used a simulation strategy.

In support of such results, Kan et al. (2003) performed fMRI scans while participants completed the same task used in Solomon and Barsalou and showed that areas of the left fusiform gyrus involved in object recognition and visual imagery were active when participants responded to the associated false trials, but not the unassociated. Therefore, the overall results from the work of both Solomon and Barsalou and Kan et al. do show that participants simulate objects when thinking about them in support of the situated simulation model of conceptual knowledge.

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[5] This was a general prediction, but in fact there should be differences between the conditions. For the participants in the imagery condition, the image they generate should be richer in detail given that they were explicitly instructed to generate a mental image.

However, this is clearly not the only strategy and that participants do use both simulation and word association strategies while performing property verification tasks.

Wu and Barsalou (2009) offers further support for simulation theory using compound nouns. The theory suggests that the simulation created is specific in two ways. First, the simulation created, which can be a conscious or subconscious process depending on the task, is an imagined visual image and does rely on those areas of the brain involved in imagery processes (Kan et al., 2003; Santos et al., 2011). As stated above a variety of factors will influence the simulation created and the simulation will vary based on tangibility, meaningfulness and grain size (Yeh & Barsalou, 2006). Second, the simulations are situated with object-relevant contexts. Without specific instructions to do so, an object will naturally be simulated within a context that it is normally found within. They are not generated in a decontextualised manner, simulated against a white background, but are imagined within a dynamic scenario and hence background information will be present and often influence task performance[6].

Wu and Barsalou used a feature listing task and investigated how participants simulate concepts when they are accompanied by a modifying descriptor. For example, they were interested in whether or not participants would generate the same features/properties for the noun *watermelon* as they would for the modified noun *half watermelon*. If participants are simulating the objects in a visual manner then such descriptions should lead to different simulations. In particular, the authors were interested in how participants generated the internal or external features of the objects. For the nouns, a visual simulation should focus on the external features of the object and occlude the internal features since they cannot be seen. The reverse pattern should be found using the modified nouns, since the internal features are no longer occluded and participants should be more likely to generate such features using the modified nouns. In the above example using the modified nouns, participants should generate *seeds* as a property of the watermelon but should be less likely to do so with the standard noun. In addition, focusing on such internal features with the modified nouns means that to some extent the external features of the objects should be less visible

[6] Supportive evidence for such can be found in Chapter 5 (Experiment 8) where the protocol analysis showed that participants gave thematic/situational reasons for making their choices on the triad task.

and they should be less likely to generate such. The instructions were manipulated in a similar manner to Solomon and Barsalou (2004) where participants were either assigned to a neutral or imagery condition, or asked to generate word associates[7].

Manipulating the task instructions showed support for simulation theory where equivocal results were seen between the neutral and imagery instructions. This would therefore suggest that participants automatically simulated the concepts during task performance. Furthermore, in favour of the simulation model of concepts, the results showed that participants generated more external features for the nouns compared to internal features. The reverse pattern was found on the modified noun-phrases with more internal than external features. This supports the previous notions that participants generate a visual image of the objects when simulating them. The presence of the noun modifiers influenced the simulation in such a way to reveal a different set of properties in relation to the object.

Wu and Barsalou (2009) further demonstrated that participants are able to simulate objects with which they have had no previous experience, such as simulating a *glass car* (Experiment 2). The responses followed the same pattern as in Experiment 1, in that noun modifiers revealed more internal and less external features of the object. Wu and Barsalou also provided evidence for the notion that simulations are embedded within context by analysing the number of situational properties generated. Across the three experiments, between 26% and 50% of the responses from participants were situational features. If it was the case that participants were not simulating the objects in a relevant context, then participants should not generate situational properties. The fact that they did suggests that thinking about concepts is not decontextualised, but embedded within dynamic situations.

1.14 Extensions to Simulation Theory

Previous theories including Paivio's dual code theory (1986, 1991) and Glaser's lexical hypothesis (1992) suggest that the linguistic information can be accessed irrespective of conceptual knowledge. Recent proponents of simulation theory have suggested that conceptual knowledge consists of not only a simulation

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[7] Traditional (amodal) theories on categorisation would predict that if the organisation of concept knowledge resembles organisation of language then the results of the neutral and word association instructions should be similar because participants can bypass the conceptual system and use the linguistic system (Santos et al., 2011) to respond to the task. The results showed that this was not the case.

component, but also a linguistic component (Barsalou Santos, Simmons & Wilson, 2008; Santos et al., 2011; Simmons et al., 2008). Barsalou et al. (2008) have posited the Language and Situated Simulation (LASS) theory to include both components. Upon processing words both components become active, but have different processing rates. The linguistic system becomes the first to activate and peaks faster than the simulation system. The linguistic system has access only to information about the word such as form and whether or not it is a word or non-word. This also includes the activation of word associations derived from the linguistic system, which are retrieved without accessing conceptual knowledge. This is therefore a rather superficial strategy where only basic word form information is retrieved. At the same time, the simulation system becomes active but is slower to peak. At this point, conceptual information is retrieved when the objects are simulated. The theory falls in line with previous work on how task responses can be based on perceptual and linguistic information (Solomon & Barsalou, 2004; Wu & Barsalou, 2009). However, the LASS theory predicts differences in the time frame of which both types of information are activated.

In support of this, Santos et al. (2011) showed differences in how participants generate properties as time progresses through the task. In their first experiment, participants completed a property generation task for approximately three seconds, and were stopped on the task as soon as they reached a pause and struggled to produce new properties. The answers generated were then coded as to whether or not the answers were linguistic, taxonomic or situated. In line with the LASS theory, the initial properties produced were linguistic in nature. Taxonomic and situated responses were only produced after linguistic responses. This falls in line with the predictions of the LASS theory in which the linguistic system is activated initially while the situated system is slower to peak. However, once it does it then takes over task performance.

The same results were found in the second experiment where participants were allowed a full 15 seconds to generate properties and also completed a lexical decision task embedded within the procedure. Experiment 2 also indicated that taxonomic responses were produced just as quickly as linguistic responses, suggesting that the linguistic system is responsible for producing taxonomic associations. This makes sense in light of data that shows that strong word associations are often taxonomic in nature, for example *cat* is strongly associated with both *dog* and *mouse* which also share strong taxonomic relations (Nelson, McEvoy & Schreiber, 1998). In further support of the LASS theory, Simmons et al. (2008) used fMRI scans to show how different neural regions were active during the property generation task. They showed that areas of the frontal gyrus responsible for word form processing and word associations, including Broca's area, were active when participants generated linguistic but not situated properties. Those areas of the brain implicated in mental imagery, episodic memory and spatial localisation were active when participants generated situated properties. The fMRI data from Simmons et al. and the behavioural data from Santos et al. support the notion of conceptual knowledge comprising of both a linguistic and a situated component.

It is clear that an explanation is required for the increase in evidence indicating a stronger influence of action on task performance than might have previously been expected. This can take the form of adapting established (traditional) theories or the adoption of substantially different ways of thinking about concepts. Whilst neither approach is without its drawbacks (see Section 7.4 for a return to this), it is felt that simulation theory can offer a clearer account of the role of action in the type of tasks used in this thesis and opens new avenues for further experimental exploration; it consequently forms the main explanatory framework for this thesis.

1.15 The Current Research

The key points from the above literature review that informed the programme of work reported in the following chapters are:

(i). A close relationship between action and perception has been established to the extent that action can exert an influence on cognitive tasks such as reach to grasp and gesture mimic tasks, and even on action-irrelevant tasks such as object recognition and feature listing tasks (Borghi, 2004; Bub & Masson, 2010, 2012; Chao & Martin, 2001; Ellis & Tucker, 2000; Helbig et al., 2006, 2010; Tucker & Ellis, 1998, 2001, 2004).

(ii). Action is arguably automatically activated, but task dependent and short-lived in cognitive tasks (Bub et al., 2003; Bub et al., 2008; Bub & Masson, 2006).

(iii). The influence of action on cognitive tasks is subject to context effects (Borghi et al., 2012; Bub & Masson, 2010; Kalénine, Peyrin, Pichat, Segebarth, Bonthoux & Baciu, 2009; Kalénine et al., 2014; Vanio et al., 2008; Yee & Thompson-Schill, 2016).

The majority of the work reviewed has assessed the influence of action in tasks where participants were instructed to make action-based responses (action-required tasks). Only a few of the action-irrelevant studies involved a further category decision that could be potentially driven by action, and these category decisions were general classifications (natural vs man made) rather than more complex categories (tool vs fruit). The aim of this program of study was to use a more complex, action-irrelevant categorisation task to investigate the conditions under which action influences categorical performance. It should be noted that for the purposes of this research, action is defined as the direct interface between objects and the human body and the action required to use the object for its functional purpose. For example, the functional action of a rifle would be the grasp made by the hand around the handle and the squeezing of the trigger, rather than the functional goal of the rifle to shoot or to kill someone. This distinguishes between the 'functional action' of an object and the 'functional goal'. The research takes a different view of action compared to other research (Tsagkaridis, Watson, Jax & Buxbaum, 2014) where objects are viewed as sharing an action because they are used together (e.g. wine and corkscrew).

1.16 The Task

The forced-choice triad task is one that is used within cognitive psychology and has been increasingly used within the area of categorisation. In the task, participants are allowed to see three objects (one target object, two choice objects) before selecting which of the choice objects they feel "goes best" with the target item (Lin & Murphy, 2001; Mirman & Graziano, 2012). This task has been successfully used to demonstrate that adults make use of thematic information as well as taxonomic (Lin & Murphy, 2001). In a similar manner, the reported experimental work used the triad task to compare objects that shared either an action relation to a target or a taxonomic relation. Furthermore, the context the objects were shown in was manipulated in showing items in a functional context, or against a "context-lean[8]" background. Given the research showing both the importance of taxonomic information, and that action information (along with other 'features' of objects) becomes more salient within context, it was predicted that action would be primarily drawn upon to base choices only when shown in context. Taxonomic information, which from a classic theoretical standpoint should dominate choices in this task, should be most influential when the objects are shown without context. Since the triad task is viewed as a categorisation task (Lin & Murphy, 2001; Mirman & Graziano, 2012) and does draw upon semantic knowledge, it is predicted that action will play a strong role within this task. This is in spite of the fact that such knowledge is not necessary for task completion; participants will not be asked to mimic the actions of the objects or respond with any object related action.

[8] The term 'context-lean' has been used as opposed to 'no-context' or 'context-free' because of the notion suggested by Barsalou (2008, 2016b) that the latter do not exist. Even in situations when no other information is present, the objects are not context-free because of the contextual instantiation applied by the simulation system.

Chapter 2

Rifles and Swords, or Rifles and Water Pistols: Examining Object Categorisation by Shared Actions or Shared Taxonomic Relations in a Triad Task

The previous chapter outlined research showing how action influences performance across a variety of cognitive tasks. Chapter 2 has investigated how action is used in making categorical decisions on the forced-choice triad task. The task consisted of a target object presented with two choice objects where participants select the object that "goes best" with the target. Previous research has shown how participants group objects together by either shared thematic or taxonomic relations (Golonka & Estes, 2009; Lin & Murphy, 2001). The research presented in this chapter has investigated how participants group objects together by shared actions or taxonomic relations. Action has been investigated in terms of *competition* and *additive* effects. To investigate the competition effects action was directly pitted against taxonomic information (*Different Category Objects triads*). In such triads the target (*rifle*) was presented with a taxonomic choice (*sword*) and an action choice (*water pistol*). To investigate the additive effects, action was combined with taxonomic information (*Same Category Object triads*). In such triads the target (*orange*) was presented with a choice option sharing both an action and a taxonomic relation (*banana*), and one choice sharing just a taxonomic relation (*strawberry*). Participants saw both triad types in a within-subjects design. Context was further manipulated between-subjects where half of the participants saw the objects on a white background (*context-lean condition*), and half saw the objects being used by an agent for its functional purpose (*context-rich condition*). Selection of the action choice was measured across the triads and showed that a strong context effect was found with greater selection of the action choice in the context-rich condition. Furthermore, the action choice was more likely to be selected on the same category triads compared to the different category triads showing that action is less likely to base category membership on its own, but has a strong additive effect.

Four experiments are reported here in the present chapter including the experiment outlined above. The further experimental work has additionally investigated potential factors that might bias the interpretation of the results including shared perceptual characteristics (inherent given the ergonomics considered when designing such objects), the typicality of the objects and the instructions used in the triad task.

2. Experiment 1

Using The Forced-Choice Triad Task To Examine Categorical Decisions Using Shared Taxonomic Or Action-Based Relations

2.1 Introduction

Chapter 1 outlined the aim of the following research, namely to investigate the circumstances under which knowledge of object interaction becomes a relevant property for categorisation within an action-irrelevant task. In order to do this the forced-choice triad task (hence forth referred to as the triad task) was selected. The triad task here is seen as an action-irrelevant task because no physical action is required in order to respond on the task other than a key press. Participants are not asked to mimic or perform any action similar to those needed to use or handle the stimuli.

The standard format of a triad task is to present a target object with two choice objects as either pictures or words. The choice options are manipulated so that they match the target in a specific respect (e.g. taxonomically or thematically, see Lin & Murphy, 2001). The participants' selection is inferred to be a reflection of how they organise category knowledge (Estes, Golonka & Jones, 2011, Lin & Murphy, 2001). The instructions vary across experiments (see Experiment 4 for a further review) but generally ask participants to select the choice option that "goes best with" or "is most like" the target.

Lin and Murphy (2001) successfully used the triad task to show that adults often group objects together by shared themes rather than in taxonomic categories. Previously, it had seemed that only young children, the elderly, and uneducated people make use of such thematic information before a thematic-to-taxonomic shift occurs in late childhood (Luria, 1976: Smiley & Brown, 1979). Lin and Murphy matched the choice options in a triad so that one shared a thematic relationship while the other shared a taxonomic relation. For example, the target of *bee* was presented with *honey* (thematically related) and *flies* (taxonomically related). They found that when participants were asked to select the item that "goes best with" the target, participants selected the thematically related item on 62% of trials (Experiment 1[9]).

[9] Variations in this have been found using different task instructions and this will be reviewed later in Experiment 4.

Other research has since supported this showing that adults do make use of thematic relations, that such relations may arguably be considered a semantic property, and show differences in neurological topography (Estes et al., 2011; Golonka & Estes, 2009; Kalénine et al., 2009; Lin & Murphy, 2001; Mirman & Graziano, 2012; Murphy, 2001; Sachs, Weis, Krings, Huber & Kircher, 2008; Sachs et al., 2008; Wamain, Pluciennicka & Kalénine, 2015; Wisniewski & Bassok, 1999).

Tsagkaridis et al. (2014), using a triad task, investigated the strength of thematic relations (over taxonomic) when they also shared a functional action. For example, *wine bottle* and *corkscrew* share not only a thematic association but also a 'joint use' action since one must be used to open the other. In comparison, *wine bottle* and *cheese* share only a thematic relation and no action. These were also compared to a choice object sharing a taxonomic relation such as *wine bottle* and *water bottle*. Their experimental design included three sets of triads manipulating the competition effect between the choice options on how they were related to the target: thematic+action vs taxonomic, thematic+action vs thematic-action, taxonomic vs thematic-action. Across the triads, participants were most likely to select the thematic object which shared an action with the target (89%) followed by the taxonomic object (62%). The thematic items that shared no action were selected with the lowest frequency (44%). These results showed that thematic relations between items may be even stronger than taxonomic, and arise from not only a spatial/temporal relation but also a shared functional co-occurrence.

However, a strong possibility that might bias this interpretation is the notion of shared frequency of co-occurrence between the objects sharing a thematic relation and an action. In nearly all occasions when a corkscrew is used it is for the purpose of opening a wine bottle and, therefore, one is rarely found without the other. Cheese can occur in a wide variety of situations without a wine bottle associated, as well as situations in which they both occur. It might not be that the wine bottle and corkscrew are categorised together because of the shared functional action, but because they are more strongly associated to a specific situation. In addition, the item-to-event strength of such items would differ. In considering a *dinner party* event both wine bottle and corkscrew would have a stronger item-to-event association than cheese and are hence more likely to be grouped together.

What should be noted at this point is that there is a difference between the definition of the term 'action' taken by Tsagkaridis et al. and in the current experimental work. Tsagkaridis et al. take the view that two objects share an action because they are physically used together for the same purpose. In the experimental work in this chapter (and the remainder of this thesis) items are described as sharing an action when they require the same physical action to use/operate them, but are not used in conjunction with one another. An example of this is *rifle* and *water pistol*, which share the same grasp and a 'trigger' action to operate them both. However, the items are not used together for a sole purpose, nor do they share a function[10]. Action here is operationalised in the same manner as by Myung et al. (2006) where *piano* and *typewriter* share an action because of the way the fingers and hands move when playing or typing. The definition of action used here distinguishes between the *functional action* of an object and the *functional goal*. For example, the functional action of a rifle would be the grasp made by the hand around the handle and the squeezing of the trigger, rather than the functional goal of the rifle, which would be to shoot or perhaps to injure/kill.

Using the above definition of action, the aim of Experiment 1 was to investigate whether participants would match items in a triad based on shared actions, and how this commonality would compete against items that could be matched on taxonomic membership. Despite the strong influence of thematic relations within the triad task (Lin & Murphy, 2001) and the strength of thematic associations when combined with a goal-based action (Tsagkaridis et al., 2014), thematic associations were not included in the design of the triads. The aim here was to test how influential action knowledge is in making categorical decisions[11].

As outlined above the notion of 'action' is taken to mean the initial grip on the object and the action needed to operate it to use it for its functional purpose (e.g. squeezing the trigger on a rifle, peeling an orange). Previous research using the triad task has researched action as a source of information in categorical decisions, but not using the definition outlined above and often views shared actions as shared goals

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[10] A rifle and a water pistol could be argued as sharing an overall goal to "shoot someone" and this is a potential source of information in categorising the objects together. See Chapter 5 for further analysis of the stimuli used in Experiment 2.

[11] However, despite this it is possible that some of the items do share some thematic information. This is because of (i) individual differences in levels of previous interaction with the objects and (ii) the stimuli used and the difficulty in collecting common items of taxonomic categories that do not share thematic information. For example, common items of the category *FRUIT* will share some thematic information because people might have a personal preference for them, might keep them together in their homes or can buy them from the same location. The potential for thematic relations being an influential factor in the present task is addressed later in Chapter 5 using protocol analysis.

(Kalénine et al., 2009; Tsagkaridis et al., 2014). Furthermore, research has demonstrated that function plays an important role in categorisation and concept knowledge (Barsalou et al., 2005; Barton & Komatsu, 1989; Chaigneau & Barsalou, 2008; Chaigneau et al., 2004; Keil, 1989, Malt & Johnson, 1992, Rips, 1989) and might even serve as a 'core' feature (Medin & Smith, 1984; Smith & Medin, 1981; for an alternative view see Malt & Johnson, 1992). Since taxonomic links do include perceptual and functional features (Medin & Smith, 1984), this would explain why taxonomic information influences decision making in the triad task. However, given the evolutionary stance that concept knowledge should be in the service of actions (Franks & Braisby, 1997) and the view that conceptual knowledge is grounded in multimodal representations (Barsalou, 1999, 2003, 2008; Wu & Barsalou, 2009; Yeh & Barsalou, 2006), then knowledge of shared actions between two objects could potentially present them as a better "pair" in the triad task.

In order to investigate the competition effects of taxonomic and action relations in the triad task, two sets of triads were developed. To test the specific competition effect of taxonomic against action, one set of triads were developed where one choice option shared a taxonomic relation to the target while the other shared an action. These are referred to as the Different Category Object (DCO) triads. For example, the target of *rifle* was presented with *sword* (both weapons but used differently) and *water pistol* (a toy, not a weapon, but also operated by a trigger). In these triads neither choice option shared both a taxonomic and an action relation. Rather, the DCO triads allowed for the direct comparison of when participants group objects together based solely on shared actions, or shared taxonomic features.

The second set of triads looked at the effect of action when it was in combination with taxonomic information, hence referred to as Same Category Object (SCO) triads. In these SCO triads the target object was presented with two choice objects where all three belonged to the same category. In addition, one of the choice options also shared an action with the target. For example, the target of *orange* was presented with *strawberry* (sharing no action) and *banana* (both peeled before eating). These SCO triads allow for the comparison to see what effect action has on categorical choices when it is also combined with taxonomic information. Wisniewski and Bassok (1999) showed that items are rated more similarly when they share both a taxonomic and a thematic property (*milk* + *coffee*) rather than just a taxonomic relation (*milk* + *lemonade*). In a similar manner, it might be the case that action also has an additive effect in that participants could be more likely to select the action item when it also shares a taxonomic relation with the target (also in line with the '+ action' effects found in Tsagkaridis et al., 2014).

The second aim of Experiment 1 was to investigate whether the activation of action information is context-dependent or independent, given that previous research indicates both context-dependent and independent properties in concept knowledge (Barsalou, 1982). Research with children has shown that presenting a context before they engaged in a triad task modulated their responses (Blaye & Bonthoux, 2001). Using groups of 3 and 5-year-old children, Blaye and Bonthoux presented them with a triad based pre-test where the children were asked which item "went best with" the target between a taxonomic and a thematic choice. One week later they repeated the task, only the experimental group were shown a picture of a scene linked to one of the items designed to bias their choice. It was found that the 3-year-olds, the scene had no effect on their choices and they were able to switch between the taxonomic and thematic choices. The 5-year-olds in the control group were stable in their choices from the previous week, but those shown a scene were strongly influenced and often selected the opposing choice compared to the week before. This choice then remained stable one week later in a post-test analysis. This not only confirms that children can make use of both types of semantic information, but more importantly shows that context does influence triad responses in children. In addition to this, further research has shown that action responses are heightened when shown in context on other, non-triad, cognitive tasks as outlined in Chapter 1 (Borghi et al., 2012; Estes, Verges & Barsalou, 2008; Kalénine et al., 2014).

Following from this, the DCO and SCO triads shown in Experiment 1 were manipulated between-subjects, based on context. Given the difficulty in defining the term 'context' (Bazire & Brézillon, 2005) it is important to define the meaning of this for the experimental work. For the purpose of this thesis, context is defined as images presenting the items within an action-based scenario with the objects used for their functional purpose. This is similar to Palmer (1975) who showed that object recognition was faster in a congruent rather than incongruent scenario. This was done differently in Experiment 1 compared to Blaye and Bonthoux (2001) where, rather than the context preceding the trial presentation, the context in Experiment 1 was presented during the trial. All three items in the triads were presented as words, however, the target was also accompanied with a picture of the object. Participants saw the object either in isolation on a white background (context-lean condition) or shown within an action based scenario with the objects being used by an agent (context-rich condition). In order to prevent a perceptual bias and stop the participants from selecting the item that looks most similar, only the target was shown as an image accompanying the word.

Based on the previous research, it was predicted that action would influence participants' choices in the triad task. Upon seeing the target item participants should simulate the objects in accordance to the situated simulation view of concepts (Barsalou, 1999), drawing upon all modalities and including the motor cortex. This should make the shared action element salient and hence present as a candidate for selection in this task. As such, it is plausible that the action-related item may be selected with a higher frequency than the opposing choice. This should be particularly true of the SCO triads where the action item also shares taxonomic membership. As the items share both relation types then action should act in an "additive" manner making the action choice a better category match[12]. What is interesting here is to examine the effects of the DCO triads where the participants can choose between a taxonomic and an action-related item. To date, no known research has directly compared taxonomic and action choices in such a task. Given the strength of taxonomic membership in concept knowledge it is possible that this might dominate choices when compared to only an action-related item, however, at this point such effects are uncertain. It was further predicted that the action choices are more likely to be selected when the items are presented within a functional context (context-rich) rather than against a white background (context-lean).

2.2 Method

2.2.1 Participants

Forty undergraduate students (24 females) from the University of Hertfordshire took part in the experiment with a mean age of 26.81 (*SD* = 8.03, age range: 17-51 years). Participants were recruited through opportunity sampling. The sample size was calculated following an a priori power analysis using G*Power. Given that the triad task reported here has not previously been tested, the analysis was

[12] The same would be predicted of the 'probabilistic' view of concepts (Medin & Smith, 1984; Smith & Medin, 1981) but the discussion will outline why this is unlikely to be the case here.

conducted using a moderate effect size (*f* = .25, see Cohen, 1992), with a correlation between repeated measures of .5. Assuming α =.05 and $1 - \beta$ =.80, the a priori power analysis indicated that a similar effect size would be detected using a sample of 34 participants.

2.2.2 Design

The experiment was composed of a forced-choice triad task presented in a 2x2 mixed design. All participants saw two types of object triads (within-subjects factor); Different Category Object (DCO) triads and Same Category Object (SCO) triads. The between-subjects factor was the context in which the triads were presented. The target on each triad was either presented as an image of the object on a white background (context-lean condition) or presented as an image of the object being used by an agent in a functional based scenario (context-rich condition). There were two dependent variables of interest here being the response time on the triads, and the frequency of which the participants selected the choice item sharing an action to the target on the DCO and SCO triads (henceforth referred to as the 'proportion of action choice').

2.2.3 Materials

In order to design the triads, an object pool was initially developed drawing on the stimuli used by Rosch (1975), and developing additional objects that matched on an action relation. Thirty object triads were initially designed for this experiment consisting of 15 of each DCO and SCO triads. The SCO triads consisted of two choice options in which both pertained to the same taxonomic category, with one choice option additionally sharing the same action. For example, for the target item of *pencil* the two options were *elastic band* (taxonomic relation only) and *paintbrush* (taxonomic and action relation). In the DCO triads only one of the choice options pertained to the same taxonomic category while the other shared an action but did not share category membership. For example, for the target item of *rifle* the two choice options were *sword* (taxonomic relation only) and *water pistol* (action relation only).

When designing the triads it became apparent that while most objects have a main method of hand manipulation, others could be used in different ways. A pilot was conducted in order to ascertain that all of the items used shared the same functional action. Ten participants (5 females) from the University of Hertfordshire were given a questionnaire of all the triad items formed into triplets, and asked to identify which shared the same action. All possible object combinations (within each triad) were coded and a Chronbach's alpha of .21 revealed little cohesion among the items. Removal of the lowest eight items increased this to an acceptable .72, with combinations matching the definition of action outlined above.

The category membership of the objects was also piloted in the same manner described above. Ten participants (9 females) recruited from the University of Hertfordshire were given a similar questionnaire to the previous pilot, with the triads shown in the form of triplets, and asked to select the objects that belonged in the same category. Chronbach's alpha of .60 revealed an acceptable alpha level for these items based on their category membership. As such, the experiment ran with 22 target triads, 13 DCO triads and 9 SCO triads (a full list of the triads can be seen in Appendix F). The object triads were matched with 22 animal triads that acted as foils and the choice data from the latter was not analysed. Only the target picture in each triad was presented with an image of the target which was collected using a Google Image search on the item and selecting the appropriate picture for use in both conditions, either the object itself on a white background or being used by an agent in the objects functional sense. An image only accompanied the target as it was possible that by showing images of all the objects participants would simply base their responses on perceptual properties.

2.2.4 Procedure

The participants sat in front of a 15" Macintosh laptop and were shown the task instructions. They were informed of the nature of the task; they would be shown a target word with two choice options underneath. The instructions asked them to "Please indicate which of the two items goes best with the target at the top of the screen". Participants were instructed to press the 'a' key to choose the item on the left-hand side of the screen and the 'l' key for the item on the right-hand side of the screen. They were asked if they had any questions and then the Superlab program ran through the forty-four triads. Each triad began with a fixation cue presented on the screen for 1000 milliseconds after which the cue disappeared and the target word appeared along with the appropriate image depending on which condition the participant was assigned to. After 1500 milliseconds the two choice options appeared beneath the target word and image, both of which remained on the screen while the participant made their choice. After they had made their choice the target, image and choices disappeared and the fixation cue appeared again for the next triad. All triads were presented in a randomized manner and the action choice in each triad was counterbalanced as to whether it appeared on the left or right of the screen. The participant's frequency of action choices was recorded on both the SCO and the DCO triads along with their response time. Their choices on the animal triads were of no theoretical importance for the purposes of this experiment (as they were not manipulated on a taxonomic or action basis) and as such were not recorded.

2.3 Results

2.3.1 Response Time

The mean response time on the SCO and the DCO triads are reported in Table 2.1. Participants appeared faster at responding to the triads in the context-rich condition ($M_{DCO} = 2359.22$, $M_{SCO} = 2350.81$) than in the context-lean condition ($M_{DCO} = 2854.84$, $M_{SCO} = 2664.96$) A 2x2 mixed Analysis of Variance (ANOVA) showed that the main effects of triad type, $F < 1$, the main effect of context, $F\ (1, 38) = 1.51$, $p = .23$, $\eta^2 = .04$, and the interaction effect, $F < 1$, were not statistically significant.

The reaction time data was further analysed for outlying scores and normality. After removing the outlying scores (x1) the reaction time on the SCO triads was statistically normal, $D(39) = .09$, $p > .05$, however the reaction time on the DCO triads was positively skewed, $D(39) = .15$, $p = .036$. A square root transformation was applied and a 2x2 mixed ANOVA was conducted. The results of the previous analysis was replicated where the main effect of triad type, $F(1, 37) = .23$, $p = .23$, $\eta^2 = .04$, the main effect of context, $F < 1$, and the interaction effect, $F < 1$, were not statistically significant. This would indicate that the time taken to make categorical decisions did not differ between artificial objects when category membership amongst the items varied considerably, nor did they vary when the objects were shown in a functional context.

2.3.2 Action Choices

The mean proportion of action responses in the SCO and the DCO triads across the two conditions are reported in Table 2.2. Within the DCO triads the action choice was made relatively infrequently when compared to the taxonomic alternative. In these triads participants showed a strong preference for the taxonomic item and the effect of context appeared to have no influence here ($M_{context\text{-}lean} = .29$, $M_{context\text{-}rich} =$

.29). In comparison to this, the action choice appeared to have a much stronger influence in the SCO triads with 51% selection of the action choice in the context-lean condition and 61% in the context-rich condition. A 2x2 mixed ANOVA on the mean proportion of choices was conducted with triad type as a within-subjects factor, and context as a between-subjects factor[13]. The analysis revealed a significant main effect of triad type with action choices being made more frequently across the SCO triads than the DCO, F (1, 38) = 84.81, $p < .001$, $\eta^2 = .69$. The main effect of context was not significant, F (1, 38) = 2.86, $p = .10$, $\eta^2 = .07$, nor the interaction effect between the two factors, F (1, 38) = 3.34, $p = .08$, $\eta^2 = .08$.

Table 2.1

Mean Response Time (Standard Deviations) in Milliseconds Across Triad Type and Context.

Context	N	Triad Type	
		DCO	SCO
Lean	20	2854.84 (1313.96)	2664.96 (1224.70)
Rich	20	2359.22 (810.06)	2350.81 (944.18)

Table 2.2

Mean Frequency (Standard Deviation) of Action Responses Across Triad Type and Context.

Condition	N	Mean percentage of choice (SD)	
		DCO triads	SCO triads
Context-lean	20	.29 (.16)	.51 (.12)
Context-rich	20	.29 (.13)	.61 (.12)

[13] It has been suggested that because the data is not normally distributed and the choice reflects a binomial distribution that the data should be analysed using the Generalized Linear Mixed Model approach. The data was re-analysed using the GZLM and the same pattern of results was found with a significant main effect for triad type, F (1, 76) = 73.12, $p < .001$, but not for context, F (1, 76) = 3.43, $p = .07$, and no interaction effect, F (1, 76) = 1.71, $p = .20$. Given the robustness of the ANOVA design all analysis henceforth has been completed using standard ANOVA's rather than the GZLM and any differences found are reported in the footnotes.

2.3.3 Age and Gender

Of theoretical interest was whether the number of action choices was influenced by the age and gender of the participants. The influence of the participant's age was examined by repeating the same ANOVA conducted in Section 2.3.2 after removing those participants whose age was more than two standard deviations above mean[14]. If it was the case that the age of the participants was affecting the action choices then removing those participants ($N = 4$) should alter the patterns seen in previous analysis. The ANOVA showed that the same patterns found in the previous analysis were replicated with a significant main effect of triad type, F (1, 34) = 70.50, $p < .001$, $\eta^2 = .68$, based on higher action choices on the SCO triads. Once again, neither the main effect of context, F (1, 34) = 3.70, $p = .063$, $\eta^2 = .10$, nor the interaction effect, F (1, 34) = 2.75, $p = .11$, $\eta^2 =.08$, were significant. This would therefore indicate that triad patterns held consistent across the age of the participants.

Gender was examined by conducting using a 2x2x2 mixed ANOVA using triad type as a within-subjects factor, and both context and gender as between-subject factors. The same patterns found previously were again replicated with a significant main effect of triad type ($p < .001$), but no main effect of context ($p > .05$) or interaction effect ($p > .05$). Of importance here, the main effect of gender was not significant, F (1, 36) = 2.12, $p = .16$, $\eta^2 = .06$, indicating that selection of the action choice was consistent between males and females. In addition, gender did not interact with either triad type ($F < 1$) or context ($F < 1$), and the three-way interaction was also non-significant ($F < 1$).

2.4 Discussion

Overall, the results have shown that participants were very quick at making their decisions on the triads with choices taking typically less than three seconds. There was no difference found between reaction times on the SCO and DCO triads, presumably due to the fact that they both contain artefacts rather than natural objects and should therefore activate the same neural topography. However, the main data of interest here is the frequency of the action choices made. The data here show that participants make categorical decisions on the triad task primarily through the use of

[14] It was not appropriate to perform a repeated measures Analysis of Covariance (ANCOVA) because age was not significantly correlated to the number of action choices on the DCO or SCO triads, therefore violating the ANCOVA assumptions.

taxonomic information. When participants were presented with items that matched a target based on either taxonomic or action-based properties (DCO triads) they chose the taxonomic choice in nearly three quarters of their responses. For example, given the target of *rifle* participants were more likely to group this with *sword* than they were *water pistol*. Therefore, even when not given explicit categorisation instructions participants use category membership to make their decisions on the triad task. However, what the data do show is that while action may not be used as the primary basis for category membership, it did appears to have an additive effect. When participants were presented with items that both matched a target on taxonomic membership (SCO triads) they were more likely to select the choice item that additionally shared an action to the target. For example, given the target of *pencil* participants were more likely to group this with *paintbrush* rather than *elastic band*. While action here is not salient enough, generally, to override taxonomic membership, it did increase the commonality between a target and its match. The action choice was thus the preferred option and hence presumably stands as a better match to the target. Furthermore, the follow up analysis has shown that selection of the action choices was consistent across the age and gender of the participants.

The results are in line with the situated view of concepts posited by Barsalou (1999). Under this view, when participants think about the objects they mentally simulate them drawing upon a multi-modal representation. As this includes a re-instantiation of the neurons in the motor cortex originally activated upon encountering the object, the shared actions of the objects become more salient, and is hence more likely to be used here.

However, the same pattern of results would be predicted of the probabilistic view of concepts (Medin & Smith, 1984; Smith and Medin, 1981) which would suggest that the paintbrush is more likely to be selected with the pencil because sharing more than one common element with the target makes it more probable as a category member. Therefore, rather than simulating the objects, it could be argued that the participants are, in an amodal fashion, mentally consulting a list of known 'information' about the items. This cannot explain all the data from this first experiment, however, because a probabilistic view would also suggest that the action item in the SCO triads should be selected in all of the triads given that it has the most 'amount' of shared features with the target and this was not so; as was seen in the data, wide variations occurred and the action choice in the SCO triads was not chosen on 100% of the trials. In addition, such a view takes the stance that all properties of an object are weighted equally, which is not the case as some properties are more salient as others given the context they appear in.

An interesting finding here was that despite predictions that context would have a significant effect on the choices made by increasing the salience of the shared action relation between the target and the match, this effect was not found. This may have been caused by the format chosen for triad presentation. Previous experimental work using triads (Kalénine et al., 2009: Lin & Murphy, 2001) has used the format in which all of the items were seen as all words or all images. It was originally thought that if participants saw images of all the targets and matches then their choices would simply be made based on perceptual properties and so only the target appeared as a picture whilst the choice items appeared as words. However, it is possible that only including an image of the target may have in fact occluded the action element between the target and choice options. For example, seeing only the image of a pencil might invoke a number of properties of the object and potentially make others more salient than the shared action between them. Bub et al. (2008) suggested that words only cannot potentiate actions and evoke gestural knowledge. However, simulation theory would predict that words on their own can instantiate action knowledge and research does support such a claim (Hauk et al., 2004: Santos et al., 2011; Simmons et al., 2008; Solomon & Barsalou 2004; Wu & Barsalou, 2009). Therefore, one aim for the next experiment was to redesign the triads so that participants saw images of all of the objects accompanied by its name.

Looking at the data above it is not possible to conclude with complete certainty that the participants made their decisions based on the associated actions between the target and match. It is possible that choices were made based on perceptual properties between the items. For example, it could be the case that *rifle* was grouped with *water pistol,* and *pencil* was grouped with *paintbrush,* because they look similar to each other rather than sharing a functional action. The nature of design ergonomics means that items that are operated in the same manner will invariably look similar because they are designed to work within the parameters of the human body. A *pencil* and a *paintbrush* are both designed to sit within the Thenar space between the thumb and index finger and as such will be used in the same manner and look very similar to each other. The purpose of Experiment 2 was to address this issue of action versus perceptual information. A new set of triads was designed in which a target was linked to choice items that shared either an action or perceptual properties and shared no category membership between them. If participants were selecting items based on perceptual properties then it would be predicted that on the new triads they would select the choice item that looks the same rather than the one sharing an action.

2.5 Experiment 2

Rifles Go With Water Pistols Because They Look Alike: Assessing How Action-Based Choices Are Biased By Perceptual Characteristics

2.6 Introduction

Experiment 2 was primarily designed to address the issues raised in the previous discussion concerning the perceptual bias in the triad task used in Experiment 1. This led to two main changes. First, the format of the triads was changed so that each item in the triad was presented as the target word and an image of the object. The image was once again manipulated by context so that all items in the context-lean condition were shown as a sole object against a white background and those in the context-rich were shown in a functional scenario with the object being used by an agent. If it is possible that only presenting an image of the target object (as in Experiment 1) concluded the shared action element between the objects then overall action choices should be higher when all the items are shown as images.

The second aim here was to assess if participants are selecting the objects in the triads because of shared perceptual qualities rather than shared actions. For example, it could be that participants are selecting *water pistol* to go with *rifle* not because of the shared 'trigger' action between them, but because they share perceptual qualities as a result of the way in which the objects are designed. In order to test this, the second main change was the introduction of a third set of triads where participants chose between items that either shared an action or perceptual qualities.

In these Perceptual Category Object (PCO) triads, none of the objects shared category membership with the targets. One choice object shared an action with the target, but did not look similar, while the other choice looked similar to the target but did not share an action. For example, the target of *cocktail shaker* was presented with *maracas* (sharing an action but appearing dissimilar) and *vase* (visually similar but sharing no action). If it was the case that perceptual similarity (that coincided with a shared action) was driving the choices made in the SCO and DCO triads of Experiment 1, then it would be reasonable to expect that this would extend to items which are clearly perceptually similar in the PCO triads and therefore action choices for thus new condition would substantially lower than in the SCO triads.

The conceptual system stores a vast amount of information for concepts, and therefore objects can be categorised together based on numerous factors (functional, perceptual, thematic, autobiographical, etc.) Therefore, it could be the case that participants would use entirely different strategies in completing the DCO and the new PCO triads rather than drawing upon action knowledge in both. This however, is believed to not be the case and there are reasons to believe that the influence of action should be consistent not only between participants, but also within trials. The research outlined above in Chapter 1 has shown that the influence of action is consistent. In many of the experimental paradigms used (Borghi, 2004; Borghi et al, 2012; Bub & Masson, 2006, 2010, 2012; Bub et al., 2008; Chao & Martin, 2000; Tucker & Ellis, 1998, 2001), the influence of action was apparent across all participants. For example, the priming work of Bub and Masson (and colleagues) showed that for all of the participants, response latencies were decreased when shown a congruent action prime demonstrating that the recruitment of action information is consistent across participants. Therefore, it is predicted that the influence of action knowledge on the triad task developed in this thesis should be consistent and not limited to a few participants or on a few trials.

Research has further shown that participants are relatively consistent with their categorisation choices which have been shown to remain stable across experimental procedures (Deák & Bauer, 1995; Hampton, Dubios & Yeh, 2006; Lin & Murphy, 2001; Simmons & Estes, 2009). If it is the case that participants were selecting the action choices on the DCO, and SCO, triads because of shared perceptual features then participants should be more likely to select the perceptual choice on the PCO triads (i.e. choose *vase* with *cocktail shaker*). If, however, participants were selecting the action choice because of the shared actions between them then they should be more likely to select the action choice on the PCO triads (i.e., choose *maracas* with *cocktail shaker*).

2.7 Method

2.7.1 Participants

Fifty undergraduate Psychology students (36 females) from the University of Hertfordshire with a mean age of 25.31 (*SD* = 7.92, age range: 18-49) were recruited through opportunity sampling and took part in the experiment in return for course credit. The sample size was calculated following an a priori power analysis using G*Power. The analysis was based on the observed effect size for the 2 x 3 interaction of context on triad type found in Experiment 1 (η_p^2 = .081) which corresponded to a medium effect size (f = .30), with a correlation between repeated measures of .072[15]. Assuming α =.05 and $1 - \beta$ =.80, the a priori power analysis indicated that a similar effect size would be detected using a sample of 36 participants.

2.7.2 Design

Experiment 2 comprised a forced-choice triad task presented in a 3x2 mixed design. All participants saw three types of object triads (within-subjects factor); DCO triads, SCO triads and the new PCO triads. The DCO and the SCO triads were taken from Experiment 1 (with adjustments made to the triads, see Section 2.7.3). In the PCO triads the target was presented with two choice options, one of which shared perceptual properties with the target, but no action, while the remaining choice option shared an action, but no perceptual properties. Thus the target and choice items shared no category membership amongst each other. The between-subjects factor was the same as in Experiment 1, i.e., the context in which the triads were presented. There were two dependent variables of interest; (i) choice response time and (ii) the frequency of selected choice items sharing an action with the target on the DCO, SCO and the PCO triads.

2.7.3 Materials

The same SCO and DCO triads from Experiment 1 were used for Experiment 2 with minor alterations made. Some participants from the previous experiment volunteered information after the experiment that several of the triads had been chosen due to sharing thematic information rather than using taxonomic or action based information. For example, several participants said that they grouped *cake* with *ice cream* rather than *pizza* because you eat the two together as *cake and ice cream*.

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[15] Power calculations for subsequent experiments using the 2x3 triad task were calculated using the corresponding figures from Experiment 1.

Therefore, in the SCO triads one (*cake*) was removed while in the DCO triads one was removed (*dice*) and two were redesigned to become SCO triads (*ketchup* and *orange*). This resulted in 10 SCO and 10 DCO triads for use in this experiment.

The PCO triads were constructed from a target and two choice options in which neither shared category membership to the target, but one shared perceptual properties with the target but no action while the other shared an action but no perceptual properties. For example, the target of *clarinet* was presented with the perceptual item *wooden spoon* and the action item of *balloon*. A total of 15 triads were designed in this manner and piloted using the same procedure as in Experiment 1 to ensure for consistency in action usage across the items. Ten participants (6 females) from the University of Hertfordshire were given a questionnaire formed of triplets and were asked to identify which items shared the same action. A Chronbach's alpha of .46 revealed a moderate level of cohesion. Removal of the lowest five items increased this to a high level of .78. As such the experiment ran with these 10 PCO triads combined with the 10 SCO and 10 DCO (see Appendix M). All target and choice items in the triads were presented as images collected using a Google image search, and with the word underneath the image. Images were selected on the basis of appropriateness for the conditions, being either the item on a white background for the context-lean condition or as the image being used in a functional context for the context-rich conditions.

2.7.4 Procedure

The procedure was the same as in Experiment 1.

2.8 Results

2.8.1 Response Time

The mean response time on the SCO, DCO and PCO triads are reported in Table 2.3. Participants appeared faster at responding in the context-lean (M_{DCO} = 2074.77, M_{SCO} = 2130.48, M_{PCO} = 2772.44) compared to context-rich condition (M_{DCO} = 2345.68, M_{SCO} = 2450.31, M_{PCO} = 3115.48). A 2x3 mixed ANOVA revealed that the main effect of triad type was significant using the Greenhouse-Geisser adjustment[16], F (1.62, 77.55) = 35.92, $p < .001$, $\eta^2 = .43$. Post-hoc analysis using the Bonferroni adjustment showed that the difference between the SCO and the DCO triads was not significant ($p = .75$). However, reaction times on the PCO triads were significantly slower compared to both the SCO ($p < .001$) and the DCO triads ($p < .001$). Neither the main effect of context, $F(1, 48) = 1.16$, $p = .29$, $\eta^2 = .02$, nor the interaction effect, $F < 1$, were significant.

The reaction time data was further analysed for outlying scores and normality. After removing the outlying scores (x2) the reaction time on the SCO and the PCO triads were statistically normal, SCO: $D(48) = .09$, $p > .05$; PCO: $D(48) = .08$, $p > .05$, however the reaction time on the DCO triads was positively skewed, $D(48) = .15$, $p = .013$. A square root transformation was applied and a 2x3 mixed ANOVA was conducted. The analysis found that the main effect of triad type was significant, $F(1.72, 78.89) = 40.28$, $p < .001$, $\eta^2 = .47$. Follow up analysis using the Bonferroni adjustment showed that the reaction times on the PCO triads were significantly longer than the SCO ($p < .001$) and the DCO ($p < .001$), but no difference was found between the latter ($p = .23$). The main effect of context, $F(1, 46) = 1.59$, $p = .21$, $\eta^2 = .03$, nor the interaction effect, $F < 1$, were statistically significant. This would indicate that participants are slower at making categorical decisions when the objects are not linked by category membership.

Table 2.3

Mean Response Time (Standard Deviations) in Milliseconds Across Triad Type and Context.

Context	N	Triad Type		
		DCO	SCO	PCO
Lean	25	2074.77	2130.48	2772.44
		(939.09)	(1041.06)	(1286.69)
Rich	25	2345.68	2450.31	3115.48
		(898.57)	(971.86)	(1331.67)

2.8.2 Action Choices

[16] Mauchly's test of Sphericity was found to be significant; $\chi^2 = 12.77$, df = 2, $p = .002$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .81$.

The mean proportion of action responses in the DCO, SCO and the PCO triads across the two conditions are reported in Table 2.4. As with Experiment 1, participants were most likely to select the action choice in the SCO triads in both the context-lean (61%) and context-rich (70%) conditions. The lowest levels of action choices were in the DCO triads in both conditions ($M_{context\text{-}lean}$ = .32, $M_{context\text{-}rich}$ = .53). Within the PCO triads there was a relatively large proportion of action choices made accounting for nearly half of the choices in the context-lean condition (48%) and nearly three quarters of those in the context-rich condition (69%). It also appears that participants were more likely to select the action choices in the context-rich condition than the context-lean condition across all three triad types.

A 2x3 mixed ANOVA was conducted on the mean proportion of action choices using triad type as a within-subjects factor and context as a between-subjects factor. The analysis revealed a significant main effect of context with more action choices made in the context-rich than context-lean condition, F (1, 48) = 39.22, $p < .001$, $\eta^2 = .45$, as well as a significant main effect of triad type, F (2, 96) = 22.77, $p < .001$, $\eta^2 = .32$. Post hoc analysis using the Bonferroni adjustment revealed that there were significantly more action choices in the SCO than the DCO triads ($p < .001$), and in the PCO than the DCO triads ($p < .001$). The mean number of action choices between the SCO and the PCO triads was not significantly different ($p = .09$). Finally, the interaction effect between context and triad type was not significant, F (2, 96) = 2.33, $p = .10$, $\eta^2 = .05$. The variables account for a large amount of explained variance with eta-squared close to 80%. Overall participants were more likely to select the action choice when selecting objects sharing both an action and category membership, and particularly more likely when the objects were seen in context.

2.8.3 Age and Gender

The influence of the participant's age was examined using a 2x3 mixed ANOVA after removing those participants whose age was more than two standard deviations above mean ($N = 2$)[17]. The ANOVA showed that the same patterns found in the previous analysis were replicated. The main effect of triad type was significant,

[17] The age of the participants was significantly correlated with the number of action choice on the SCO triads , $R = .33$, $p = .019$, showing a weak but positive correlation. However, age was not correlated with the number of action scores on the DCO ($p > .05$) or PCO triads ($p > .05$) and therefore it was decided that it was not appropriate to perform an ANCOVA because the effects were not consistent and violate the ANCOVA assumptions.

F (2, 92) = 20.38, $p < .001$, $\eta^2 = .31$, based on lower action choices on the DCO triads compared to the SCO ($p < .001$) and the PCO triads ($p = .002$), but no difference between the SCO and PCO triads ($p = .13$). The main effect of context was also significant, F (1, 46) = 45.13, $p < .001$, $\eta^2 = .50$, based on higher action scores in the context-rich condition. The interaction effect was again non-significant, F (2, 92) = 2.56, $p = .083$, $\eta^2 =.05$. This would therefore indicate that triad patterns held consistent across the age of the participants.

Gender was examined by conducting using a 3x2x2 mixed ANOVA with triad type as a within-subjects factor, and both context and gender as between-subject factors. The same patterns found previously were again replicated with significant main effects of triad type ($p < .001$) and context ($p < .001$), but no interaction effect ($p > .05$). Of importance here, the main effect of gender was not significant, $F < 1$, indicating that selection of the action choice was consistent between males and females. In addition, gender did not interact with either triad type, $F < 1$, or context, $F < 1$, and the three way interaction was also non-significant, F(2, 92) = 2.81, $p = .066$, $\eta^2 = .06$.

Table 2.4

Mean Frequency (Standard Deviations) of Action Responses Across Triad Type and Context.

Condition	N	Mean percentage of choice (SD)		
		DCO	SCO	PCO
Context-lean	25	.32 (.13)	.61 (.15)	.48 (.2)
Context-rich	25	.53 (.21)	.70 (.15)	.69 (.14)

2.9 Discussion

The results here support and extend the findings of Experiment 1. The reaction time data showed no difference was found again between participants' reaction times on the SCO and DCO triads. Interestingly, participants were slower to respond on the PCO triads suggesting that participants find it more difficult to make categorical decisions when taxonomic information between the items is not present.

However, of main interest here are the data on the choices made. It was found once again that participants were more likely to select the action item on the SCO triads when the choice items shared an action as well as taxonomic information. This is in comparison to the DCO triads where the item that only shared an action was generally less likely to be selected than the taxonomic competitor. This supports the data from Experiment 1 showing that action has an 'additive' effect when combined with a taxonomic relation. The action choices on the DCO triads were lower compared to the SCO triads suggesting that action information is less likely to be used on its own as a basis for category membership. When action is combined with taxonomic information this becomes a better category when combined with the target. However, when presented in context action becomes a stronger source for categorisation, and is used at least as much as taxonomic information.

One suggestion regarding the format of the triads in Experiment 1, was that the presentation of only the target as an image may have occluded both the shared actions between the objects, and the context effect. This may in fact be the case since comparison of Experiments 1 and 2 showed that action scores in the context-rich condition were higher in Experiment 2.

As outlined in Section 2.6, previous research has indicated that the effects of action are not only strong, but consistent across participants and across item trials (Borghi, 2004; Borghi et al, 2012; Bub & Masson, 2006, 2010, 2012; Bub et al., 2008; Chao & Martin, 2000; Tucker & Ellis, 1998, 2001). However, the possibility existed that perceptual characteristics were driving categorical choices on the triad task rather than the shared actions. The reported experiment sought to address this through the development of the PCO triads. If participants were selecting the action item on the triads because of the shared perceptual characteristics between them, then action choices on the PCO triads where perceptual similarity was manipulated to be particularly salient in one choice item that did not share any action with the target, would be low in comparison to the other triad conditions. However, the action choices on the PCO triads was high, and there was very little difference overall between the SCO and PCO triads suggesting that action was used in categorising the target object.

Even in the context-lean condition action seemed to show a reasonably high level of influence with choices at nearly a matched ratio between the two. This supports the notion that participants were using action to group the items together rather than shared perceptual characteristics. Had participants been using only shared perceptual features then a high level of perceptual choices would have been predicted. This was not the case, indicating that the context-lean condition may potentially encourage participants to use a more ‘surface’ based approach on perceptual features, where the context-rich condition may encourage a deeper level of analysis based on how the stimuli influence the simulations generated by participants. This is in line with research on how participants report external and internal properties of as a result of noun-modifiers influencing simulations (Solomon & Barsalou, 2004; Wu & Barsalou, 2009).

Overall, the triad task has shown that action is an influencing factor in an action-irrelevant categorisation task[18]. However, its effects do not overshadow other object properties, and the use of action in this task is dependent on the presence of a competing taxonomic relation. Action is only a strong influence either in combination with a taxonomic relation, or in its absence.

An additional finding of the current experiment was that a significant effect of context was found, unlike in Experiment 1. Showing images of the objects within a functional context seemed to raise the salience of the action relation between the items in the sense that the chance of the action item being selected was significantly increased. Participants showed a strong preference for groupings based on taxonomic information on the DCO triads in the context-lean condition. However, when functional images were shown in the context-rich condition participants became more likely to group using action rather than taxonomic information. This effect has now been demonstrated across all triad types when the items were shown as a functional scenario. This supports the previous claim made with regard to Experiment 1 that the use of only a target image may have occluded the shared action between them. The most likely reason for this is that the context raises the salience of the shared actions between them.

Simulation theory would predict that upon viewing the objects we generate a mental simulation of the objects (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006). When the objects are presented in the context-lean condition it is possible that the ‘vagueness’ of the image in not suggesting a specific context allows for participants to generate a wide possible variety of simulations that may not focus solely on the shared action element between them. For example, upon seeing *water pistol* this may instantiate a ‘buying’ rather than a ‘using’ context. What the context-rich condition

[18] The potential exists that this is not a categorisation task due to the instructions of “goes best” used here which does not specifically invite a category decision. Please see Section 2.14 for a counter-argument to this.

does is to refine this potential simulation from a wide variety of possible scenarios to a more specific one, where the action is not only included, but may also constitute the primary focus of this simulation. As a result, participants were more likely to select the shared action item with the target given that they were directly simulating using the objects.

Overall, the results here show that action has a strong influence on categorical decisions. The salience of action is heightened by the functional context in which it is presented and it becomes more likely to be used in category decisions than taxonomic information alone. When action is presented alongside taxonomic information it has an additive effect in highlighting such items as being stronger category members, irrespective of the context in which it is presented. Furthermore, the current data shed light on the notion that participants draw upon the action relation between the items rather than drawing upon perceptual properties that may exist between the items as a result of the design process. However, in order to test this fully a new set of triads would need to be developed in which items were matched to a target based on taxonomic and action relations between them but did not share perceptual properties. Unfortunately such items do not exist (or are very rare) since members of the same category already often share perceptual properties and this becomes even more prevalent when the items also share an action between them (see Chapter 7 for more details).

The aim of the next two experiments was to rule out two potential confounding variables that might bias the participants to one particular choice over the other. Experiment 3 aimed to rule out the influence of object typicality on the items. On the SCO triads participants were given the chance of selecting one of two choice options that all shared category membership with the target. For example, participants were presented with *orange* as the target and had to choose between *banana* and *strawberry*. The results showed that participants were most likely to choose the option that shared an action, e.g. choose *banana* with *orange*. However, on such triads where all the items belonged to the same category it is possible that participants selected the option that was more typical of the category. For example, it might be that bananas are more typical of fruit than strawberries. There is seen to be a monotonic relationship between typicality and categorisation, objects that are more typical of a category are more likely to be classed as members of that category (Rosch, 1975; Rosch & Mervis, 1975; Rosch, Simpson & Miller, 1976).

The more properties that an object has in common with other category members, the more typical it has been argued to be. However, this is not always the case and research has shown differences in how participants judge typicality and category membership. Rips (1989) gave participants a scenario where they judged the size of the average quarter (approx. 1 inch) and the size of the average pizza (approx. 12 inches). Pizzas do naturally vary in size and are therefore 'variable' whereas the quarter is 'fixed' because its size is governed and does not vary. Participants were then asked to imagine a fictitious 3-inch object and were either asked which of pizza and quarter is the 3-inch object more likely to be, more typical of, and more similar to. The results showed that the participants were more likely to classify the object as a pizza given their knowledge of how pizzas can vary in size while quarters cannot. However, when asked which is it more typical, a 50/50 choice between the fixed and the variable category was seen.

This shows that there are differences in categorisation and typicality decisions and that the two processes do not always track each other (see Chapter 6 for more details of this experiment using categorisation, typicality and similarity instructions). However, for many real world objects typicality does influence category membership and theories of categorisation do place an emphasis on typicality (Rosch & Mervis, 1975). For example, category examples that are most typical of a category are often seen as being "better" members (Rosch, 1975). Therefore, the aim of Experiment 3 was to remove this as a possible confounding variable on the SCO triads. In order to ascertain if participants were selecting the object on the SCO triads because they were more typical than the opposing choice, Experiment 3 collected typicality ratings of the items.

Experiment 4 examined the possibility that participants were biased towards the action choice because of the task instructions, and to ensure that participants were using a categorisation strategy during the task. Task instructions are particularly important in the experiments reviewed thus far, but these are inconsistently formulated. Research has shown that variations in the task instructions lead to different choices selected on the triad task as shown by Lin and Murphy (2001) when participants were asked to select the item that "goes best" or "goes best to form a category". Simmons and Estes (2008) also showed different levels of thematic preference across different experiments when participants were instructed to select the item "most similar to" (46%), "most different to" (39%) or "most like to" (57%).

Mirman and Graziano (2012) specifically used the instructions of "goes best" so as not to cause a taxonomic bias within the task.

While the triad task is seen as a categorisation task (Estes, Golonka & Jones, 2011; Golonka & Estes, 2009; Lin & Murphy, 2001; Murphy, 2001; Simmons & Estes, 2008), the task appears to favour a thematic strategy until participants are given more explicit category instructions. However, such instructions are somewhat unclear in what they ask participants to do given that they do not specifically ask participants to categorise the objects. It could be that participants, rather than categorising the objects, are selecting the item most similar to the target.

While categorisation and similarity are seen as related processes, where models of categorisation rely on similarity and those exemplars most typical to the category are often most similar to other members (Medin & Schaffer, 1978; Rosch & Mervis; 1975; Rosch et al., 1976), there are dissociations between them and can act independent of one-another (Goldstone, 1994; Rips, 1989; Smith & Sloman, 1994). Following this line, there are two potential criticisms of Experiment 2; first, that the instruction of "goes best" could favour an action rather than a categorisation strategy, and second, that the task itself does not reflect a categorisation task. Therefore, the aim of Experiment 4 was to test the processes involved in the use of the triad task by manipulating task instructions.

2.10 Experiment 3

Assessing How Action-Based Triad Choices Are Biased By Object Typicality

2.11 Method

2.11.1 Participants

Forty-six undergraduate students (36 females) from the University of Hertfordshire with a mean age of 23.07 (*SD* = 6.13, age range: 18-50) took part in the experiment.

2.11.2. Design

The experiment was composed of a typicality rating task where participants were presented with the items in the triads (the target and the choice objects) used in the SCO triads of Experiment 2 in a within-subjects design. The dependent variable of interest was the typicality ratings given on a scale of 1 (low typicality) to 9 (high typicality).

2.11.3 Materials

The items presented were taken from the SCO triads (targets and both choice options) of Experiment 2, which comprised 30 items. The items were presented along with their category heading taken across the categories FRUIT, TOOLS, STATIONERY, KITCHEN UTENSILS, LITERATURE, GARDEN TOOLS, ELECTRONICS, FURNITURE, ENTERTAINMENT, CONDIMENTS and KITCHEN WARE. Within each category the items were presented in alphabetical order, however, there was not an even number of items within each category set. Alongside each item was a scale presented from 1 to 9 where 1 was indicated as a poor example of the category, and 9 was indicated as an excellent example of the category.

2.11.4 Procedure

The experiment was completed online using Qualtrics. Participants were sent the online link and once they had consented moved through the questionnaire at their own pace. Participants were instructed that they would see the name of a category at the top of the page with a list of items belonging to that category underneath. They were asked to rate on a scale of 1 (poor example) to 9 (excellent example) as to how good an example that item is of the named category. It was decided to avoid using the word 'typicality' in the instructions to the participants as in previous experiments[19] participants tend to not fully understand this notion, so were instead asked to rate the items on how good an example of the named category they were. The questionnaire lasted between 15 and 30 minutes.

2.12 Results

The typicality ratings of the items can be seen below in Table 2.5. For each pair, a repeated measures t-test was conducted on the typicality ratings of the two choice options. As can be seen in the table below, only three of the pairs were cause for concern showing differences between the pairs. For the *poster/newspaper* (*leaflet*)

[19] Unpublished work completed by the research team.

triad, the action choice was rated as significantly higher for typicality than the taxonomic only choice ($p < .001$). For the *elastic band/paintbrush* (*pencil*) triad and the *screw/plug* (*pin*) triad, the taxonomic only choice was rated as significantly more typical than the action choice (pencil: $p = .014$, pin: $p < .001$).

2.12.1 Experiment 2 Data Re-analysed

The purpose of the next section was to re-analyse the data from Experiment 2, while bearing in mind differences in the typicality ratings. This was completed in two steps; first, looking at the distributions of choices on the triads where differences in typicality were seen between the choice items, and second, the mean of the SCO triads was recalculated without those items where significant differences were found between the choice options (hence referred to as the $SCO_{adjusted}$ triads). Table 2.6 shows the percentages of the choice items on the *pencil*, *pin* and *leaflet* triads where significant differences were found between the typicality of the choice items. The *pin* triad is the only one of concern here. The participants used here rated *screw* as more typical of the category *TOOLS* than *plug*, and participants of Experiment 2 where more likely to choose *screw* (72%)[20]. In the *leaflet* triad, *newspaper* was seen as more typical but there was very little difference between the percentages of the choice items selected from Experiment 2. The *pencil* triad further shows that the choice option identified as more typical (*elastic band*) was in fact the least likely option to be chosen from Experiment 2 (10%).

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[20] The *pin* triad is also of further concern because while participants in Experiment 8 identified pins as being a tool, but are more commonly associated with stationery. Therefore, this technically may not conform to the rules of the SCO triads.

Table 2.5

The Mean Typicality Ratings (Standard Deviations) for the Objects used in the SCO Triads.

Target	Taxonomic choice	TC Mean (SD)	Action choice	AC Mean (SD)	*t* value	*p* value
Pencil	Elastic band	5.04 (2.44)	Paintbrush	3.89 (2.31)	2.57	.014
Glass	Jug	7.89 (1.70)	Cup	7.87 (2.00)	-.60	.55
Spatula	Can opener	8.20 (1.36)	Saucepan	8.53 (1.24)	-1.83	.08
DVD player	Television	8.13 (1.60)	CD player	8.15 (1.43)	.11	.92
Bed	Sofa	8.54 (1.11)	Wardrobe	8.80 (.54)	1.63	.11
Orange	Strawberry	8.35 (1.14)	Banana	8.50 (1.11)	.80	.43
Ketchup	Salt	7.31 (2.35)	Vinegar	7.49 (2.54)	-.62	.54
Pin	Screw	5.50 (2.90)	Plug	4.17 (2.63)	-4.03	<.001
Spade	Shears	8.22 (1.43)	Trowel	8.30 (1.28)	-.50	.62
Leaflet	Poster	4.02 (2.30)	Newspaper	6.57 (2.20)	7.33	<.001

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For the second analysis the $SCO_{adjusted}$ means were calculated from those SCO triads where no differences were shown in the typicality ratings for the choice options. The overall means for the $SCO_{adjusted}$ triads were similar to those seen in the SCO triads, and in fact were slightly higher (see Figure 2.1 below). A mixed ANOVA was conducted using context as a between-subjects factor and triad type as a within-subjects factor consisting of the DCO, PCO and $SCO_{adjusted}$ triads. The pattern of the results was exactly the same as the previous analysis, with a significant main effects of context, F (1, 48) = 43.56, p < .001, η^2 = .48, a significant main effect of triad type using the Greenhouse Geisser adjustment[21], F (1.76, 84.29) = 31.19, p < .001, η^2 = .39, and a non-significant interaction between the two, F (1.76, 84.29) = 1.69, p = .19, η^2 = .04.

Table 2.6

The Percentage of Choice Items Selected on the Triads in Experiment 2 That Showed Significant Differences in Typicality.

Target	Taxonomic choice	TC Percentage	Action choice	AC Percentage
Pencil	Elastic band*	10%	Paintbrush	90%
Pin	Screw*	72%	Plug	28%
Leaflet	Poster	52%	Newspaper*	48%

*The choice item identified as more typical of the category.

21 Mauchly's test of Sphericity was found to be significant; χ^2 (2) = 7.03, p = .03, and therefore the Greenhouse-Geisser adjustment was used; ε = .88.

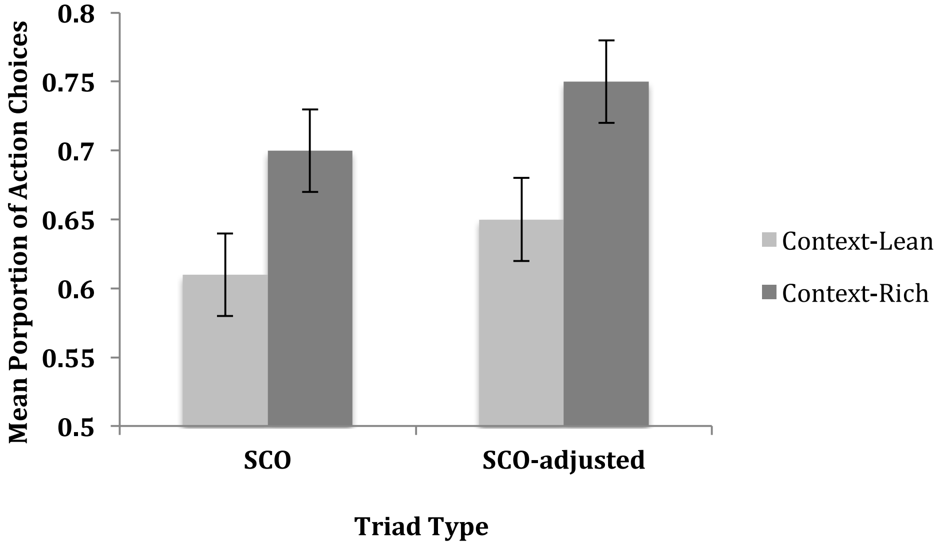

Figure 2.1. The proportion of action choices selected on the SCO triads and $SCO_{adjusted}$ triads.

2.13 Discussion

The typicality data collected was important because of the possibility that on the SCO triads participants were selecting the object that was most typical as a category member. The data rejects this as a possibility. In only three triads were differences found in the typicality of the choice options, and in only one case of the triads was it found that participants were more likely to select the item that was more typical of the category. Exclusion of these triads showed that the same pattern of results was found between the triads, and in fact the means on the SCO without such were significantly increased. Therefore, the results show that object typicality played little role in how participants made their decisions on the triad task.

2.14 Experiment 4

Shakers and Maracas: Action-based Categorisation Choices In Triads Are Influenced By Task Instructions

2.15 Introduction

As previously discussed in Section 2.9, the aim of Experiment 4 was to test the strategy that participants are using when engaging in the triad task. The same triads from Experiment 2 were used and again presented either in the context-lean or context-rich conditions. However, three sets of instructions were used where participants were asked either to select the item that "goes best" (as used in

Experiments 1 and 2), “goes best to form a category”, or “is most similar to the target”. If it is the case that participants on the triad task intuitively use a categorisation strategy then there should be little difference in action-based choices between “goes best to form a category” and “goes best”. If it is the case that “goes best” biases participants towards using an action strategy, then the action choices using such should be higher compared to using “goes best to form a category”. In addition, if it is the case that participants are completing the triad task using a similarity strategy, then there should be little difference between “goes best” and “is most similar to”.

2.16 Method

2.16.1 Participants

Ninety undergraduate Psychology students from the University of Hertfordshire (65 females, M_{age} = 21.19, SD = 6.12, age range: 18-43) took part in the experiment in return for course credit. The sample size was calculated following an a priori power analysis using G*Power. Assuming α =.05 and $1 - \beta$ =.80, the a priori power analysis indicated that a similar effect size to that found in Experiment 1 would be detected using a sample of 66 participants.

2.16.2 Design

The same forced-choice triad task used in Experiment 2 was presented in a 3x2x3 mixed design with one within-subjects (triad type) and two between-subjects factors (context and instructions). All participants saw the same SCO, DCO and PCO triads used in Experiment 2 (within-subjects) presented either in the context-rich or context-lean conditions (between-subjects). The instructions given to the participants differed between the conditions (between-subjects) where participants were either asked to select the choice items that “goes best with the target”, “goes best with the target to form a category” or “is most similar to the target”. The dependent variables of interest were again the response time on the triads and the frequency of which the participants selected the action choice on the DCO, SCO and PCO triads.

2.16.3 Materials

The same 30 triads (10 SCO, 10 DCO, 10 PCO) triads used in Experiment 2 were used. The triads were once again present in either the context-lean or context-rich conditions. No differences were present in the program used except for the instructions given at the beginning.

2.16.4 Procedure

The procedure was the same as that used in Experiment 2. Once allocated to their condition, participants were either instructed to select the choice item that "goes best with the target", "goes best with the target to form a category" or "is most similar to the target". In the same manner as Lin and Murphy (2001), participants in the category instruction condition were presented with a category definition in order to emphasise the nature of the task. Participants were told that "A category is defined as a set of things that share some communalities - be it functions, purposes, physical and perceptual characteristics, or behavioural predispositions". Participants in each condition were then allocated to one of the two context conditions and ran through the Superlab program as in previous experiments.

2.17 Results

2.17.1 Reaction Times

Reaction times were calculated overall on the SCO, DCO and PCO triads for each participant and between the context and instructions used of goes best (GB), goes best to form a category (GBFC) and most similar (MS). As with the previous experiments, participants appeared quicker overall on the SCO (M = 2303.97, SD = 1198.47) and the DCO (M = 2107.12, SD = 1351.99) triads compared to the PCO triads (M = 2841.74, SD = 1462.49). In addition, participants appeared faster in the context-lean condition (M = 2290.02, SD = 1010.93) than the context-rich condition (M = 2733.98, SD = 1482.37), and faster when given the GB instructions (M = 2212.48, SD = 714.13) and MS (M = 2229.76, SD = 1057.25) compared to GBFC (M = 3093.76, SD = 1698.37).

A 3x2x3 mixed factor ANOVA was conducted using triad type (SCO vs DCO vs PCO) as a within-subjects variable and both context (lean vs rich) and instructions (GB vs GBFC vs MS) as between-subject variables. A significant main effect of triad types was found, F (2, 168) = 32.28, $p < .001$, $\eta^2 = .28$. Follow up procedures using the Bonferroni adjustment showed that there was no difference between the reaction times on the SCO and DCO triads (p = .71) but the PCO triads were significantly slower than both the SCO ($p < .001$) and the DCO triads ($p < .001$). In addition, the main effect of instructions was significant, F (2, 84) = 5.37, p = .006, η^2 = .11. Using the Bonferroni adjustment it was found that the instructions to select item that GBFC was significantly slower then both the GB (p = .016) and the MS instructions (p = .019). No difference was found between the GB and MS instructions (p = 1.). The main effect of context was not significant, F (1, 84) = 3.13, p = .08, η^2 = .04, nor was the two-way interactions between triads and instructions, $F < 1$, the two-way interaction between context and instructions, F (4, 168) = 1.82, p = .13, η^2 = .04, and the three-way interaction between triads, context and instructions, F (2, 84) = 2.56, p = .08, η^2 = .06. However, the two-way interaction between triads and context was found to be borderline significant, F (2, 168) = 2.92, p = .057, η^2 = .03. The data indicated that in all three triad types reaction times were higher in the context-rich condition, but the difference was only significantly so on the DCO triads (p = .019).

The reaction time data was further analysed for outlying scores and normality. After removing the outlying scores (x4) the reaction time on all of the triad types was positively skewed, SCO: $D(86) = .14$, p = .002; DCO: $D(86) = .12$, $p < .001$; PCO: $D(86) = .12$, p = .002. A square root transformation was applied and a 2x3x3 mixed ANOVA was conducted using context and instructions as between-subject factors. The analysis found that the main effect of triad type was significant, $F(2, 160)$ = 41.66, $p < .001$, η^2 = .34. Follow up analysis using the Bonferroni adjustment showed that the reaction times on the PCO triads were significantly longer than the SCO (p < .001) and the DCO ($p < .001$), but no difference was found between the latter (p = .23). The main effect of instructions was significant, $F(2, 80)$ = 3.29, p = .044, η^2 = .08. Follow up analysis using the Bonferroni adjustment showed that the reaction times using the GBFC instructions was borderline significantly longer than the MS instructions (p = .052) but no different to the GB instructions (p = .17). No difference was found between the MS and GB instructions (p = 1.0). Therefore, the strong main effect found in the previous analysis was partially removed once the reaction times were normalised. The main effect of context was not significant, $F(1, 80)$ = 1.93, p = .17, η^2 = .02, nor any of the two-way and three-way interaction effects.

Table 2.7.

Mean Reaction Times (Standard Deviations) Across Triad Types, Context and Instructions.

Instructions	Context	N	Triad Type		
			SCO	DCO	PCO
Goes Best	Lean	15	1859.49	1793.71	2365.47
			(622.45)	(570.81	(959.09)
	Rich	15	2135.23	2458.55	2662.43
			(792.69)	(789.15)	(867.98)
Goes Best to	Lean	15	2477.03	2235.97	2836.12
Form			(1088.66)	(823.49)	(1160.50)
Category	Rich	15	3201.19	3648.93	4163.33
			(1961.85)	(2423.38)	(2036.43)
Most	Lean	15	2147.49	2196.60	2698.31
Similar			(1146.42)	(1087.71)	(1743.90)
	Rich	15	2003.40	2007.97	2324.81
			(712.07)	(794.74)	(946.92)

2.17.2 Action Choices

The mean proportion of action response choices was calculated for the SCO, DCO and PCO triads across context and instructions. As was found in Experiment 2, participants showed a tendency to select the action choice more often with the SCO (66%) than with the PCO (57%) and DCO (54%) triads, and more so in the context-rich (67%) condition than context-lean (51%).

A 3x2x3 mixed ANOVA revealed a significant main effect of context with a higher number of action choices in the context-rich condition, F (1, 84) = 44.70, p < .001, η^2 = .35. The main effect of triad type was also significant, F (2, 168) = 17.91, p < .001, η^2 = .18. Post hoc analysis using the Bonferroni adjustment found that the action responses on the SCO triads were significantly higher than both the DCO triads (p < .001) and the PCO triads (p < .001). No difference was found between the DCO triads and the PCO triads (p = .86). The main effect of instructions was not significant, F (2, 84) = 2.70, p = .073, η^2 = .06, nor was the two-way interaction between context and instructions, F < 1. The two-way interaction effect between context and triads was significant, F (2, 168) = 11.47, $p < .001$, $\eta^2 = .12$. The results showed that in all three triad types, the mean percentage of choices was higher in the context-rich condition than in the context lean condition, but the effect was stronger in the SCO ($p < .001$) and PCO triads ($p < .001$) than in the DCO triads ($p = .035$). The two-way interaction between instructions and triads was also significant, F (4, 168) = 2.51, $p = .044$, $\eta^2 = .06$. Post hoc analysis showed that the only differences were found on the PCO triads where GBFC led to a higher mean proportion of action choices compared to GB ($p = .033$) and MS ($p < .001$). The difference between GB and MS was marginally significant ($p = .051$).

However, of main interest here is the three-way interaction between context, instructions and triads which was significant, F (4, 168) = 5.01, $p = .001$, $\eta^2 = .11$. Figures 2.2 and 2.3 show the mean percentage of action choices in each triad type across the different instructions, and spilt across the two contexts. Looking at the proportion of action choices in the context-lean condition (see Fig. 2.2) no differences were found between the instructions on the SCO triads. Post hoc analysis found that on the DCO triads the category instructions (GBFC) led to higher action choices than GB ($p = .028$). In addition, on the PCO triads the similarity instructions (MS) led to lower action choices than both GB ($p = .006$) and GBFC ($p = .003$).

Examining the context-rich condition (see Fig. 2.3), no differences were found on the DCO triads. On the SCO triads the MS instructions led to significantly lower action choices than GB ($p = .049$) and GBFC ($p = .0.36$), but no difference was found between GB and GBFC ($p = .90$). In addition, on the PCO triads the category instructions (GBFC) led to higher action choices than GB ($p = .006$) and MS ($p = .006$). The data here shows that under no conditions did the GB instructions lead to statistically higher action choices than the GBFC instructions, and the similarity instructions led to proportionally lower action choices overall.

2.17.3 Age and Gender

The influence of the participant's age was examined using a 2x3 mixed ANOVA after removing those participants whose age was more than two standard deviations above mean ($N = 5$)[22]. The ANOVA showed that the same patterns found

[22] The age of the participants was significantly correlated with the number of action choice on the PCO triads, $R = .32$, $p = .002$, showing a positive correlation. However, age was not correlated with the number of action scores on the SCO ($p > .05$) or DCO triads ($p > .05$) and therefore it was decided that

in the previous analysis were replicated. This included the main effects of triad type ($p < .001$) and context ($p < .001$), and the three-way interaction effect ($p = .003$) as described above in Section 2.17.2. Post hoc analysis using the Bonferroni adjustment showed that on only a few comparisons did the GB and GBFC instructions significantly differ, and at no point did the GBFC instructions lead to lower action choices compared to the GB instructions. The only difference found was that the main effect of instructions was no longer significant as it was in the previous analysis, $F(2, 79) = 2.58$, $p = .082$, $\eta^2 = .06$.

Gender was examined by conducting using a 3x2x3x2 mixed ANOVA with triad type as a within-subjects factor, and context, instructions and gender as between-subject factors. The same patterns found previously regarding the main effects and interaction effects were again replicated. Of importance here, the main effect of gender was not significant, $F < 1$, indicating that general selection of the action choice was consistent between males and females. In addition, gender did not interact with either triad type, context or instructions (for all comparisons, $F < 1$). However, the three way interaction between triad type, context and gender was significant, $F(2, 156) = 4.40$, $p = .014$, $\eta^2 = .05$. Post hoc analysis using the Bonferroni adjustment showed that the only difference between males and females occurred on the DCO triads in the context-lean condition where males were more likely to select the action choice than the females ($p = .027$)[23]. This might indicate that there is some preference for males to select the action choice more than women. However, this pattern is not consistent across the other triads, nor in the previous experiments, and the results therefore do not show a reliable gender effect.

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it was not appropriate to perform an ANCOVA because the effects were not consistent and violate the ANCOVA assumptions.

[23] Within the remaining chapters, the effects of age and gender were analysed using the same procedures outlined within the current chapter, but are only reported when significant patterns have been found (see Experiment 7, Section 4.8.1 and Experiment 8, Section 5.6.1).

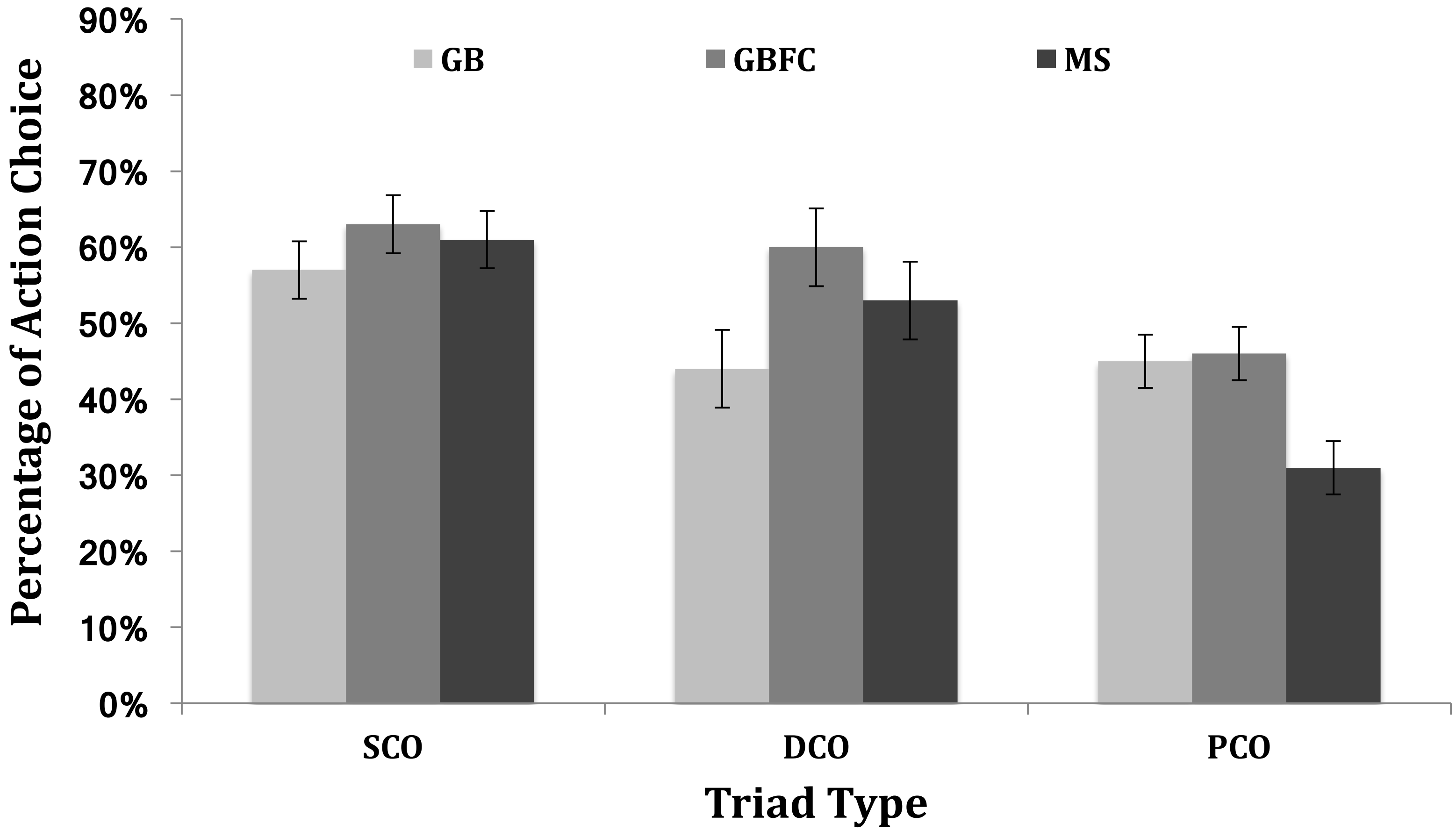

Figure 2.2. Mean percentage of action choices in the context-lean condition with the Same Category Object (SCO), Different Category Object (DCO), and Perceptual Category Object (PCO) triads between the Goes Best (GB), Goes Best to Form a Category (GBFC) and Most Similar (MS) instructions. Error bars are standard errors of the mean.

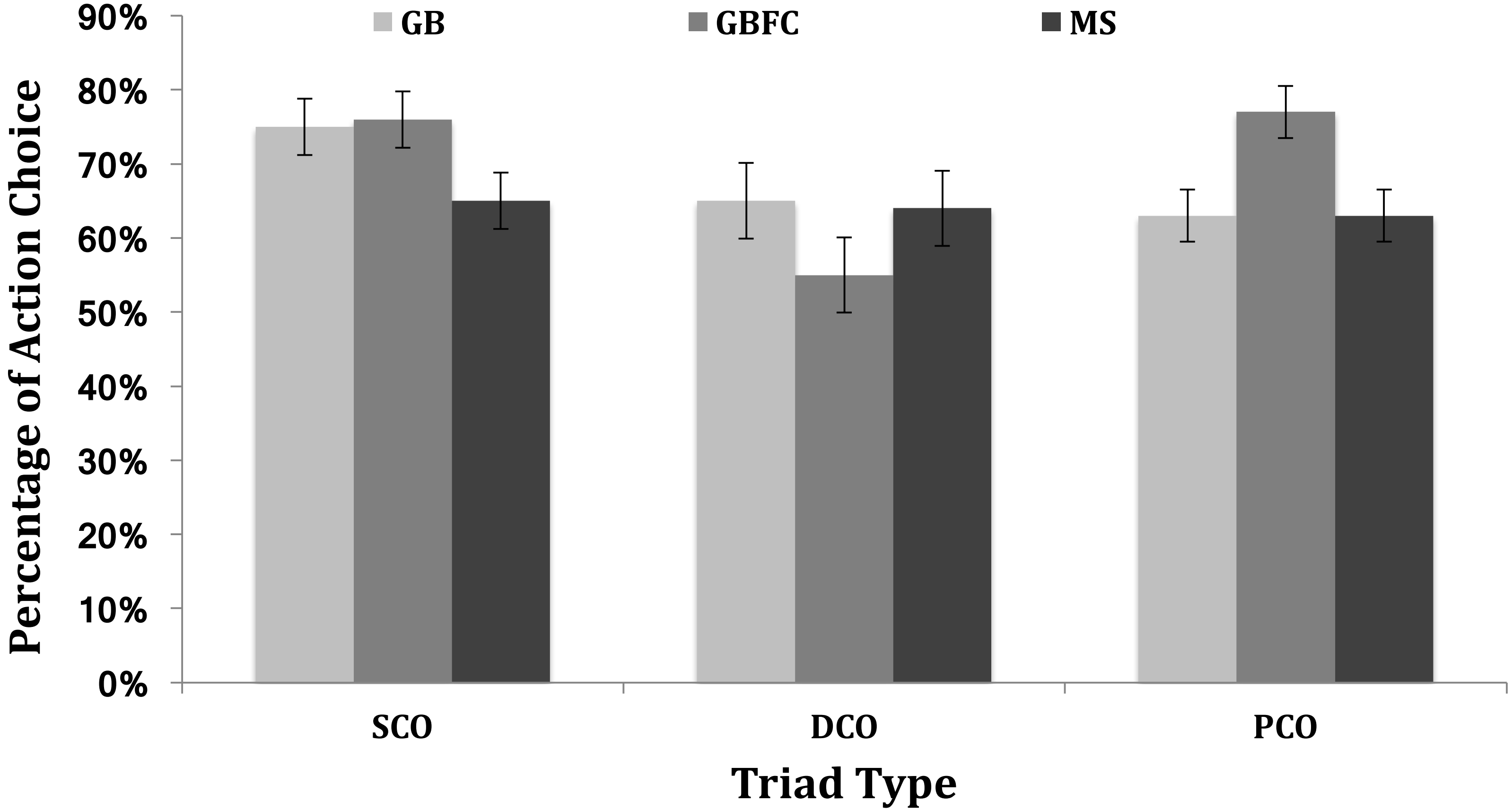

Figure 2.3. Mean percentage of action choices in the context-rich condition on the Same Category Object (SCO), Different Category Object (DCO), and Perceptual Category Object (PCO) triads between the Goes Best (GB), Goes Best to Form a Category (GBFC) and Most Similar (MS) instructions. Error bars are standard errors of the mean.

2.18 Discussion

The results reported here replicate those of Experiment 2. The reaction times on the triads were faster on the DCO and SCO triads compared to the PCO. As with Experiment 2 this is presumably because participants find it more difficult to categorise objects in the absence of taxonomic information. With regards to the instructions, and after accounting for the normality of the data, no difference was found on the reaction times between the GB and GBFC instructions. This suggests that engaging with both instructions does encourage the participants to use a categorical strategy in assessing the triads. This is in line with previous research which does view the use of the 'goes best' instructions as reflecting a categorical decision (Estes et al., 2011; Lin & Murphy, 2001; Mirman & Graziano, 2012; Sachs et al., 2008).

The data on the action choices was also in line with that found in Experiment 2. Participants were more likely to select the action choice on the SCO triads when it also shared taxonomic information. This is in comparison to the DCO and PCO triads where choices were lower, but greater than 50%.

The main effect of context was also replicated from Experiment 2 where action choices were significantly higher when the items were shown in a functional context compared to shown in isolation. Although a significant increase due to context was seen in all three triad types, this effect was strongest for the SCO and PCO triads compared to the DCO triads. This data is in line with the explanation of Experiment 2. When participants are simulating the objects in use the shared actions between the objects becomes more salient given that the context narrows the range of potential simulations to one that shows the item in use, and thus the simulation becomes more focused on the object's motoric component. The context-lean condition has the potential to create a wide variety of possible simulations which may not focus on the shared actions between the objects and hence makes the shared actions less salient, and less likely to influence the choices made. However, it should be noted that not all participants use action in their choices, and not on all the triads.

However, of main interest was the effect of task instructions. A potential criticism of the results reported in Experiment 2 was that the use of the "goes best" instructions might have encouraged participants to use a non-categorical strategy on matching the triads, and led to more reliance on action. The significant three-way interaction reported here deflects this as a potential criticism. If it were the case that participants were not using a categorisation strategy, then action choice preferences with GBFC instructions would be significantly lower than with the GB instructions. Overall, the GB instructions did not lead to significantly higher action choice frequencies than the GBFC instructions. In contrast, there are examples within the triads where GBFC instructions actually led to higher action choice frequencies than GB instructions. Therefore, rather than the more ambiguous GB instructions inflating action choice frequencies, it appears that these instructions are, if anything, reducing the probability of picking the action item.

A second possibility on the triad performance was that participants were not specifically categorising the objects, but using overall similarity to judge the items and therefore selecting the object most similar. If it were the case that participants were using a similarity rather than a categorisation strategy, then the MS instructions would result in choice preferences more similar to those obtained with the GB instructions. However, the results show that action frequencies were lower when participants were invited to select the most similar item. This is supported by previous evidence from Iachini, Borghi and Senese (2008) who showed that action influences category decisions, but not similarity ratings[24]. This further suggests that the triad task is a categorisation task and not one that reflects only assessments of similarity. Overall, the results help to refute this possibility outlined from Experiment 2. Given that the results of the 'goes best' instructions were not significantly higher than those to directly form a category, the criticism that participants were biased, and not engaging in a categorisation task, has been negated.

An interesting finding here relates to the use of the GBFC instructions on the DCO triads. With these triads and instructions, the overall frequency of action choices was higher in the context-lean than in the context-rich condition. Theoretically speaking, it would be predicted that action choice frequencies should be fairly low with DCO triads when participants are asked to group by category when the taxonomic item was designed to share category membership with the target, and the action choice was not. For example, the *rifle* and *sword* are both weapons and therefore when asked "goes best to form a category" participants

[24] See Chapter 6 for additional support with similarity ratings on the stimuli developed in Experiment 2.

should be more likely to select *sword* over *water pistol*. However, in both conditions the participants were more likely to select the action choice compared to the taxonomic choice.

There are two possible explanations for this pattern. The first is that the definition of a category given to the participants emphasised perceptual characteristics as being a source of commonality. As discussed in Section 2.4, perceptual characteristics are potentially a source of bias on the DCO triads given the shared ergonomics between the action choice and the target. Therefore, when the participants are instructed to make a category, and clearly given perceptual characteristics as a reason to do so, they select the action choice on the triad. The fact that the action choices were higher in the context-lean condition could be explained by the design format of the triads. Objects shown in the context-rich condition are partially obscured by the agent holding the object. For example, in the *rifle/sword/water pistol* example the handle of the rifle and the water pistol are obscured by the person holding it. Therefore, as such elements are blocked from the agent's view then perceptual properties might be less likely to influence the choice made compared to the context-lean condition where the objects are shown un-obscured. Overall, participants were less likely to use perceptual reasons to make their choices in the context-rich than context-lean condition, and hence less likely to select the action choice in the former. This would also be in line with the higher action choices found on the PCO triads in the context-rich condition. Participants would be less likely to use perceptual properties and hence were more likely to pick the action choice (as was found in the data).

The second possible explanation is that participants were creating goal derived, rather than functional categories. For example, participants might be grouping *screwdriver* with *key* because of the general goal of 'opening' rather than their specific function. This is highlighted by the context shown and therefore, in combination with lower perceptual features, might increase the salience of such goal-derived categories. This would also explain why a high percentage of action choices were seen in the PCO triads where none of the items shared category membership with the target, when participants was explicitly asked to group the objects into a category. An example of this would be with a triad with *cocktail shaker* as the target and *maracas* as a choice option where participants would not put them together based on shared functions (one makes a drink and one makes music) but derived on the ad hoc notion of "things that are shaken". The most likely option however is that both of these explanations work together when participants make their choices. This is further investigated in Chapter 5 using protocol analysis.

In conclusion, the results showed that participants were more likely to select the action-related item in the triads when given specific category instructions. Previous concerns that action choices were inflated by the "goes best" instructions have been alleviated following the comparison of such instructions with choice preferences elicited with "goes best to form a category" instructions. However, what is not clear here is the type of category participants create on the fly when engaging with a triad tasks, whether these are categories that cohere in terms of their semantic or goal derived features.

2.19 General Discussion

The reported research aimed to show how action may be used to group objects together in an action-irrelevant, conceptual task. The triad task requires no physical action for task performance and therefore if participants match items together based on shared actions, then this would show how such knowledge is automatically recruited and used in such categorisation tasks. There were two main findings of interest from the work reported in this chapter. The first was that participants were more likely to base their choices on action when the items are presented in context. This is not unexpected given that previous research shows object properties, including action, are more salient when presented within context (Barsalou, 1982; Borghi et al., 2012; Kalénine et al., 2014). This would leave two possibilities in interpreting the data, that either action is not automatically recruited in such tasks or that action is automatically recruited, but this does not necessarily mean it will be used to base such categorisation decisions. Given that previous research (Borghi, 2004; Campanella & Shallice, 2012; Chao & Martin, 2001; Myung et al., 2006; Tucker & Ellis, 1998, 2001) has shown implicit effects in action-based responses it is unlikely that the action is not automatically simulated when thinking about objects. What is more likely here is that such knowledge is recruited when thinking about objects, but this does not guarantee that it will influence category decisions in all cases. It is the simulation (Barsalou, 1999, 2003, 2008, 2016b) that determines which features participants focus on for making category decisions. The simulation is determined by the context presented and therefore participants in the context-rich condition are given a salient context that narrows and specifies the simulation generated, hence participants are more likely to use action as a source of categorisation.

The second main finding is that action is less likely to ground category membership on its own, particularly when competing against shared taxonomic information. However, what the results do show is that action has an additive effect. When items are matched on their taxonomic relation participants are more likely to select the option that also shares an action. Experiment 3 has removed the possibility that participants were selecting the item that was more typical of the category. What can be seen across the triads is that participants are not always consistent in how they respond in this task. For example, it is not the case that participants always use action in basing their choices. If this were the case then participants would always select the action choice across all the triads. Instead, participants' performance is modified by the stimuli used, and the context within each specific trial. As such they may not always use the same strategy across each trials.

Simmons and Estes (2008) also found, when using the triads of Lin and Murphy (2001), that there were individual differences across the triads with some participants showing around a 50% chance of selecting either the thematic or the taxonomic choice. It is therefore clear that participants do vary in their *global* and *local* strategies across the triad task. It is most likely, especially in the context of the current experimental work, that participants engage in a local strategy across the triad task where their reasoning and strategy for completing each trial varies given the nature of the stimuli. For example, the same participant might choose *banana* for *orange* because of the shared action, but then might choose *elastic band* for *pencil* because of the shared taxonomic relation. Even within the same triad type participants do not use the same strategy, further exemplified but the fact that there is a wide variation in participants' scores between 0% and 100% on each triad type.

There is also the possibility that participants are using strategies outside of taxonomic, action or perceptual, for example choosing *banana* over *strawberry* because they do not like strawberries (personal preference). While it is believed that such circumstances are limited, it is still a possibility (see Chapter 5 for supportive evidence for this). There is, additionally, the possibility that participants are not making semantic categories but are, in fact, forming ad hoc categories (Barsalou, 1983). Given the embodied view of cognition, which posits that concept knowledge is ‘grounded’ across multimodal representations, participants can be influenced by a wide range of activated systems (as opposed to relying on a static feature list) of which action is only one potential feature and so these may affect choices differentially for participants.

In the next chapters, the experimental work has sought to identify other circumstances under which actions are likely to influence decisions in the triad task (Chapters 3 and 4), but also sought to identify the types of strategies that participants use across the two contexts (Chapter 5).

Chapter 3

What Counts as the 'Context'?

Experiments 2 and 4 have both demonstrated that the likelihood of participants selecting the action item in the triads, significantly increased when the items were presented in context. The context images, while confirming to the design remit, themselves do vary in nature. A visual analysis of the items used suggested that those images where the hands were clearly using the objects were more likely to lead to the action choice in the triad task, suggesting that participants were looking more at the hands than the objects. However, simulation theory would predict that participants focus on the image as a whole, rather than the individual elements (i.e. the object itself or the hands holding it). This was measured using eye-tracking software, which showed that participants do not particularly focus on the hands, and spend little time looking at the objects. Rather, participants focus on the image as a whole supporting a 'simulated' view of task performance.

3. Experiment 5

Using Eye-Tracking to Assess Which Elements of the Context are most Likely to Drive Action-Based Choices

3.1 Introduction

The previous chapters have shown that, within the triad task developed in Chapter 2, participants were more likely to select the action choice when the items are shown in context. Definitions of context vary across subject areas and disciplines and the notion of context is therefore difficult to constrain (Bazire & Brézillon, 2005; Brézillon, 1999). Bazire and Brézillon (2005) suggested that it is difficult to understand context based on knowing what is included within the context, and whether the context should include the person, the task, the situation or even the interaction between all of them. Despite such difficulties in defining the term, it has been clearly demonstrated that participants 'benefit' in task performance (across various cognitive tasks) by presenting items in context (Barsalou, 1982; Borghi et al., 2012; Bransford & Johnson, 1972; Godden & Baddeley, 1975; Kalénine et al., 2013; Palmer, 1975; Roth & Shoben, 1983; Smith, 1994; Smith & Vela, 2001).

The data presented in Chapter 2 suggested that the effects of context were not consistent across the triads. Stronger contextual influences were seen on some triads compared to others. For those others, context appeared to have no effect on increasing selection of the action choices. The primary explanation offered in Chapter 2 for the context effect, was that the context images help to reduce and narrow the simulation produced by the participants from a possible 'bank' of scenarios involving the objects (Yeh & Barsalou, 2006). It was suggested that when participants view the triads in the context-lean condition, participants are able to generate a wide range of possible simulations given that the context does not specify anything particular. However, the context-rich condition suggests a specific context and this in turn should influence the simulations so that participants generate their own scenario based on the image seen. For example, seeing the images of a person peeling and orange and a banana should influence the participants to generate their own simulation based on peeling fruit. This would include the action of the object and hence make this more salient for choosing an item in the triad.

This explanation implies that when participants are viewing the images they are focusing not only on the objects in the picture, but on the agent as well. In essence, participants view the scene as a whole rather than focusing on individual elements. A visual analysis of the materials used in Chapter 2 indicated that those triads in which participants were more likely to select the action choice was clearer in terms of the hand being seen grasping on the objects. Therefore, this might indicate that participants' attention is drawn to how the objects are used, along with the object itself.

The aim of the following experiment was to examine which aspects of the images participants spent more time looking at. Participants should, theoretically, be looking at the image as a whole and processing the scene being acted out (according to simulation theory and the explanation posited above). However, the visual analysis indicated that participants might focus more on the agents holding the objects than the objects themselves. From a situated perspective it would be predicted that participants look at the image as a whole since instantiating a given situation requires taking in all aspects of the image. However, it is possible that participants focus on more specific elements of the images used. In analysing the images used in Experiment 2 it was noted that those that were more likely to lead to the action choice clearly displayed the hands holding/using the objects. The images used in the triad task show the agent interacting with the objects in a specific manner. Therefore, it would be expected that the participants look at the hands of the agent as well as the objects in order to help understand the context in the image, which cannot be done by just looking at the object alone.

In order to assess which elements of the pictures participants spent more time looking at, eye-tracking was used while participants performed the triad task. As the research was interested in how participants spent time looking at the context images, the triad task was conducted using only the context-rich condition. The context-lean images consisted of only the object, and therefore, only a single point of interest. In general terms, preferential looking should predict selection of the choice item. Therefore, it was predicted that the choice item participants spend more time looking at should (positively) correlate with selection of that choice item. More specifically, it was of interest if participants focus on using the objects as much as they focus on the objects themselves (i.e. looking at the hands on the objects as much as looking at the objects), and as much as they focus on the image as a whole. Therefore, it was predicted that no differences would be found between looking times for the object and the agent. In addition, it was further predicted that the triad pattern seen in the previous experiments would be replicated here, with lower action choices on the DCO triads compared to the SCO triads.

3.2 Method

3.2.1 Participants

Twenty-seven undergraduate students from the University of Hertfordshire took part in the experiment. Participants were recruited through opportunity sampling and consisted of 4 males and 23 females with a mean age of 19.44 (*SD* = 1.69, age range: 18-27).

3.2.2 Design

The experiment consisted of a forced-choice triad task using the same 30 triad items as in Experiment 2 (10 x SCO, 10 x DCO, 10 x PCO). However, unlike Experiment 2, triads were only shown to participants in the context-rich condition. There were five dependent variables measured. As with the previous triad experiments, the number of action choices for each type of triad was recorded. In addition, using the eye-tracking software Areas of Interest (AoI's) were set up on each triad for the object label of the triad, the object itself, the hands of the agent on the object as well as on the image as a whole. This allowed for the recording of how long participants spent looking at each AoI (in seconds).

3.2.3 Materials

The same 30 triads (objects only) used in Experiment 2 (10 x SCO, 10 x DCO, 10 x PCO) were again used and presented using Tobii Studio v.3.2.1 software on a Tobii X2-30 portable Eye Tracker system. As the software cannot randomize the trials, they were presented using a Latin Square design ensuring that triads of the same type did not precede each other. All triads were presented within the context-rich condition only.

3.2.4 Procedure

Experiment 5 was set up so that it resembled Experiment 2 as closely as possible. The Tobii portable Eye Tracker unit was a relatively small device (18.4 x 2.8 x 2.3cm) mounted on top of 15” Dell laptop and therefore unobtrusive to the participant (unlike other eye tracking systems, no additional headwear was required of the participant). The laptop was placed directly in front of the participants and the participants were asked to sit so that they were comfortable with a clear view of the screen, and could easily operate the keyboard. In this way, the set-up of the experiment, including the display and the participant’s distance from the screen, matched the experiment set up used in the previous experiments. The only differences being the software used to present the triads, and the order in which they were presented (see Section 3.2.3). However, the software utilised the images and arrangement of those in the previous experiments and therefore the visual display seen by the participants in the current experiment was the same as those in the previous. The experiment took place in a (University of Hertfordshire) campus lab room and therefore the physical context (including lighting and the participant/experimenter seating arrangement) matched that of the previous experiments.

Before engaging in the experiment participants were calibrated to the Tobii software to track eye movements. This involved the participant following a dot around the screen and took less than 30 seconds to complete. Following this the procedure was the same as that of Experiment 2 in which participants were shown the triads and instructed to select the option that “goes best” with the target object. The triads were shown using the Tobii software with the same timings as in Experiment 2 (fixation cue = 1000ms, target only = 1500ms, target and choice options = until participant key press). Unlike the previous experiments where participants responded using designated keys, they were instructed to press the space bar as soon as they had made a decision, which would remove all the triad items from the screen, and they would then state their choice verbally. This was recorded by the experimenter. The participant would then press the space bar again to begin the next trial.

3.3 Results

3.3.1 Choice Analysis

The frequency of action choices on the DCO, SCO and PCO triads are reported below in Table 3.1. As can be seen, a high frequency of action choices was recorded in all of the triad sets with scores ranging between 64% on the DCO triads and 74% on the PCO. In the previous experiments, the DCO action choices were lower than the SCO and the PCO triads. A 1x3 repeated measures ANOVA was conducted on the data using the triad type as the within-subjects factor. The main effect of triad type was significant, F (2, 52) = 3.96, p = .03, η^2 = .13. Planned comparisons using the Bonferroni adjustment showed that the difference between the DCO and the PCO triads approached significance (p = .07) but did not cross the alpha threshold. No difference was found between the DCO and SCO triads (p = .73), nor between the SCO and the PCO triads (p = .73). These results showed that a high level of action-based choices was made overall, and there were no differences between the triad types.

Table 3.1

Mean Percentage (Standard Deviations) of Action Choices Across Triad Type.

Triad	Mean percentage of choice (SD)
DCO	64% (17%)
SCO	69% (13%)
PCO	74% (11%)

3.3.2 AoI Analysis

The results of the time participants spent looking at the choice options can be seen below in Table 3.2. Across all of the triads, participants spent more time looking at the choice option that shared an action (M = .25, SD = .03) than the taxonomic-based choice (M = .20, SD = .02). In addition, participants looked at the PCO triads (M = .28, SD = .04) triads longer than the SCO (M = .21, SD = .02) and the DCO triads (M = .19, SD = .02). Of particular interest in this experiment was the time participants spent looking at the three Areas of Interest (the hands, objects and the object labels), measured using eye-tracking software. From the data in Table 3.2, it appears that participants spent longer looking at the labels of the triads (M = .48, SD = .08) than the objects (M = .14, SD = .02) and the hands (M = .06, SD = .01).

A 2x3x3 repeated measures ANOVA was conducted on the data using the choice options (action vs taxonomic), triad type (DCO vs SCO vs PCO) and AoI (hand vs object vs title) all as within-subjects factors. The main effect of choice option was significant showing that the participants spent longer looking at the action related item than the competitor, $F\ (1, 26) = 12.19$, $p = .002$, $\eta^2 = .32$. The main effect of triad type was also significant using the Greenhouse-Geisser adjustment[25], $F\ (1.2, 31.16) = 12.68$, $p = .001$, $\eta^2 = .33$. Post hoc comparisons using the Bonferroni adjustment showed that participants spent longer looking at the PCO triads than the DCO ($p = .002$) and the SCO triads ($p = .013$). In addition, participants spent longer looking at the SCO triads than the DCO ($p = .017$). The main effect of AoI was significant using the Greenhouse-Geisser adjustment[26], $F\ (1.03, 26.81) = 28.09$, $p < .001$, $\eta^2 = .52$. Post hoc comparisons using the Bonferroni adjustment showed that participants spent longer looking at the labels of the triad than either the object ($p < .001$) or the hands interacting with the object ($p < .001$), and they looked at the objects longer than they did the hands[27] ($p < .001$). At face value this would suggest that labels play a strong role in how participants make their choices on the triads and that the hands interacting with the objects play a rather weak role with little attention paid to them. Section 3.4 will consider why this may not be the appropriate interpretation.

The interaction between the choice items and the triad type was not significant, $F\ (2, 52) = 1.53$, $p = .23$, $\eta^2 = .06$, nor was the interaction between triad type and AoI[28], $F\ (1.49, 38.70) = 2.84$, $p = .09$, $\eta^2 = .10$. However, the interaction between the choice type and the AoI was significant using the Greenhouse-Geisser adjustment[29], $F\ (1.5, 39.07) = 6.87$, $p = .006$, $\eta^2 = .21$. Post hoc comparisons using the Bonferroni adjustment showed that participants spent significantly more time ($p = .005$) looking at the objects in the action choice ($M = .16$) than in the competitor

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[25] Mauchly's test of Sphericity was significant; $\chi^2\ (2) = 27.64$, $p < .001$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .60$.

[26] Mauchly's test of Sphericity was significant; $\chi^2\ (2) = 70.14$, $p < .001$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .52$.

[27] This pattern was true for the majority of the triads seen, but not for all of them.

[28] Mauchly's test of Sphericity was significant; $\chi^2\ (2) = 78.10$, $p < .001$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .37$.

[29] Mauchly's test of Sphericity was significant; $\chi^2\ (2) = 10.05$, $p = .007$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .75$.

item (*M* = .11). In addition, participants spent significantly more time (*p* = .004) looking at the labels of the action choice (*M* = .53) than of competitor item (*M* = .43). However, no difference was found between the time participants spent looking at the hands in the action choice (*M* = .06) and the taxonomic choice (*M* = .07, *p* = .46). The ANOVA further revealed that the three-way interaction between choice type, triad type and AoI's was not significant, F (4, 104) = 1.37, p = .25, η^2 = .05.

Table 3.2

Mean Time (Standard Deviations) in Seconds Spent Looking at the Area of Interests (AoI) Across Choice Option and Triad Type.

Triad	AoI	Choice Option	
		Action	Taxonomic
DCO	Hand	.03 (.04)	.06 (.05)
	Object	.17 (.13)	.08 (.06)
	Label	.45 (.37)	.35 (.29)
SCO	Hand	.05 (.06)	.05 (.06)
	Object	.11 (.08)	.10 (.10)
	Label	.53 (.42)	.45 (.26)
PCO	Hand	.10 (.07)	.09 (.08)
	Object	.20 (.17)	.16 (.11)
	Label	.62 (.64)	.49 (.47)

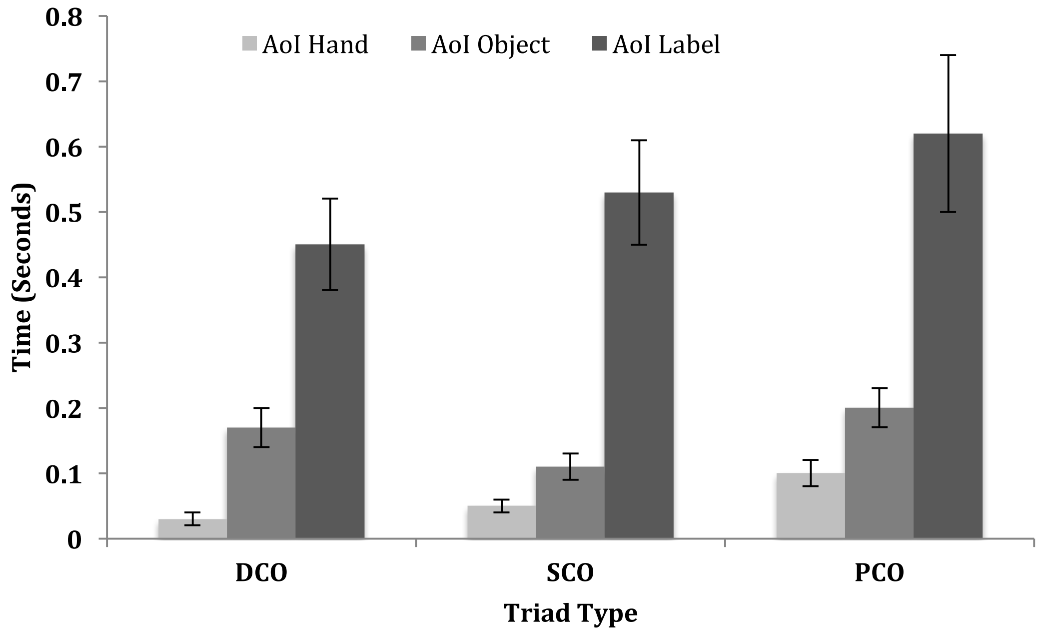

Figure 3.1. The mean time (seconds) spent looking at the Areas of Interest across triad type on the action choice. Error bars represent the standard error of the mean.

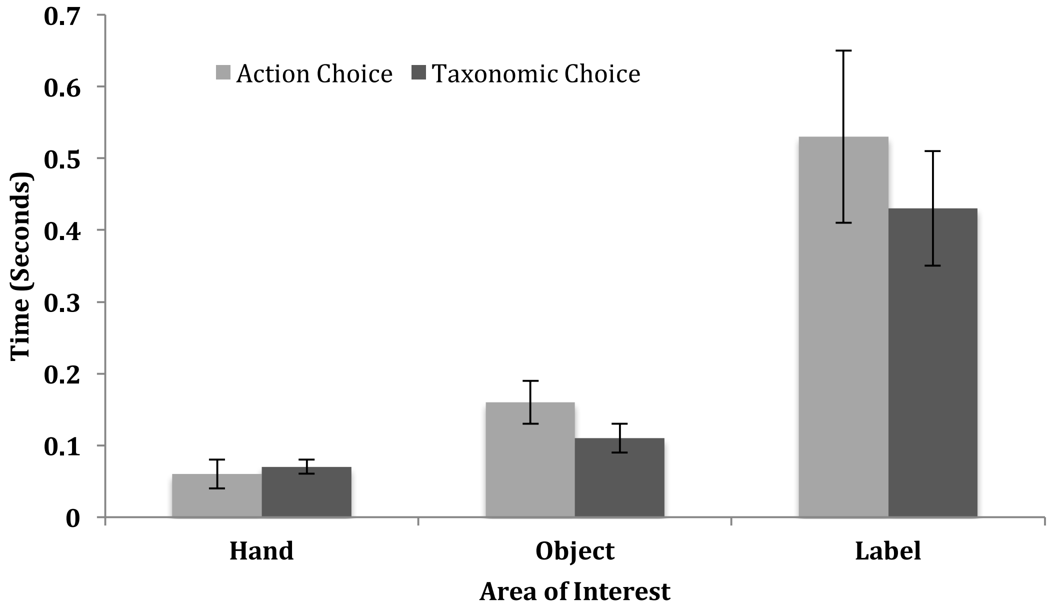

Figure 3.2. The mean time (seconds) spent looking at the Areas of Interest on the choice items (collapsed across all triad types). Error bars present the standard error of the mean.

The initial analysis showed that participants spent more time looking at the labels of the words than they did looking at the hands of the agent and the objects in the picture. However, it is important to note that the images used consisted of more than just the object and the hands on them, but represented a visual scenario.

Therefore, as well as analysing the individual elements of the picture, it was important to examine how participants looked at the image as a whole. To do this, the time participants spent looking at the title of the words was compared against the image used as a whole picture. The results can be seen below in Table 3.3. It appears that participants spent more time looking at the image as a whole compared to the title of the words.

A 3x2x2 repeated measures ANOVA was conducted on the mean looking times using triad type, choice and AoI as within-subjects factors. The results showed that the main effect of triad type was significant using the Greenhouse Geisser adjustment[30], F (1.28, 33.33) = 6.64, p = .010, η^2 = .20. Post hoc analysis using the Bonferroni adjustment showed that the mean looking times between the SCO (M = .57) and the DCO triads (M = .56, p = 1.0) did not differ, but that participants looked more at the PCO triads (M = .66) than both the SCO (p = .031) and the DCO triads (p = .046), replicating that found in Experiments 2 and 4 where longer reaction times were seen on the PCO triads. The main effect of choice was also significant, F (1, 26) = 20.37, p < .001, η^2 = .44, with greater looking times for the action choice (M = .65) than the competitor item (M = .55). In addition, the main effect of AoI was also significant, F (1, 26) = 7.96, p = .009, η^2 = .23, with greater looking times for the image as a whole (M = .72) than the label of the objects (M = .47). None of the two-way or the three-way interaction effects were significant.

Correlational analysis was conducted on the time that participants spent looking at the images on the triads and the percentage of the action choice selected. It was initially predicted that the time spent looking at a choice objects should correlate with selection of that choice. For all three triad types it was found that the time spent looking at the action choice image did not correlate with the percentage of action choices made (DCO: r = .27, p = .17; SCO: r = -.16, p = .43; PCO: r = .05, p = .80). This therefore suggests, that there is no relationship between how long participants spent looking at the choice items and whether or not they selected the action choice.

[30] Mauchly's test of Sphericity was significant; χ^2 (2) = 20.54, p < .001, and therefore the Greenhouse-Geisser adjustment was used; ε = .64.

Table 3.3

Mean Time (Standard Deviations) in Seconds Spent Looking at the Area of Interests (AoI) Across Choice Options and Triad Type.

Triad	AoI	Choice Option	
		Action	Competitor*
DCO	Image	.72 (.30)	.72 (.32)
	Title	.48 (.38)	.35 (.30)
SCO	Image	.74 (.28)	.61 (.28)
	Title	.50 (.41)	.38 (.26)
PCO	Image	.82 (.34)	.72 (.36)
	Title	.62 (.64)	.49 (.47)

*Note. For the DCO and SCO triads the competitor shared a taxonomic relation where as for the PCO triads it shared a perceptual relationship.

3.4 Discussion

The aim of the Experiment 5 was to investigate which of the elements of the context-rich images participants spent more time looking at. Simulation theory would predict that participants focus on the whole image because rather than processing the individual elements of the image, participants should process the context. However, it was still possible that participants would focus more on the objects, and on the hands holding/using the objects, rather than the scene as a whole.

Participants overall spent very little time looking at the hands and no difference was found between the action and the opposing choice item. In contrast, participants spent more time looking at the objects in the images compared to the hands. In particular, participants looked at the object for longer in the action choice compared to the opposing (taxonomic/perceptual) choice item. The data on the triad type shows that participants spent more time looking at the PCO triads than the SCO or DCO. This reflects the reaction times seen in Experiments 2 and 4 where participants were slower to respond to the PCO triads. In both cases, the most probable explanation is that the PCO triads are naturally more difficult to categorise given that no clear functional relation and/or no clear category label presents itself when confronted with all three items. Hence, participants were slower to respond and spent more time looking at the PCO triads.

The time spent looking at the areas of interest (AoI's) shows that overall, participants spent the longest amount of time looking at the titles on the images compared to the objects and the hands. The face value interpretation of this is that participants were influenced more by the words than the images. However, given the relatively short times here (participants spent on average under half a second looking at the words) it is believed that this most likely reflects their natural reading time of the word.

What the results do suggest is that the selection of the action choice is not influenced by the single elements within the images used, but by the image as a whole. Participants spent more time looking at the whole image rather than the words or the individual elements within it. In addition, participants spent more time looking at the images on the action choice than on the competitor. However, while this was the case, the results rather surprisingly do not suggest that selection of the action choice was linked to the time spent looking at it. Despite this participants were more likely to select the action choice in all three triad types.

What can be determined from the consistent effect of context in enhancing the number of the action choices (found in Experiments 2 and 4), is that viewing the image does in some way influence the choice made. The eye tracking data does not indicate that this is the result of particular visual attention to the hands interacting with the objects, as was originally anticipated when designing the triads, but more on overall appraisal of the entire image. This supports the view that participants focus on the scene as a whole rather than the individual elements, which in turn should influence their simulations of the objects. However, while the data does show how participants spend their time viewing the objects, it is not able to tell us exactly why participants select these items after viewing them. It might be expected that the length of time participants spend looking at the objects should be reflected in the simulation they create and hence be more likely to select the action item (since they spend more time looking at it). The highest amount of action choices were selected in the PCO triads which were also the triads that participants spent more time looking at (and the previous experimental work shows longer reaction times on such). However, no correlation was found between the time taken looking at the objects and selection of the action choice.

An interesting point here, is whether potentially visual attention to the areas of interests prevents visual attention to other ‘neighbouring’ elements of the images. While it could be that certain elements of the images draw participants’ attention, it is believed to not be a detrimental factor here. The images used were relatively small and chosen to highlight the intended action of the object. Therefore, the only elements visible were part of the design manipulation. No additional background information was included in the images which could have drawn attention away from the intended focus of the research. Additionally, many of the images used were close up and highlighted the action, while not supplying other ‘distractor’ information. The ‘looking’ data in Table 3.3 suggests that participants were not just looking at the specific elements but at the image as a whole, which all occurred within a relatively short space of time. The context images were selected to imply the specific action where all aspects of the image were relevant to this, which would not imply that areas fixations would have a detrimental impact.

While varying the contextual images used should influence the simulations the participants make, this does not guarantee that the action choice is selected. Nor is it guaranteed that the action choice is selected for that reason itself. The aim of Chapter 4 was to investigate the effects of physical interaction on the objects in the triads. The previous chapters have shown (some of) the circumstances under which action becomes influential for categorisation in an action-irrelevant task. In Experiments 1 to 5, participants were not required to make any physical action before or during the task outside of pushing a button. And yet, action was still influential in the task. Therefore, Chapter 4 aimed to measure the effects on the triad task when participants were required to perform relevant physical actions before undertaking the same triad task.

Chapter 4

Turning Passive into Active: Using Physical Actions to Prime Action-Based Triad Responses

The previous chapter showed how action is used in a passive categorisation task. In particular, action is most likely to be used when it is presented alongside taxonomic information, and when shown within a dynamic context. The results are important for two reasons; (i) they show that action is used as a source of information for categorisation and (ii) they show that action is influential even under action-irrelevant conditions where action is not necessary for task performance. The results are discussed within the framework of simulation theory. In such a view, thinking about objects would partially instantiate those neurons that were active at the initial encounter with the objects.

The aim of Chapter 4 was to see if action choices could be decreased, or increased through physical actions. Experiment 6 attempted to increase action choices on the triad task by first requiring participant to physically use the objects. Prior to the triad task, participants engaged in one of three priming tasks either (i) functionally using the objects, (ii) sorting the objects into groups, or (iii) moving the objects. It was predicted, based on simulation theory and previous research, that recent (but not concurrent) actions should activate a simulation based on such interaction. Therefore, recently using the objects in a functional manner should raise the saliency of action information, and in turn increase action choices on the triad task. The results followed this prediction and are discussed in light of simulation theory.

Based on simulation theory, and the notion that neurons are partially re-activated, Experiment 7 attempted to decrease action choices on the triad task. It was predicted that performing concurrent, manual actions should activate the motor cortex and 'block' the conceptual system from reinstantiating such neurons when simulating the objects in the triad task. By preventing simulation, and hence preventing such action information from being simulated, participants should be less likely to select the action choice in the triads. The results showed that performing concurrent actions did not influence action choices. The results are discussed in light of the 'dual-process' nature of the triad task.

4. Experiment 6

Orange Goes with Banana Because I've Just Peeled One: The Influence of Physical Priming on Categorical Choices

4.1 Introduction

The research reviewed in the previous chapters has shown that knowledge of action is highly influential in a range of cognitive tasks. This lends support to the claim that action information is incorporated into our conceptual representations of objects. It is widely agreed that one of the primary functions of concepts is to support inferences and predictions. While functional, perceptual and thematic information are valuable in concepts, action might arguably be perhaps the most important in being able to navigate the environment (Franks & Braisby, 1997). Therefore, research should focus not only on using action-irrelevant tasks to show when action knowledge influences task performance but also tasks where participants are required to physically interact with objects. This should be a primary focus in research given that such knowledge is not incorporated into concepts simply for the purpose of possessing such knowledge, but to act as a guide in later situations when it is necessary to perform relevant actions.

Empirical evidence has, to date, shown that there are differences in task performance comparing the intention to interact against physically interacting with objects. For example, using the Stroop paradigm with congruent and incongruent actions, Bub et al. (2003) showed only differences in response latencies when participants were asked to perform the associated gesture to use the objects rather than simply naming them. This is supported by further research that has found action knowledge to be influential in task performance when participants are given physical training phases prior to task onset (Borghi et al., 2007; Bub & Masson, 2006), but not under passive conditions. Such research might suggest that action only influences task performance under conditions where the participants are required to make (or trained with) physical actions.

In contrast, Vainio et al. (2008) showed that action information was influential in a task when participants responded both verbally and physically. This was demonstrated using dynamic, as opposed to static, primes. In their task, participants saw a prime of a hand making a precision or a power grasp, followed by an object superimposed on top of the prime. Participants made a categorical decision in deciding if the target object was natural or man-made. Participants were faster on object congruent trials than incongruent trials. The same results were found when participants responded verbally or physically mimicked the precision and power grasps (see Chapter 1 for more details).

Jax and Buxbaum (2010) and Osiurak et al. (2013) provide strong evidence for differences in task performance based on the intention to act versus physically interacting with objects. Jax and Buxbaum presented participants with conflict and non-conflict items and asked participants to place their hands on the objects as though they would either pick them up and use them or grasp them and pass them to the experimenter (use and grasp was within-subjects and was counterbalanced for order). The results showed that, for the conflict objects, participants were slower to make use-based actions than grasping the objects. In addition, they also showed that grasping the objects first had no effect on later using the objects. However, when participants had to use the items first for their function they were then slower afterwards to grasp the conflict items. This effect was not found for the non-conflict items. The authors suggest activation of functional knowledge is relatively long lasting and results in a long-term use-on-grasp interference effect because functional information is stronger and requires semantic activation[31] whereas structural information can be accessed independent of this.

Osiurak et al. (2013), however, found the opposite results. In a partial replication of Jax and Buxbaum (2010), they required participants to physically pick up and use or pick up and pass the objects to the experimenter rather than simply putting their hand on them. They found that, in contrast to Jax and Buxbaum, participants were faster to pick up and use the objects than to grasp them and pass them to the experimenter. The most likely explanation for the difference in results is that physically carrying out the action requires activation of non-spatial information such as weight and fragility, which is not required in simply putting your hand on the object. In addition, the act of passing it to another person also includes allocentric information such as the location of the receiver. Further research using similar

[31] It should be noted here that the authors discuss this as a general activation of semantic information. It could theoretically be supposed that this activation represents a 'Barsalouian' simulation. Though Jax and Buxbaum (2010) do not suggest this, it is assumed in the thesis that such activation represents a simulation.

methodologies supports the differences between gestures to use or to transport with faster initiations times for transporting rather than using objects (Chainay, Brüers, Martin & Osiurak, 2014; Osiurak, Bergot & Chainay, 2015; Sartori, Straulino & Castiello, 2011; Valyear, Chapman, Gallivan, Mark & Culham, 2011). Only Osiurak et al. (2013) has found evidence for faster reaction times for use over grasp actions.

A factor that has been shown to influence priming effects is the type of prime used. Priming studies typically use visual stimuli (Borghi et al., 2007; Bub & Masson, 2006, 2010; Bub et al., 2008; Lee et al., 2013; Vanio et al., 2008) and have been shown to be more successful in priming action-based responses compared to using words. For example, Bub et al. (2008) showed that visual primes increased reaction times when participants responded to them on the graspasaurus (see Chapter 1 for more details). However, the same objects shown as words had no priming effect demonstrating that passive reading of words cannot act as a prime. Masson et al. (2008) however, showed that functional actions were primed by reading sentences containing no reference to manual action. For example, "kicking the calculators" which does not suggest a (direct) manual action still facilitated grasp-based responses on the graspasaurus. The same effect was not found for volumetric/structural actions linked to movement. However, one key difference to note here is the use of words alone against whole sentences as Bub et al. (2008) did not find action-based facilitation effects using only words. Clearly priming is only effective in the context of comprehending sentences as opposed to reading words alone. Perhaps this occurs because the sentences contain both an action and a verb, hence suggesting a clear situation and therefore evoking a simulation. However, research has demonstrated that simulations can be evoked from words alone (Barsalou et al., 2008; Santos et al., 2011; Simmons et al., 2008). It is possible that both sentences and words alone can evoke simulations, but that simulations following from the sentences are 'richer' in detail given the additional information provided.

Osiurak et al. (2015) directly compared visual primes against words using a gesture to use/transport task. In their task participants performed both tasks where they either picked up a bottle of water to pour it into a glass (use) or moved it to a target destination (transport). The weight of the bottle was manipulated depending on whether it was one-third full (light) or two-thirds full (heavy) and participants were primed either with a word prime which they had to read aloud (Experiment 1) or passively viewed a visual object (Experiment 2). The results demonstrated that participants were always faster in the transport condition than the use condition, supporting previous research on differences in use and transport actions (Chainay et al., 2014; Jax & Buxbaum, 2010). Of main interest here was that no priming effects were found for the words used in Experiment 1. However, using the visual primes in Experiment 2 showed that initiation times were fastest in the use condition for the light compared to the heavy object. No priming effects were seen for the transport condition. In line with the findings of Bub et al. (2008), the results demonstrate that the use of words created no priming effects and as such passive viewing of words does not evoke potential actions. However, it does appear that target words in the context of sentence comprehension do instantiate potential actions as was found in Masson et al. (2008) and Lee et al. (2013).

Experiment 6 investigated whether action choices on the triad task could be influenced through physical interaction. In the same manner as Experiment 2, the triads were presented within-subjects but divided between the context-lean and context-rich conditions. However, prior to completing the triad task, the participants assigned to one of three priming tasks. For the priming tasks all, of the items in the triads were physically collected and placed on a centre table when participants walked in the room. Participants were either asked to use the items for their functional purpose (action priming), group them into categories (taxonomic priming) or simply move them from one table to another (movement priming). The aim of the latter was to engage participants in interacting with the objects, but not to use them for their functional purpose. Therefore, the movement priming reflected a more 'structural/volumetric' condition (Bub et al., 2008; Bub & Masson, 2010, 2012; Jax & Buxbaum, 2010). Three main predictions were made based on the previous experimental work included within the current thesis and also based on the previous research:

(i). The proportion of action choices should be highest on the SCO triads replicating the "additive" effect of action found when combined with taxonomic information in Experiments 2 and 4 and lowest on the DCO triads (ii). The proportion of action choices should be highest when the items are presented in the context-rich condition, replicating the context effect found of Experiments 2 and 4.

(iii). The proportion of action choices should be highest following the action-priming phase compared to after the other two priming activities. If it is the case that use-actions have a long-term effect (as found by Jax and Buxbaum, 2010), this long-term activation of functional actions should make participants more likely to select the action choice on the triads compared to those in the taxonomic and the movement priming.

4.2 Method

4.2.1 Participants

Fifty-six undergraduate Psychology students (47 females) with a mean age of 22.87 (*SD* = 6.34, age range: 18-45) from the University of Hertfordshire took part in the experiment in return for course credit. The sample size was calculated following an a priori power analysis using G*Power. Assuming α =.05 and $1 - \beta$ =.80, the a priori power analysis indicated that a similar effect size to that found in Experiment 1 would be detected using a sample of 66 participants[32].

4.2.2 Design

The forced-choice triad task was presented in a 3x3x2 mixed design. All participants saw the same SCO, DCO and PCO triads used in the previous experiments (within-subjects factor) presented either in context-lean or context-rich (between-subjects factor). Prior to undertaking the triad task, participants were assigned to one of three priming tasks (between-subjects factor) consisting of three levels; action, taxonomic and movement. In the action priming the participants interacted with the items in a functional manner using the same action as depicted in the context-rich images. In the taxonomic priming participants were asked to sort all of the objects out into categories. In the movement priming the participants interacted with the objects in terms of moving them from one table to another but not using them for their intended purpose. The dependent variables of interest were, once

[32] Due to complications with the equipment/materials, recruitment did not reach the intended target.

again, the response time on the triads and the frequency with which the participants selected the action choice on the DCO, SCO and PCO triads.

4.2.3 Materials

The SCO, DCO and PCO triads from Experiment 2 were used in Experiment 6. It was not feasible, due to physical constraints of the items (e.g. *fax machine, bed, piano)* or to ethical considerations (*rifle, saw, axe*) to include all the triad items used in the previous experiments and so five of the SCO triads (*spatula, DVD player, bed, spade, ketchup*), four of the DCO triads (*fax machine, rifle, computer, knife*) and five of the PCO triads (*axe, baseball bat, clarinet, nut, gun*) were removed from the Superlab program and not used in this particular experiment. The remaining 16 triads were presented in the same fashion as the previous experiment. All of the 48 items were then physically collected for use in the priming tasks. The action-priming task was designed so that participants were presented with a list of tasks that involved using each item in its functional capacity such as writing their name with a pencil or reading a passage from a book (a full list of tasks used here can be seen in Appendix Z).

4.2.4 Procedure

All participants saw the 48 items used in the triads presented on a table and were assigned to one of the three priming tasks. Those in the action priming condition were read out a list of tasks by the experimenter one-by-one and asked to complete before moving on to the next task. Each task involved using the object in its functional capacity and could either be completed on its own (e.g. *"tie the shoelace on the shoe", "open the book on any page and read out the top line"*) or were presented with additional resources (e.g. *"write your name on a piece of paper"* – where paper was provided to the participant though was not a triad item). Participants were instructed to move at their own pace and that there was no time limit to this task.

Participants in the movement priming were simply asked to pick up each item and move it to the next table along so that they interacted with the object but not in its intended function. Again, no time limit was imposed and participants performed at their own pace.

Participants in the taxonomic priming were asked directly to sort the items into categories. They were told that they could sort them however they liked providing that each group had a minimum of two members and that they would also have to explain their groupings afterwards. They were also told that each sorting must have a valid reason behind it and no items should be grouped together based simply on being remaining items that did not fit into other categories. After the priming task concluded, participants in each condition were allocated into either the context-rich or context-lean conditions and sat in front of a 15" Macintosh laptop to undertake the triad task using the same instructions to select the item that "goes best" with the target as was used in Experiment 2[33]. Response times for the triads and the frequency of action choices were recorded for analysis.

4.3 Results

4.3.1 Response Time

The overall mean response time on the SCO, DCO and the PCO triads are reported in Table 4.1. Participants appeared faster at responding to both the SCO (M = 1952.59, SD = 886.79) and the DCO triads (M = 2008.78, SD = 874.70) than the PCO triads (M = 2157.70, SD = 1030.58). A 3x2x3 mixed ANOVA was conducted on the reaction times using triad type as a within-subjects factor and both context and priming as between-subjects factors. The analysis revealed that the only significant main effect found was of triad type using the Greenhouse-Geisser adjustment[34], F (1.69, 84.54) = 5.35, p = .01, η^2 = .10. Post hoc analysis using the Bonferroni adjustment showed that the response time on the SCO triads was significantly quicker than on the PCO triads (p = .03) and the difference between the DCO and PCO triads was borderline significant (p = .063). No difference was found between the SCO and the DCO triads (p = 1.0). No other main effects and no significant interaction effects were found.

The reaction time data was further analysed for outlying scores and normality. After removing the outlying scores (x3) the reaction time on the SCO and

[33] Despite differences between the instructions, that the "goes best to form a category" instructions led to the highest percentage of action choices in Experiment 4, it was decided here to use the "goes best" instructions. This was to keep the main instructions consistent and to allow for data comparison across experiments.
[34] Mauchly's test of Sphericity was found to be significant; χ^2 (2) = 9.59, p = .008, and therefore the Greenhouse-Geisser adjustment was used; ε = .85.

the PCO triads were statistically normal, SCO: *D*(53) = .07, $p > .05$; PCO: *D*(53) = .08, $p > .05$, however the reaction time on the DCO triads was positively skewed, *D*(53) = .15, $p = .003$. A square root transformation was applied and a 2x3x3 mixed ANOVA was conducted using context and priming as between-subject factors. The analysis found that the main effect of triad type was significant, $F(2, 94) = 7.01$, $p = .001$, $\eta^2 = .34$. Follow up analysis using the Bonferroni adjustment showed that the reaction times on the PCO triads were significantly longer than the SCO ($p = .003$), but no difference was found between the PCO and DCO ($p = .14$), nor the SCO and DCO triads ($p = .22$). No other main effects or interaction effects were significant. Therefore, the results of the previous analysis were replicated.

Table 4.1.

Mean Reaction Time (Standard Deviations) Across Triad Type[35]*.*

Triads	Response time	
	Mean (milliseconds)	SD
SCO	1952.59	886.79
DCO	2008.78	874.70
PCO	2157.70	1030.58

4.3.2 Action choices

The mean proportion of action responses on the SCO, DCO and PCO triads across context and priming are reported in Table 4.2. The results appear similar to those in Experiment 2 with lower levels of action responses in the DCO triads in both the context-lean (43%) and context-rich (45%) conditions. Higher levels of action responses were seen in the SCO and PCO triads (compared to DCO) with the highest seen in the context-rich conditions (56% and 67% respectively). Table 4.2 also shows the action responses across the three priming conditions. Action responses were highest in the action priming where participants interacted with the objects in a standard functional manner (*M* = 59%, *SD* = .18) than in the taxonomic (*M* = 48%, *SD* = .13) or movement priming (*M* = 48%, *SD* = .13).

[35] The means are collapsed across context and priming given that the main effects, nor the interaction effects, were statistically significant.

A 3x2x3 mixed ANOVA was conducted on the mean number of action choices using triad type as a within-subjects factor and both context and priming as between-subjects factors. As predicted (hypothesis No. i), the main effect of triads was significant, F (2, 100) = 6.74, p = .002, η^2 = .12. Post hoc analysis using the Bonferroni adjustment found that the action responses on the DCO triads were significantly lower than both the SCO triads (p = .046) and the PCO triads (p = .004). No difference was found between the SCO triads and the PCO triads (p = 1.). The analysis revealed a significant main effect of context (hypothesis No. ii) with higher action choices in the context-rich condition, F (1, 50) = 5.25, p = .026, η^2 = .1. The main effect of priming (hypothesis No. iii) was also significant, F (2, 50) = 3.84, p = .028, η^2 = .13. Post hoc analysis using the Bonferroni adjustment revealed that the difference between the action and taxonomic priming (p = .063) and the action and movement priming (p = .066) approached significance. The difference between the taxonomic and movement priming was not significantly different (p = 1.).

Unlike Experiments 1 and 2 the two-way interaction effect between context and triads was statistically significant, F (2, 100) = 4.58, p = .012, η^2 = .08. Post hoc analysis using the Bonferroni adjustment (see Figure 4.1) found that action responses were significantly higher on the PCO triads presented in the context-rich condition than they were context-lean (p < .001). No differences were found between the contexts on the DCO triads (p = .92) and the SCO triads (p = .45). The two-way interaction between priming and triads was not found to be significant, F (4, 100) = 2.02, p = .10, η^2 = .08, nor the two-way interaction between priming and context, F (2, 50) = 1.72, p = .19, η^2 = .06, or the three-way interaction between context, priming and triads, F < 1.

Table 4.2.

Mean Proportion (Standard Deviations) of Action Choices Across Triad Type, Context and Priming.

Context	Priming	N	Triad Type		
			DCO	SCO	PCO
Lean	Action	10	.53 (.25)	.48 (.23)	.48 (.19)
	Taxonomic	10	.32 (.23)	.60 (.21)	.50 (.11)
	Movement	8	.46 (.25)	.48 (.10)	.40 (.19)
Rich	Action	10	.58 (.20)	.66 (.23)	.78 (.25)
	Taxonomic	10	.35 (.27)	.54 (.13)	.58 (.15)
	Movement	8	.40 (.25)	.48 (.21)	.65 (.21)

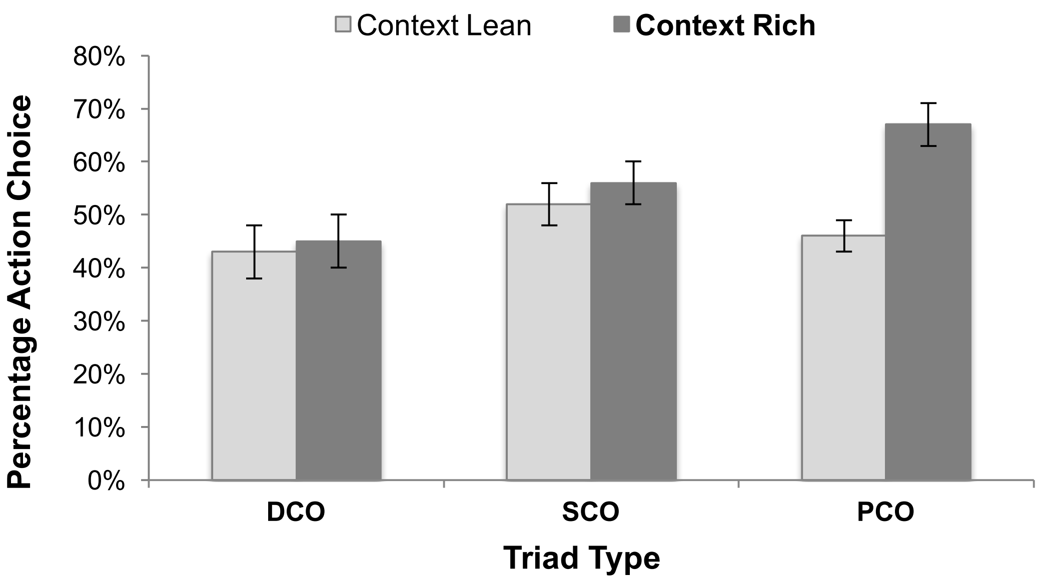

Figure 4.1. The percentage of action choices across triad type and context. Error bars represent the standard error of the mean.

4.3.3 Data Re-Analysed

In order to compare the effects of action priming, the data from those participants who were primed with the functional actions of the objects was analysed against the means on the same selection of 16 triads from Experiment 2. In all other respects the experiments were the same with the exception of the priming of the current experiment. A 3x2x2 mixed ANOVA was conducted on the mean proportion of action choices using triad type as a within-subjects variable and both context and experiment as between-subjects variables. As with the previous experiments the main effect of context was significant with higher action choices in the context-rich than the context-lean conditions, F (1, 66) = 22.25, $p < .001$, $\eta^2 = .25$. The main effect of triad type was also significant, F (2, 132) = 6.18, $p = .003$, $\eta^2 = .09$. Post-hoc analysis using the Bonferroni adjustment showed that action choices on the DCO triads were significantly lower than the PCO triads ($p = .005$) and borderline significantly lower than the SCO triads ($p = .065$). No difference was found between the SCO and PCO triads ($p = .87$). There was a main effect of experiment, F (1, 66) = 6.70, $p = .012$, $\eta^2 = .09$, with higher action choices in the current priming experiment (59%) compared to the action means from Experiment 2 (50%). All of the two-way interactions and the three-way interaction were non-significant. Therefore, the results show that action choice on the triad was most likely to be selected when it was presented within context and following priming with the action, but these factors did not interact with each other.

4.4 Discussion

The results of the current experiment revealed three main findings. The first is the replication of the triad effect from Experiment 2. The action choice was least likely to be selected on the DCO triads when choosing between a taxonomic and an action choice compared to the SCO and PCO triads. This shows that, as with the previous experiments, action information alone is less likely to be favoured as the basis for category membership when the alternative is taxonomic information, particularly when viewed in the context-lean condition. The action item was most likely to be selected with the SCO and the PCO triads. The results on the SCO triads support the notion of action having an ‘additive’ effect making such items sharing both action and a taxonomic relation as ‘better’ category members. The PCO triads further show that when no taxonomic relation is present as an alternative, participants are more likely to use action than perceptual properties to group items together. This was particularly the case when shown in context, and the action choices on the PCO triads were particularly high compared to compared to the previous experimental work.

The second main finding is the partial replication of the context effect from Experiment 2. While previously it was found that across all three triads the action choice was most likely to be selected in the context-rich condition, this effect was limited with the PCO triads in this experiment. The most likely reason for this is the exclusion of certain triads from the original set used in Experiment 2. It is possible that these triads removed were more likely to lead to the action choice than other triads. For example, the *rifle/sword/water pistol* triad (DCO) was removed from the present experiment for practical reasons, however it has been shown to be particularly influenced by context (see Chapter 5). Therefore, those triads used here might be less susceptible to context effects than those removed.

The third main finding from this experiment is the effect of priming conditions. The results showed that participants were more likely to choose the action related item in the triads following the action priming where all the items were used in their functional capacity. It is possible that such functional activations facilitate how we think about the objects used in the triads. When participants engage in the triad task and think about objects they mentally simulate the items within a specific situation (Barsalou, 1999, 2003). This simulation is based on a partial activation of the neurons that were active at the initial time of learning including those within the motor cortex responsible for actions. Barsalou (2003) and Yeh and Barsalou (2006) suggested that the simulation is not the same every time but is dependent on factors such as how recently the object has been encountered, or acted upon. Therefore, prior engagement with the objects in the priming task should have a direct influence on the simulations made and on the choices in the triad task.

Therefore, the question becomes why do the action responses become higher after functional priming only? The priming tasks used here can be separated into two distinctive sets of actions, functional actions related to functional use and volumetric/structural actions related to general movement and interacting with the objects in a non-functional manner (Bub & Masson, 2012; Bub et al., 2008; Jax & Buxbaum, 2010; Osiurak et al., 2013). The priming effects appear to be limited to performing the functional actions on the objects and this effect can be explained by the Two Action Systems (2AS) model (Binkofski & Buxbaum, 2013; Buxbaum & Kalénine, 2010).

The 2AS model posits that the brain has separate action systems for the processing of functional and structural actions. The dorso-dorsal stream is specialized for acquiring information based on the structure of objects and their affordances. This "Structure" system becomes active by objects without activation of conceptual/semantic knowledge. The ventro-dorsal system is specialized for the retrieval of representations. Therefore, this "Function" system is heavily intertwined with conceptual knowledge. While these two systems interact with each other both systems can be activated independent of each other and functional activations tend to be long lasting and can cause interference effects on later actions (Bub & Masson, 2012; Jax & Buxbaum, 2010). Structural activations occur more quickly than functional, but decay rapidly and do not cause later interference effects.

Jax and Buxbaum showed that when participants performed a functional action on an object and then later performed a grasp action, response latencies were significantly longer than when they performed the grasp action first. This interference effect as a result of functional activation lasted for approximately 20 minutes during the entire task. While this functional activation had an interference effect on the use/grasp task, it is possible that this has a facilitation effect on the triad task. The partial re-activation of the neurons during simulation of the objects in the triad should be facilitated by the current activation of the functional system. As such the simulation itself should make the action element more salient between the triad objects and participants will therefore be more likely to select the action choice. This is further amplified by the concurrent activation of conceptual knowledge with the functional system of the ventro-dorsal stream as proposed by Buxbaum and Kalénine (2010). The same facilitation effect does not occur following the movement prime as the structural activations of the dorso-dorsal stream dissipate quickly. Hence, only the long lasting functional activations as a result of the Action priming should lead to higher action choices in the triad task.

There are two ways in which this ventro-dorsal facilitation effect could be tested and supported. First, the frequency of action choices could be analysed as the participants progress through the triad task. As functional activations of the ventro-dorsal system decay slower than their structural counterparts it is possible that given the time it takes to complete the checklist task, and the length of time such activations last (potentially more than 20 minutes, Jax & Buxbaum, 2010), then trials at the beginning of the triad task might be more influenced than those completed towards the end. Therefore, a trend could be found in which action choice frequencies decrease through the trials. A potential difficulty, however, might be that as the trials are randomised and as some trials are more likely to lead to an action choice (see Chapter 5), a trend might be difficult to predict. The second way in which the ventro-dorsal facilitation effect could be tested here would be to use the full range of triads from Experiment 2. As explained above, the full range of triads was not used in this experiment because of ethics and feasibility of priming how participants use certain objects such as *sword*. If it is the case that functional activations of the ventro-dorsal system facilitate simulations of the objects, then in the triad task used here this should result in higher action choices on the primed objects and lower action choices for those objects not primed.

In conclusion, Experiment 6 has demonstrated that the triad effect found in Experiment 2 has been replicated. Participants were more likely to use action as a source of categorisation on the forced-choice triad task when the shared actions were combination with taxonomic information, and when it was presented within a functional context. The results further imply that priming participants with the functional rather than structural actions of the objects led to increased action choices on the triad task. Such results are in line with the view that interacting with objects leads to long lasting potentiation effects (Buxbaum & Kalénine, 2010; Ellis & Tucker, 2000; Jax & Buxbaum, 2010; Tucker & Ellis, 1998, 2001, 2004), which in turn facilitates how objects are mentally simulated (Barsalou, 1999, 2003; Yeh & Barsalou, 2006).

4.5 Experiment 7
Playing Patty-Cake to Deter the Water Pistol:
Using Concurrent Manual Actions to Prevent Object Simulation.

4.6 Introduction

Experiment 6 showed that when participants physically interacted with the objects, they were then more likely to select the action choice in the triad task. The results are explained within the framework of simulation theory. Simulation theory suggests that the most recent interaction with an object should influence how it is simulated on the next occasion. As participants interacted with the objects functionally, this influenced the simulation (basing it directly on action) and hence was used in categorising the objects.

Simulation theory suggests that in simulating an object, those neurons active in the initial encounter become (partially) reactivated. Yee, Chrysikou, Hoffman and Thompson-Schill (2013) showed evidence that concurrent manual actions can prevent access to conceptual representations, and this has a direct influence on task performance. Yee et al. instructed participants to perform either a mental rotation task or a manual "patty-cake" task while classifying words as either concrete or abstract. The results showed that the patty-cake task slowed down response times for the concrete objects, but not for abstract concepts. The most interesting finding was for those objects with greater levels of manual experience. Yee et al. asked participants to rate the objects on a scale of one to seven, based on how much previous manual experience they have with the object. For the participants who performed the patty-cake task, the interference effect seen was greatest when they had greater previous manual experience. This therefore shows that performing manual concurrent actions alongside making category decision, was able to disrupt access to semantic information.

While Yee et al. did not discuss it in such terms, the suggestion made here is that (given the evidence showing how objects are simulated) the patty-cake task disrupted how participants simulated the objects[36]. This is based on the notion that simulations of objects are based within sensorimotor experience. Activating the motor system (via the patty-cake task) was able to disrupt access because the simulation system was not able to draw upon those neurons necessary to simulate the objects. Such neurons were already engaged in the concurrent task and thus were not readily available to simulate the objects. If this is the case, then engaging in a concurrent manual task while undergoing the triad task should lead to lower action-based choices.

The aim of the next experiment is to see if action choices on the triads can be decreased by "blocking" the simulation process. In order to do this, participants were

[36] Two possibilities exist here, (i) the concurrent actions prevented the simulation system from simulating the objects, or (ii) the objects were simulated, and the concurrent actions prevented retrieval of such information. Given the notion that the simulation system relies on re-instantiating the neural system, it is believed that the former is the most likely. This is the view adopted in the thesis.

instructed to perform concurrent manual tasks while completing the triad task. Participants performed one of three tasks; either completing a hand 'patty-cake' task (similar to that used in Yee et al., 2013), a leg extension (foot) task, or simply keep their hands flat on the table (still condition). Situating objects results in a partial re-activation of those neural pathways active upon previous encounters with them. Since (nearly) all of the objects in the triads are hand-operated, then engaging in concurrent manual tasks with the hands should prevent participants from simulating in the same manner since the neural pathways for using the hands are already engaged. In comparison, performing a concurrent leg extension task should not interfere with simulating the objects since different neural pathways should be used. Therefore, if the concurrent hand actions do block the simulation process then participants should be less likely to select the action choice on the triads in comparison to the foot task. However, it is possible that performing concurrent hand actions might actually facilitate the simulation effect, since simulating and partial neuron re-activation might be facilitated by the fact that those neurons are already active. In such a case the action scores on the triads would be greater following the hand condition.

In addition, there is a third possibility here. It might be the case that performing any task at the same time as undertaking the triad task might present a drain on attentional resources since participants have to engage in two tasks simultaneously. For this reason, the hand and foot tasks were designed to be as simple and repetitive as possible, and the still hand condition was introduced. If this is the case, then performing any action should result in lower action choices. Therefore, based on such three different predictions can be made:

(i). If it is the case that concurrent hand actions block the simulation process, then the hand condition should result in lower action scores overall compared to the foot and still condition.

(ii). If it is the case that concurrent hand actions facilitate the simulation process, then the hand condition should result in greater action scores overall compared to the foot and still condition.

(iii). If performing any concurrent task presents a drain on attentional resources, then the hand and the foot condition should both result in lower action scores overall than the still condition.

All three of these predictions are possible. However, given the previous research from Yee et al. (2013) and the fact that no known research to date shows that concurrent actions facilitate the simulation process, it is most likely that the first prediction will be observed. Under these circumstances it is strongly predicted that the concurrent actions will block the simulation process, and result in lower overall actions scores compared to the foot and still condition. Unlike the previous experimental work only the context-rich condition was used here. This was because participants in such a condition are more likely to create action-based simulations and therefore concurrent hand actions should have the strongest impact on such trials.

4.7 Method

4.7.1 Participants

Sixty-four undergraduate students (53 females) from the University of Hertfordshire took part in the experiment with a mean age of 21.33 (*SD* = 5.62, age range: 18-42). Participants were recruited through opportunity sampling and received course credit for participation. The sample size was calculated following an a priori power analysis using G*Power. Assuming α =.05 and 1 – β =.80, the a priori power analysis indicated that a similar effect size to that found in Experiment 1 would be detected using a sample of 45 participants.

4.7.2 Design

The experiment consisted of a forced-choice triad task using the same 30 triad items as in Experiment 2 (10 x SCO, 10 x DCO, 10 x PCO). However, unlike Experiment 2 triads were only shown to participants in the context-rich presentation. Therefore, the experiment consisted of a 3x3 mixed design with triad type as the within-subjects factor and physical task as the between-subjects factor. A pilot study using twelve participants, who did not take part in the main study, was conducted in order to check how the physical task might interfere with the main task. In a counterbalanced manner the participants completed each of the physical tasks while engaged in a counting task for one minute. Participants were presented with a passage of text and asked to count how many times the letter ‘e’ appeared on the page. Afterwards participants were asked to rate how difficult they felt the task was, and how much they felt the movement tasks interfered with their performance[37] on a scale of 1 (very easy) to 10 (very difficult). Repeated measures t-tests on the difficulty ratings showed that the participants considered the still condition (M = 2.75) much easier to complete compared to the hand (M = 4.83, t = -4.80, p = .001) and the foot task (M = 5.75, t = -3.45, p = .005). Most importantly, no difference was found between the hand and foot task (t = -1.48, p = .17) suggesting that both tasks are equal in terms of ease of completion. In addition, no difference was found between the interference ratings for the hand (M = 5.83) and the foot task (M = 6.42, t = -.87, p = .40) suggesting that both tasks equally interfered with the task.

The dependent variable in the main experiment was the percentage of action choices on each of the triads. Unlike Experiment 2, reaction times were not collected as the participants gave verbal responses that were recorded by the experimenter and do not reflect an accurate timing. The experiment was conducted like this to free up the participants' hands in order for them to perform the physical task.

4.7.3 Materials

The same 30 triads from the previous experiments were used. However, participants only saw them within the context-rich condition only.

4.7.4 Procedure

The participants sat in front of an external screen attached to a 15" Macintosh laptop. The laptop was faced towards the experimenter in order for the program to be manipulated. The participants were given the task instructions to read, displayed on the screen. The triad task ran in the same manner as described previously using the task instructions to select the choice item that "goes best" with the target. During the triad task participants performed one of three physical tasks:

(i). Still condition: Participants sat still with their hands palm down on the table in front of them.

(ii). Hand condition: Participants performed a 'patty cake' task patting the table and clapping their hands together repeatedly.

[37] Interference ratings were not collected for the still condition since such interference should be minimal.

(iii). Foot condition: Participants step/extension task with their legs one at a time.

The tasks were performed simultaneously while participants performed the triad task. Participants responded verbally and their answers were recorded by the experimenter. After the participants stated their answer on each trial, the next trial was initiated by the experimenter. The timings and procedural run through of the triad program remained the same as in Experiment 2.

4.8 Results

4.8.1 Choice Analysis

The mean percentage of action choices in the triads can be seen below in Table 4.3. The results show a similar pattern to the previous experimental work, as the means appear lowest overall in the DCO triads with little difference between the SCO and the PCO triads. However, there appears to be little difference between the means of the physical tasks. The mean percentage of action choices were compared with a 3x3 mixed ANOVA using triad type as a within-subjects variable and physical task as a between-subjects variable. The results showed a significant main effect of triad type, F (2, 122) = 11.47, $p < .001$, $\eta^2 = .16$. Post hoc analysis using the Bonferroni adjustment showed that action choices were lower in the DCO triads compared to the SCO ($p < .001$) and the PCO triads ($p = .002$), but no difference was found between the latter ($p = 1.$). The main effect of physical task was not significant, $F < 1$, nor was the interaction effect between physical task and triad type, $F < 1$.

Table 4.3.

The Mean Proportion of Action Choices Across Triads and Physical Task.

Physical Task	N	Triad Type		
		DCO	SCO	PCO
Still	22	.52 (.21)	.64 (.13)	.65 (.15)
Hand	21	.58 (.17)	.70 (.13)	.63 (.13)
Foot	21	.53 (.18)	.62 (.12)	.65 (.18)

The data above shows that performing concurrent actions while undergoing the triad task had no effect on the action scores compared to performing no action. In addition, no difference was seen between participants who performed a task with their hand or their feet. However, the triad data shows the same pattern found with the previous experimental work (see Chapters 2 - 4) that participants were less likely to use action for categorisation when it appears on its own, but it did appear to have an additive effect.

The analysis on the choice data was repeated as a 3x3x2 mixed ANOVA which also included gender as a between-subjects factor. The results showed that the main effects and interaction effects were the same as previously found above. In addition, the main effect of gender was non-significant, $F < 1$, as was the interaction effect between condition and gender, $F < 1$. However, the interaction effect between triad type and gender was significant, $F(2, 116) = 3.30$, $p = .040$, $\eta^2 = .05$. Follow up analysis using the Bonferroni adjustment showed that there were no differences between the three triad types for the males (for all comparison, $p < .05$). Significant differences were found on the females where the DCO triads were significantly lower than both the SCO ($p < .001$) and the PCO triads ($p = .001$), but no difference was found between the latter ($p = .32$). While selection of the action choice was fairly high and greater than 50% in all conditions, this result might indicate that the 'additive' effect exists only for females. However, this result has not been replicated in the remaining experimental work. In addition, there was no effect of age on the selection of action choices.

4.9 Discussion

The results above replicate the standard triad effects found in Experiment 2. Participants were less likely to select the action choice on the DCO triads in comparison to both the SCO and PCO triads. This supports the position that action is less likely to be used as a basis for categorisation on its own, in comparison to sharing both an action and a taxonomic choice with the target. This supports the additive effect seen in the previous experiments for objects that already share a taxonomic relation. Under such circumstances, the notion that the objects share a taxonomic relation is made stronger by the shared action (and presumably perceptual characteristics) between them. Furthermore, when taxonomic relations are removed from the stimuli, participants prefer to group objects together based on shared actions between them rather than shared perceptual characteristics.

Of most interest here was the prediction that performing concurrent hand actions would decrease (or possibly increase) selection of the action choice on the triads. It was argued that the simulations generated by participants could be interfered with if participants performed concurrent hand actions (but not concurrent feet actions). The results did not support this prediction. No differences were found between the participants who performed current actions throughout the triad task. In addition, the results also showed that attentional resources were not decreased during the task because the hand and foot conditions did not significantly differ from the still condition.

The important question that now must be addressed is why no differences were found between the physical task conditions. There are two possible explanations: (i) either participants are not simulating when they undergo the triad task or (ii) participants are simulating but the physical tasks failed to have any effect on such simulations. The best way to test between the two could be to test participants on the standard triad task (used in Experiment 2) using fMRI techniques[38]. If it were the case that participants are simulating on the triad task, then a similar pattern of brain activation would be found compared to the results of Kan et al. (2003) and Simmons et al. (2008). This would then demonstrate that participants are in fact simulating while performing the triad task, and the lack of an effect found in Experiment 7 could potentially be because the tasks simply failed to interfere with the simulation process. This is, unfortunately, beyond the scope of the current experimental work.

However, there is much evidence to suggest that the first explanation is implausible and the stance taken here is that participants are simulating upon thinking about the objects in the triad task. Given the previous research on findings that participants simulate upon viewing words (Barsalou, Solomon & Wu, 1999; Borghi, 2004; Santos et al., 2008; Simmons et al., 2008; Solomon & Barsalou, 2004; Wu & Barsalou, 2009), use situational strategies in generating category exemplars (Vallée-Tourangeau, Anthony & Austin, 1997) and can access word meaning in less

[38] It would not be possible to replicate Experiment 7 while undergoing fMRI scans because participants would not be able to remain still during testing.

than 200ms (Pulvermüller, Shtyrov & Ilmoniemi, 2005), it is most likely the case that participants are simulating the objects shown on the triads. Simmons et al. also argued that research in this field has “suffered an over-reliance on words” (2008, p. 117) and that visual cues such as that used in the triads would increase the likelihood and speed with which participants simulate. In such a view, the situating system might become active faster that the linguistic system when using experiential stimuli because the simulation would be more similar in nature to the information presented by the cue. Therefore, given the previous research in the area it is believed that participants do in fact simulate in this task, aided by both word and pictorial nature of the stimuli.

Given the argument made above, the second explanation must be adopted here that participants were in fact simulating but the tasks used failed to interrupt the simulation. This seems surprising at face value given the previous research showing that current actions can slow down and “block” access to semantic information (Yee et al., 2013). It is possible that the reason for the difference found between Yee et al. and the current data lies in the time frame of the experimental task. Verification and identification tasks emphasise speed and accuracy from participants whereas participants in the current experimental work are explicitly told that speed is not important for task performance. In the task of Yee at al., participants responded very quickly to the abstract/concrete judgement task with mean response times around one second. From the point of view of the LASS theory, and according to the time line of responses found in Santos et al. (2011), only the linguistic system will have reached its peak at this point. Therefore, on such a task participants are not using the simulation system to respond, but using the linguistic system and bypassing conceptual information. The time frame of such differs considerably in comparison to what happens here on the present task. Responses on the triads varied across triad type but response times were generally between 2 and 3 seconds (responses are longer on the PCO triads, see Chapter 2). However, response times on the triad program are calculated not from initial onset of the triad but from the moment that all three items appear together. The target appears on its own initially for 1.5 seconds prior to onset of the choice items and therefore the target is actually seen for between 3.5 and 4.5 seconds. At this point, according to the LASS theory and the time line of Santos et al., the simulation system should have peaked and been at full saturation (for all of the objects, but particularly the target). Therefore, the suggestion here is that concurrent manual actions do interrupt the simulations created by participants in conceptual tasks, but that such interference only occurs while the linguistic system is in use and the simulation system has not peaked. Therefore, while concurrent actions influence the early stages of the LASS theory, their effects might become diminished by the time that the simulation system is in full effect. A potential way in which to test this would be to redesign the triads so that all the items appear at the same time and the choice items are analysed by time. The simulation system should be interfered with by manual actions only when the triads have short reaction times. Reaction times were not collected due to the design of the current experiment where participants had to respond verbally and the choices were recorded by the experimenter. As such the above prediction cannot be tested because the reaction times do not reflect accuracy.

In conclusion, the aim of the experimental work here was to see if action scores on the triad program could be decreased by 'blocking' the simulation process through concurrent manual actions. The results showed that participants performing concurrent actions with either their feet or hands had no effect on their choices in the triad task. In comparison to previous research, which has shown manual actions to interfere with category decisions, this could be due to task differences and the time frame in which participants respond on the task.

4.10 General Discussion

The experimental evidence reported in previous chapters measured the circumstances in which action becomes influential source of categorisation, on an action-irrelevant task. The notion of the action-irrelevant task is particularly important given that much of the previous evidence has shown the influence of action to be task dependent. The aim of Experiments 6 and 7 was to measure the influence of action information on the triad task, after additional action tasks were added to the action-irrelevant task either preceding it or concurrent with it. The results have showed that interacting with objects prior to categorising them influenced how the objects were categorised. When participants interacted with the objects in a functional manner, they were then more likely to select the action choice on the triad task. When participants interacted with the objects in a more general manner, while they did select the action choice on the triad task, they were less likely to do so compared to those who had used the objects functionally.

The results are discussed in light of simulation theory, that the recency of the interaction influenced the simulation during the triad task. In order to test if this was the case, Experiment 7 attempted to see if the simulations could be ‘blocked’ by concurrent actions. The results showed that performing concurrent actions (either with hands or feet) did not have an effect on the triad scores. It is possible that the concurrent actions are only influential in the early stages of simulation, before the simulation system is at its peak strength. What the results clearly show, is that manual actions do influence subsequent category judgements. However, what is most important is that such actions are specifically related to the functional use of the objects rather than such ‘generic’ actions.

In Chapter 5, the triads were individually analysed in more detail. What is evident from the data in the previous experiments is that some triads were more likely to lead to selection of the action choice than others. The triads were analysed to investigate which examples were more likely to lead to the action choice, and some of the potential reasons behind why this might have been the case. In addition, the reasons behind why the participants select the choices in the triads may vary between participants. The strategies that participants used while engaging in the triad task was analysed using protocol analysis.

Chapter 5

Why *Water Pistol* Over *Sword*? An Analysis into Selection Strategy and the Individual Choices Made on the Triad Task.

The previous chapters have demonstrated that action knowledge can influence categorical decisions, but under specific circumstances. While action did have an influence across all the triads, the strongest effect was seen when objects are matched on action and taxonomic information, and when the objects are presented in a functional context. However, this effect was not consistent and for some triads action was used as a sole reason for categorising the objects, even presented out of context. In addition, some triads seem quite 'strong' in the sense that they are highly likely to lead to selection of the action choice, while others appear 'weak'.

The aim of Chapter 5 was to analyse the triad items individually. Of particular interest was the strategies used by participants in categorising the triads, and to examine the optimal conditions for encouraging an 'action-based' strategy. This was completed in two steps. First, the data from the previous studies was re-analysed with the focus on the individual triads, and the percentage of action selection seen across the experiments. Second, Experiment 8 used protocol analysis to examine participants strategies used in the triad task. Analysis of the protocols showed that, for the majority of the triads, participants reported use of functional, perceptual and action-based strategies to select their choices. However, there was variation between the triads and participants seemed to draw upon a variety of strategies for task completion. The results demonstrate the "rich" and "fluid" nature of categorisation, and the usefulness of protocols in such research.

5. Analysing the Triad Task: Why are Some Triads More Likely to Lead to Action-Based Choices?

5.1 Introduction

The results reported thus far have shown that participants were more likely to select the action choice on the triads when they were (i) presented in context, and (ii) shared both an action and a taxonomic relation. For example, in Experiment 2 participants were more likely to select *banana* with *orange* on the SCO triads than they were to select *water pistol* with *rifle* on the DCO triads. However, in studies drawing on stimuli of the type used in this programme of work, responses may always be open to varying degrees of influence from the actual items chosen for inclusion in the studies. As intimated in Chapter 4, the necessary omission of certain triads from Experiment 6 may well have led to the previously unseen differences in performance on the SCO and DCO triads with and without context. Wisniewski and Bassok (1999) showed higher similarity ratings for item pairs sharing both taxonomic attributes and a theme compared to those pairs a sharing attributes only. However, only half of the item pairs had higher ratings than their counterparts in the attribute only condition so the effect of enhancement through a shared theme was not reliable for all items.

The purpose of the work reported in the current chapter was to perform an item analysis on each of the triads. This is not only in the interests of framing claims of generalisability, but with a view to investigate whether there was a pattern that would allow inferences to be drawn about why certain item combinations encourage action choices in this task. This would help further understand the precise conditions under which action may influence choices in this action-irrelevant task. This was undertaken in two steps:

(i). Reanalysing the data from the previous experiments: Selection of the choice items on each triad and the proportion of choices was analysed against chance levels using a binomial distribution. The context images were also analysed based on what the context image consisted of. Some items showed only the hand on the object while others showed more of the agent. These were compared to see if this had any bearing on the choices made.

(ii). Protocol analysis: Given that the reasons for selecting the choice items is inferred, based on the design of the triads, protocol analysis was used to assess the reasons participants gave for selecting each item. For example, participants might be selecting *banana* over *strawberry* based on the notion of peeling (as assumed here), but may in fact be selecting *banana* simply because they prefer them. Therefore, participants were asked to make their choices and then give their reasons for doing so to assess if they did seem to have based their choices on action.

5.2 Data Re-analysed

The purpose of the next section was to re-analyse the data from Experiments 2 and 4[39,40] in order to investigate which of the triads were "best" in terms of maximising the chances of participants selecting the action choice. This was achieved by examining each of the triads individually, and looking at the proportion of action and non-action choices. In particular, it was important to look at when choices for the action and competition item did not differ from chance and merely represented a 50/50 choice. In addition, to further investigate which of the triads best encouraged selection of the action choice the context effects were examined to see which of the triads had a significant increase in selection of the action choice as a result of the context-rich condition. As such, the analysis was completed in two stages. First, the choice proportions on the triads were analysed using a non-parametric Binomial test to see if the proportions significantly differed from a 50/50 ratio, as would be predicted if the choices were merely selected by chance. Second, the context effects on each of the triad types was analysed to investigate which triads were most affected by context using a Multivariate Analysis of Variance (MANOVA).

[39] The priming experiment of Chapter 4 was not included here because it did not employ the full set of triads as used in Experiments 2 and 4.
[40] The data from the "most similar" instructions was not used here given that this reflects a different task. The data from the "goes best" and the "goes best to form a category" instructions was pooled together since no quantitative differences were found between them.

5.2.1 Choice Proportions

As stated above, the proportions of the choices selected were analysed for all thirty triads using a Binomial test. The proportions can be seen below in Tables 5.1, 5.2 and 5.3, separated by triad type. Of main interest here was to examine which proportions did not significantly differ from a chance proportion. Cause for concerns might occur in two ways; (i) items that are not significantly different in only one of the previous experiments, and (ii) items that are not significantly different in either of the previous experiments.

Given that there are individual differences in tasks such as those used here (Lin & Murphy, 2001; Mirman & Graziano, 2012; Simmons & Estes, 2008; Estes et al., 2011), those items which only differed in a single experiment were less cause for concern and allowed to continue in further testing/analysis. Items for which choices did not differ from chance in either experiment (or led more consistently to the non-action choice) were removed from the subsequent analysis. These were six DCO (*deodorant, book, computer, drink bottle, rifle, screwdriver*), four SCO (*DVD player, leaflet, glass, pin*), and five PCO triads (*axe, gun, nut, peppermill, present*). These triads were removed from the overall means for each experiment and the analysis of the choice data was repeated in the same manner as previously conducted. The analysis revealed that the means on the triads from Experiment 2 (see Fig 5.1) was similar to that conducted previously where the main effect of triad type, F (2, 96) = 3.07, $p = .051$, $\eta^2 = .06$, was borderline significant and the main effect of context, F (1, 48) = 18.68, $p < .001$, $\eta^2 = .28$, was once again significant. The interaction effect was also significant, F (2, 96) = 3.23, $p = .044$, $\eta^2 = .06$, where previously it had not been. Post-hoc analysis using the Bonferroni adjustment showed that context significantly increased action choices on the DCO ($p = .004$) and the PCO triads ($p = .004$), but not for the SCO triads ($p = .87$).

The analysis on the triads from Experiment 4 (see Fig 5.2) was similar to the analysis previously conducted in Chapter 2 in that the main effect of triad type was borderline significant, F (2, 116) = 2.92, $p = .058$, $\eta^2 = .05$, and the main effect of context, F (1, 58) = 5.40, $p = .024$, $\eta^2 = .09$, was once again significant. The interaction effect was also significant, F (2, 116) = 4.37, $p = .015$, $\eta^2 = .07$, where previously it had not been. Post hoc analysis using the Bonferroni adjustment showed that the context significantly increased action choices only for the PCO triads ($p <$

.001) and not the SCO (p = .68) or DCO triads (p = .78). Consistent across both experiments was the finding that once those triads which did not differ from chance or encouraged selection of the non-action choice were removed, the proportions of action choices increased in comparison to the original means. In fact, removal of such triads led to very high selections of the action choices ranging between 60% and 90%. Therefore, in those remaining triads the shared actions were particularly salient and seemed to exert more influence on the choices made.

It is noted however, that there are variations in performance across items within each triad set. Certain triads seemed to lead more consistently to participants selecting one choice over the other. For example, in Experiment 2 the overall proportion of participants selecting *banana* with *orange* was .70 and *paintbrush* with *pencil* was .90 (see Table 5.1). In contrast the proportion of *CD player* with DVD *player* was only .52. Therefore, there are variations in the proportions of the action choices selected within each triad, and within each triad set. In addition, there are variations in the triads as to the effect of context. In some of the triads, context had a significant effect in increasing the action choice selected but this effect was not consistent across all of them. For example, the proportion selecting *water pistol* significantly increased from the context-lean to context-rich condition, however, the proportion selecting *banana* did not. Therefore, the context effect was also not consistent across all of the items. This may be the result of inconsistencies in the context pictures used in developing stimuli that reflected everyday scenarios (see Chapter 3 for more details).

Overall, the current analysis shows that a small number of the items did not engender an overall preference for one choice item over the other and that selection of such choices did not differ from chance. After the removal of these items, and those that led to higher proportions of selecting the non-action choice, the same results were found whereby action choices were always highest when shown in the functional, context-rich, condition and were lowest on the triads in the DCO compared to the SCO and PCO conditions. However, despite being the lowest overall, action choices were still high across all three triad types.

Table 5.1

Proportion of Choice Items Selected on the DCO Triads in Experiments 2 and 4.

Target	Experiment 2			Experiment 4		
Item	Tax	Action	*p*	Tax	Action	*P*
Book	.76	.24	<.001	.43	.57	.366
Calculator	.30	.70	.007	.17	.83	<.001
Computer	.90	.10	<.001	.73	.27	<.001
Deodorant	.60	.40	.203	.43	.57	.366
Drink bottle	.82	.18	<.001	.70	.30	.003
Fax machine	.22	.78	<.001	.37	.63	.052
Knife	.18	.82	<.001	.10	.90	<.001
Paperclip	.46	.54	.672	.30	.70	.003
Rifle	.58	.42	.322	.65	.35	.027
Screwdriver	.86	.14	<.001	.53	.47	.699

Table 5.2

Proportion of Choice Items Selected on the SCO Triads in Experiments 2 and 4.

Target	Experiment 2			Experiment 4		
Item	Tax	Action	*p*	Tax	Action	*p*
Bed	.22	.78	<.001	.10	.90	<.001
DVD Player	.48	.52	.888	.42	.58	.245
Glass	.60	.40	.203	.63	.37	.052
Leaflet	.52	.48	.888	.45	.55	.519
Ketchup	.24	.76	<.001	.25	.75	<.001
Orange	.30	.70	.007	.17	.83	<.001
Pencil	.10	.90	<.001	.07	.93	<.001
Pin	.72	.28	.003	.75	.25	<.001
Spade	.04	.96	<.001	.03	.97	<.001
Spatula	.24	.76	<.001	.37	.63	.052

Table 5.3

Proportion of Choice Items Selected on the PCO Triads in Experiments 2 and 4.

Target Item	Experiment 2			Experiment 4		
	Perc.	Action	*p*	Perc.	Action	*P*
Axe	.52	.48	.888	.48	.52	.897
Baseball Bat	.10	.90	<.001	.18	.82	<.001
Clarinet	.30	.70	.007	.45	.55	.519
Cocktail shaker	.36	.64	.065	.18	.82	<.001
Gun	.56	.44	.480	.52	.48	.897
Handbag	.18	.82	<.001	.25	.75	<.001
Nut	.48	.52	.888	.55	.45	.519
Peppermill	.72	.28	.003	.78	.22	<.001
Present	.78	.22	<.001	.72	.28	.001
USB stick	.10	.90	<.001	.10	.90	<.001

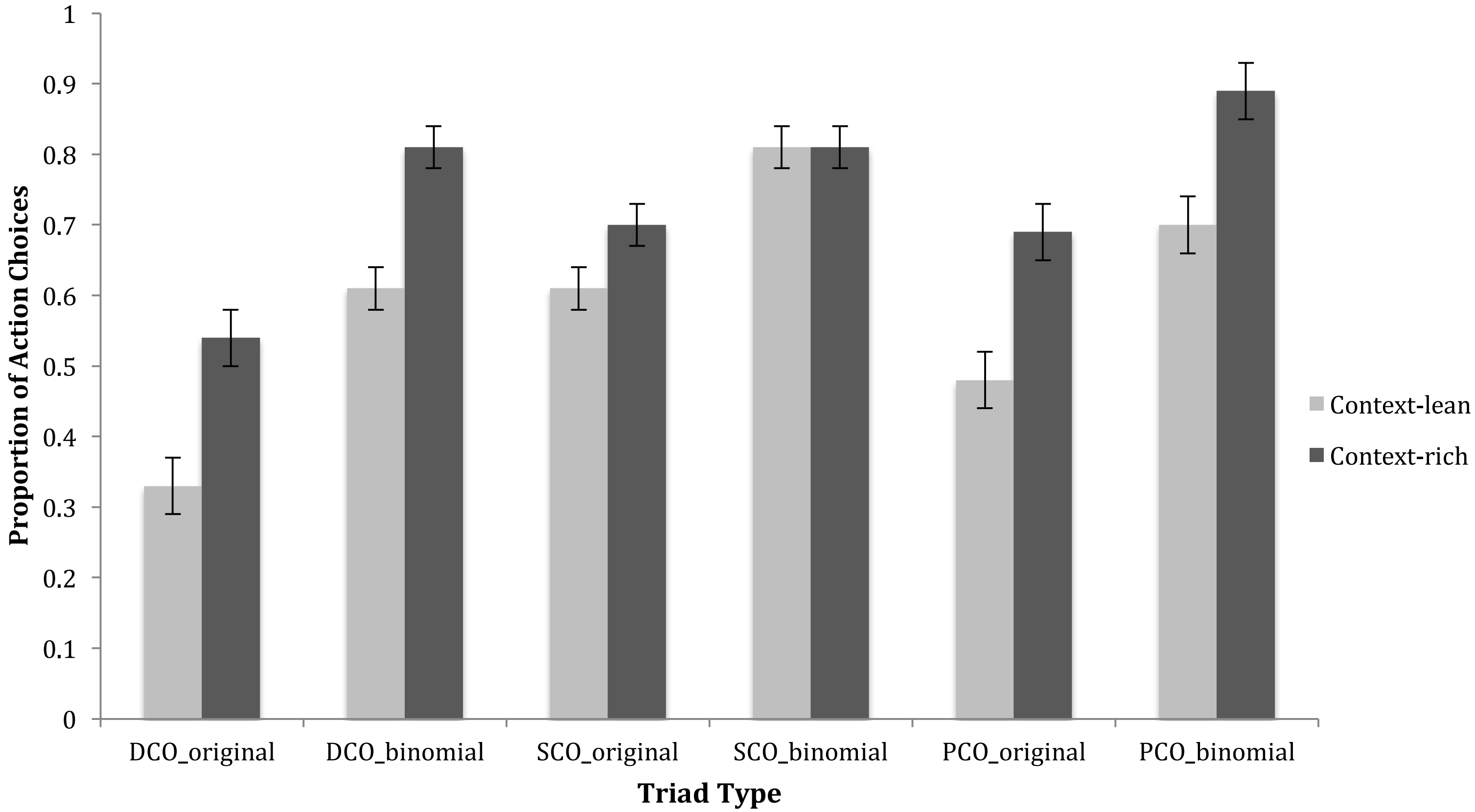

Figure 5.1. Mean percentage of action choices between the original Experiment 2 data and the current analysis with removal of those items where selection of the action item did not differ from chance. Error bars represent the standard error of the mean.

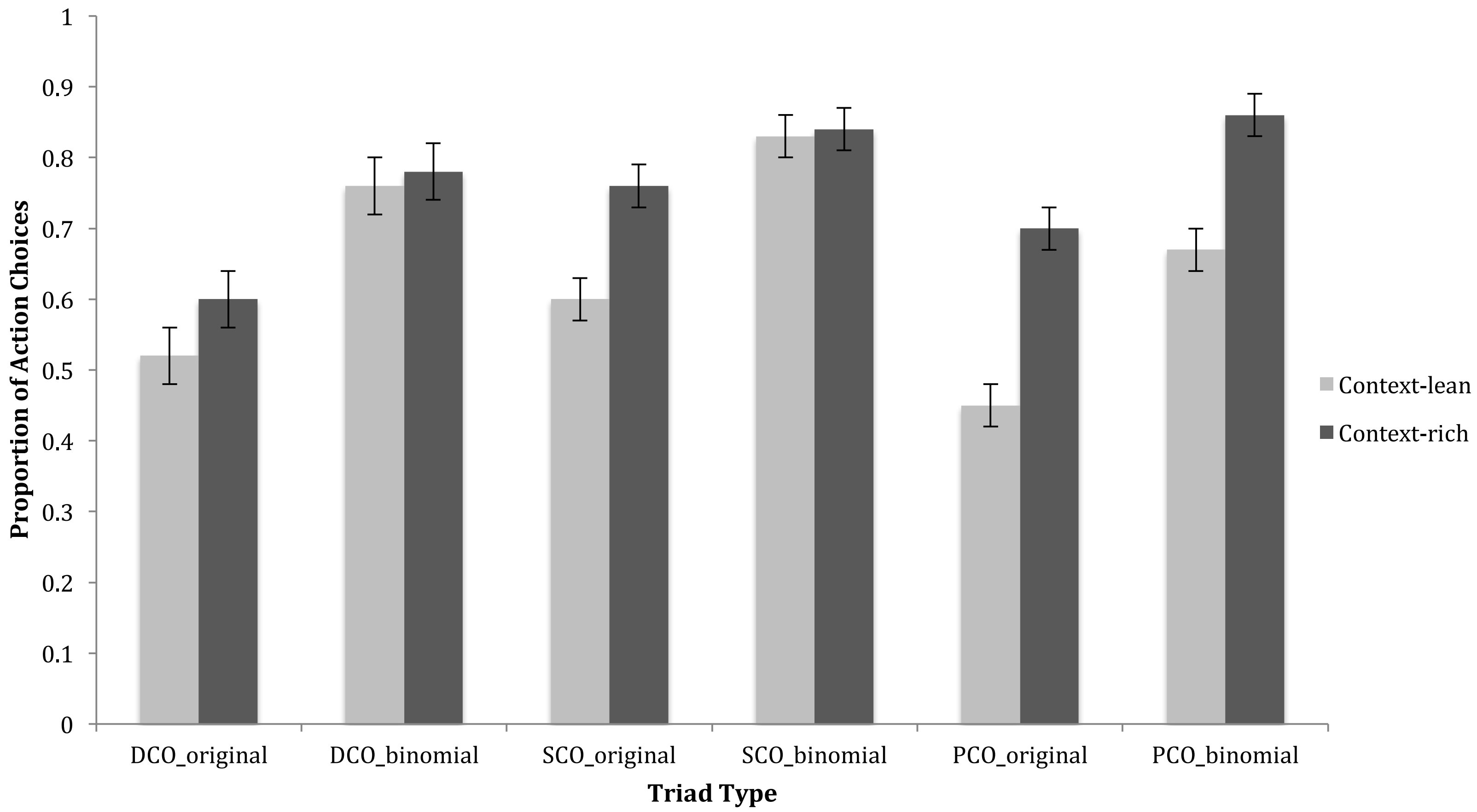

Figure 5.2. Mean percentage of action choices between the original Experiment 4 data and the current analysis with removal of those items where selection of the action item did not differ from chance. Error bars represent the standard error of the mean.

5.2.2 Context Analysis

Performance on the triads in Experiments 2 and 4 was analysed to see on which trials was selection of the action choice significantly higher when presented in context. The analysis was completed by blocking the triads together for each experiment and completing separate 2x10 MANOVA's using context as a between-subjects factor and analysing performance on the ten triads in each set[41]. Comparisons of the contexts can be seen below in Tables 5.4, 5.5 and 5.6. The results show that not all of the triads are enhanced by the context-rich condition. Of interest were those triads that did not increase the action choices in either experiment. Context had no significant influence in either Experiment 2 or 4 on twelve triads. The remaining 18 triads showed a significant increase in action choice in one, or both, of the previous experiments. This included five DCO (*calculator, computer, deodorant, rifle, screwdriver*), six SCO (*DVD player, glass, leaflet, ketchup, orange, pin*) and seven PCO triads (*axe, clarinet, gun, handbag, nut, present, USB*) showing significant increases in action scores between the contexts.

[41] The DCO triads in Experiment 4 were analysed using separate independent samples t-tests as the overall context effect on the MANOVA was not significant, F (10, 49) = 1.04, p = .43.

Table 5.4

Proportion of Action Choices Selected on the DCO Triads Between Context in Experiments 2 and 4.

	Experiment 2			Experiment 4		
Item	Lean	Rich	*p*	Lean	Rich	*p*
Book	.28	.20	.518	.60	.53	.610
Calculator	.52	.88	.005	.87	.80	.497
Computer	.00	.20	.018	.13	.40	.019
Deodorant	.20	.60	.003	.47	.67	.122
Drink bottle	.12	.24	.279	.23	.37	.267
Fax machine	.76	.80	.739	.57	.70	.292
Knife	.72	.92	.068	.93	.87	.298
Paperclip	.44	.64	.162	.67	.73	.581
Rifle	.24	.60	.009	.30	.40	.425
Screwdriver	.00	.28	.004	.43	.50	.612

Table 5.5

Proportion of Action Choices Selected on the SCO Triads Between Context in Experiments 2 And 4.

	Experiment 2			Experiment 4		
Item	Lean	Rich	*p*	Lean	Rich	*P*
Bed	.72	.82	.316	.87	.93	.398
DVD Player	.24	.80	<.001	.33	.83	<.001
Glass	.32	.28	.257	.17	.58	.001
Leaflet	.52	.44	.580	.40	.70	.019
Ketchup	.88	.64	.048	.77	.73	.770
Orange	.60	.80	.128	.73	.93	.038
Pencil	.88	.92	.646	.93	.93	1.00
Pin	.20	.36	.216	.10	.40	.007
Spade	1.00	.92	.155	1.00	.93	.155
Spatula	.76	.76	1.00	.67	.60	.599

Table 5.6

Proportion of Action Choices Selected on the PCO Triads Between Context in Experiments 2 And 4.

	Experiment 2			Experiment 4		
Item	Lean	Rich	*P*	Lean	Rich	*P*
Axe	.28	.68	.004	.33	.70	.004
Baseball Bat	.84	.96	.164	.80	.83	.744
Clarinet	.48	.92	<.001	.23	.87	<.001
Cocktail shaker	.68	,60	.565	.87	.77	.325
Gun	.28	.60	.022	.33	.63	.020
Handbag	.68	.96	.009	.63	.87	.037
Nut	.48	.56	.580	.30	.60	.019
Peppermill	.20	.36	.216	.13	.30	.121
Present	.16	.28	.316	.07	.50	<.001
USB stick	.80	1.00	.018	.83	.97	.088

Of main interest at this point, was to investigate the reasons why context increased the action scores across only certain triads. The most obvious explanation lay in the images used which were categorised dependent on whether action scores were significantly increased by context. Across certain examples of the triads used the hands appear clear on the action-related objects in a similar manner to the target. However, obvious differences can be seen in how the agent is presented. For example, some of the triads showed only hands on the objects whereas some of the triads show more of the agent. In order to assess if this influenced whether or not the action choice was chosen the whole set of triads (DCO x 10, SCO x 10, PCO x 10) were coded as to whether or not an agent was clearly visible in the images used (i.e. the person's body and face could be seen), or if just hands were seen. This led to eight levels created as to whether a not an agent was present in:

- None of the items (*handbag, pin, peppermill, nut, calculator, spatula, paperclip, spade*)

- Target only (*book, ketchup*)
- Action item only (*cocktail shaker, pencil, knife*)
- Taxonomic item only (*gun, USB, computer, present, DVD player*)
- Target and action item (*clarinet, baseball bat, glass*)
- Target and taxonomic item (*screwdriver*)
- Taxonomic and action item (*orange, drink bottle, fax machine*)
- All three (*axe, deodorant, bed, rifle, leaflet*)

It could be expected that selection of the action choice would be highest when the target and action choice are most similar in their visual appearance. The means for the levels can be seen below in Figure 5.3. The figure shows that selection of the action choice was highest for the triads in which an agent's body and face were visible in the action choice only, and visible in the target and action choice. The highest peaks in the mean selection of the action choice are on the triads where an agent was seen in the action choice only, the target and the action choice, and when the agent was seen in all three images. This would indicate that participants would be more likely to select the action choice if the image used shows a full agent using the object rather than just the hands on the object. The exception to this is the triads where no agents were seen, and all three images showed only hands on the object. Such triads led to a high percentage of the action choices being selected in both contexts. This might suggest that any simulations (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006) generated when the participants view the images are more likely to centre on the shared actions when an agent is visible. This would support the dynamic nature of the simulations that they include not only the object themselves, but are based within, and centred around, interaction with objects in a functional manner.

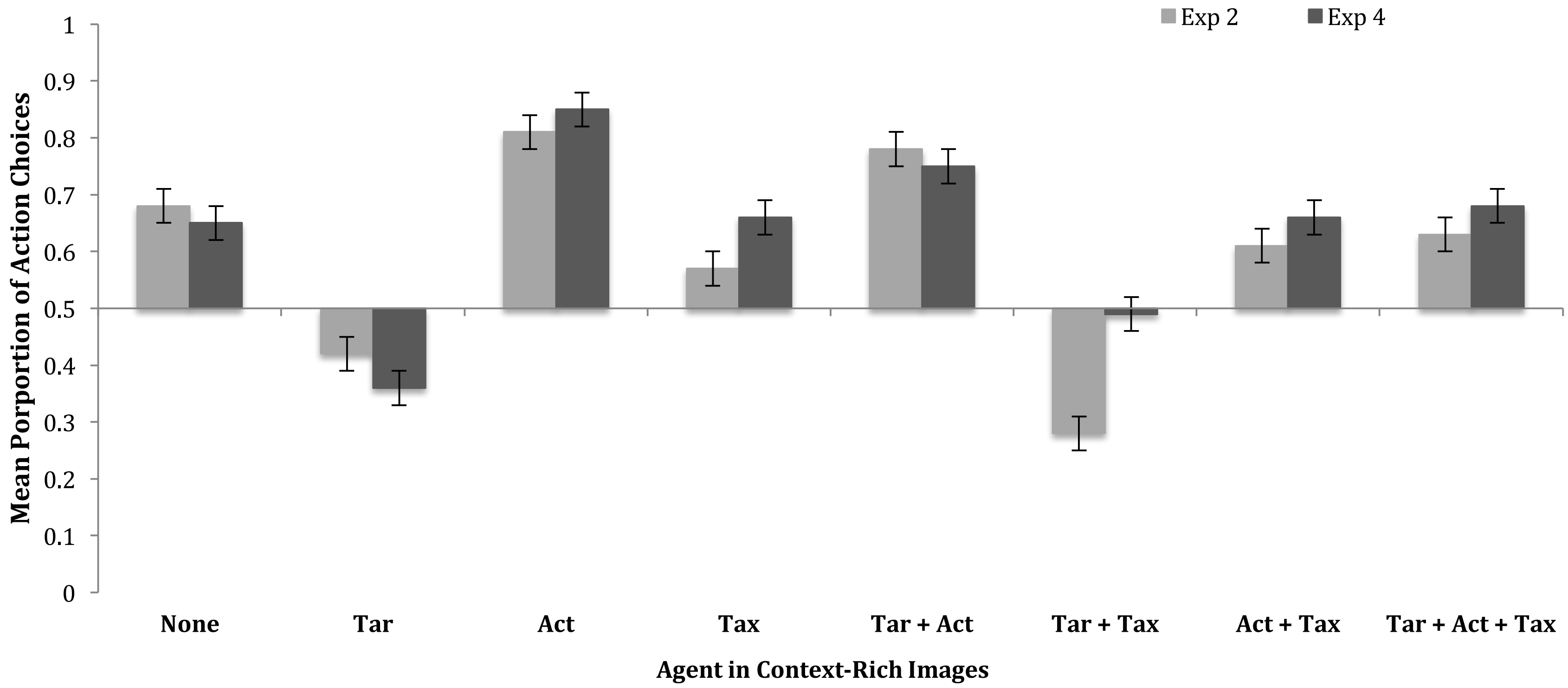

Figure 5.3. Mean percentage of action choices in Experiments 2 and 4 based on the presence of a full agent in the triads in either none of the objects (None), the target object only (Tar), the action choice only (Act), the taxonomic choice only (Tax), the target and the action choice (Tar + Act), the target and the taxonomic choice (Tar + Tax), both the choice objects (Act + Tax) or all three objects (Tar + Act + Tax). Above the .5 line indicates an action preference, below the .5 line indicates a taxonomic preference. Error bars represent the standard error of the mean.

5.3 Experiment 8

Using Protocol Analysis to Assess Strategies for Making Forced-Choice Categories

5.4 Introduction

Up to this point, the results of the experimental work have shown two main findings from the use of the triads designed here. First, action scores tend to be highest in the SCO triads where the target item and the action choice share a taxonomic/category membership with each other. For example, participants are more likely to group *orange* with *banana* over *strawberry* because they are both fruit but also share an action with one another. Selection of the action item is lowest in the DCO triads where action is pitted against taxonomic information. For example, participants are more likely to group *rifle* with *sword* because of the shared taxonomic relation rather than with *water pistol* because of the shared actions between them. In such circumstances, action is less frequently used to base category membership on its own, but does appear to have an additive effect when it is already matched with a taxonomic relation. However, it is has been shown that this is not consistently the case. While overall selection of the action choice in the DCO triads was lowest, for some cases the action choice was selected over category membership. For example, in the *knife* triad the action choice (*saw*) was consistently chosen over the taxonomic choice (*ladle*) in both Experiments 2 and 4. The second main finding here is the context effect. Showing the objects being used by an agent in a functional scene significantly increased the likelihood that participants would select the action choice in the triads. This effect has been shown across all of the triad types.

The purpose of the Experiment 8 was to further investigate the reasons why participants select the choices they made on the triad task. One of the main criticisms behind using the triad task is the inferred nature of the results based on the design format. For example, Lin and Murphy (2001) designed 38 triads based on sharing either a taxonomic or a thematic response. The results are therefore inferred based on which selection they make. For example, participants who selected *spider web* to go with *spider* are inferred to have done so because of the shared thematic relation between them. However, participants may have selected the thematic choice because of the shared linguistic property as both contain the word 'spider'. In a similar manner, the reasons behind the responses made on the triads used in this thesis are inferred based on the design manipulation of the triads. For example, participants who selected *banana* with *orange* are inferred to have done so based on the shared action between them. However, this may not be the case and there may be more 'richness' to the categorisation strategy used here.

The conceptual system contains a wide variety of information regarding objects which is not just limited to functional, perceptual and action information, and can be drawn upon to make categorical decisions. It is therefore possible that participants in the previous experiments might be selecting *banana* because of other reasons outside of action and taxonomic relations, such as personal preference or autobiographical reasons. Equally, participants might have selected *strawberry* with *orange* because of the biological basis of the two in that both have seeds. As such, it is difficult to establish the reasons why participants made their choices when only drawing inferences based on the design of the triads. Therefore, Experiment 8 aimed to further establish in which cases the participants were actually responding based on shared actions between the items. In order to do this Experiment 8, ran the triad task along with collecting written protocols from the participants asking them to explain their reasons for making their choices in the task.

The use of protocols as introspective data has been used in topics such as categorisation (Smith & Sloman, 1994; Vallée-Tourangeau et al., 1998) and problem solving (Fleck & Weisberg, 2004; Gilhooly, Fioratou, Anthony & Wynn, 2007; Newell & Simon, 1972; Russo, Johnson & Stephens, 1989). A long-standing debate exists in the literature on the use of protocols as data and whether or not participants can report accurately on higher-order cognitive processes. Nisbett and Wilson (1977) reported an experiment where word associations given by participants were directly influenced by previously seen word pairs. However, when participants were asked to report how they came to their answers they, generally, did not report the word pairs as influencing their choice. Nisbett and Wilson take this, along with other experimental work, as evidence that participants cannot introspect on higher-order processes. In their view, participants cannot introspect, but rather create a priori theories based on links between the stimulus and response. Therefore, protocols are *nonveridical* because they do not accurately reflect the cognitive process under investigation. When the protocols happen to match task performance it is purely incidental.

Smith and Miller (1978) have counter-argued that Nisbett and Wilson's criterion for judging accurate introspection in their data was too strict. In Smith and Miller's view, participants cannot be expected to introspect accurately because to do so would require the participant to understand the design manipulation of the experiment and the variables manipulated, particularly in a between-subjects design such as that used by Nisbett and Wilson. Only in such a manner where the participant knows the manipulation design can they accurately report their own mental processes. They further go on to cite research using within-subject designs that does appear to show experimental conditions under which self-reported protocols appear to be accurate (Berl, Lewis & Morrison, 1976; Newell & Simon, 1972). Smith and Miller further state that research should not focus on whether or not participants can introspect, but on the conditions which lead introspection to be accurate. However, despite the counterarguments of Smith and Miller, the debate does raise an important question as to whether or not participants have access to their higher order cognition. While recognising the limitations of this methodology for the reasons described above, protocols have been used previously with a good level of confidence (Ericsson & Simon, 1980; Gilhooly et al., 2007; Newell & Simon, 1972; Smith & Sloman, 1994; Vallée-Tourangeau et al., 1998). The aim of Experiment 8 was to collect written protocols on each of the triads to ascertain the reasons why participants were selecting each of the choices. The triads were analysed individually to see which of the items are 'good', in the sense that participants report having selected the action item because of the shared action. It also aimed to find those triads where participants selected the action choice, but seemed to have used alternative strategies for doing so.

5.5 Method

5.5.1 Participants

A total of 253 undergraduate Psychology students (209 females) from the University of Hertfordshire took part in the experiment as part of their Research Methods module with a mean age of 20.04 (*SD* = 4.03, age range: 17-54). The sample size was calculated following an a priori power analysis using G*Power.

Assuming α =.05 and 1 – β =.80, the a priori power analysis indicated that a similar effect size to that found in Experiment 1 would be detected using a sample of 52 participants.

5.5.2 Design

The experiment consisted of a forced-choice triad task using the same 30 triads as employed in Experiment 2 across the context-lean and context-rich conditions. To ensure a high quality of the responses, the triads were divided into two sets in a random order. The participants were divided into two groups and each saw only 15 (5 x SCO, 5 x DCO, 5 x PCO) of the 30 triads. It was believed that due to the length of the experiment if participants saw all 30, then the quality of their responses would deteriorate towards the end. The number of triads was consequently halved and participants only saw 15 (of 30) triads. Participants were then allocated to one of the triad sets (A or B), and to one of the contexts (lean or rich: see Table 5.7). Therefore, the experiment employed a 3x2x2 mixed design using triad type as a within-subjects factor, and triad set and context as between-subjects. As with the previous experiments the number of action choices on each triad type was recorded to give an action score for each. In addition to this, each participant gave a written protocol after each trial in response to the heading "reasons for making this choice…what sort of things were you considering?" This phrasing was used so that participants saw this more as reporting their thoughts rather than explaining their decision (Russo et al., 1989).

An important question in the design of this experiment, was when participants would generate the protocols. Research generally uses one of two methods: concurrent ('think aloud') or retrospective verbalisation. Both methods have advantages and disadvantages but have varied in their use depending on the nature of the research. *Reactivity* is one of the main concerns with participants generating protocols, that the act of generating a protocol invariably changes the cognitive process under investigation. This is particularly a problem when using 'think aloud' or concurrent verbalisation methods. For example, Schooler, Ohlsson and Brooks (1993) found that generating concurrent verbal protocols had an interfering effect on insight problem solving. They suggest that this is because participants tend to verbalise those processes which are easier to explain, but do not help in the solution of the problem. In contrast to concurrent verbalisation, reactivity does not become an issue when participants generate protocols retrospectively. Therefore, the decision was taken that participants would generate their protocols retrospectively so that verbalising would not interfere with the decision. This in turn would reflect a similar performance to that of the previous experiments, where participants would make their decisions without any potential external influence.

Table 5.7

The Number of Participants in Experiment 8 Across Context and Triad Set.

Context	Triad Set		
	A	B	Total
Lean	72	67	139
Rich	37	77	114
Total	109	144	253

5.5.3 Materials

The SCO, DCO and PCO triads from Experiment 2 were used here with the triads being randomly divided into two sets (see Table 5.8). Each participant was presented with a response sheet that provided enough room for them to write down their choice as well as their reason for choosing it.

5.5.4 Procedure

The procedure was similar to that used in Experiment 2. All of the participants within each group were tested in two sessions where all participants completed the task simultaneously. The experiment ran on a 15” Macintosh laptop using Superlab and shown on an overhead projector. On the presentation of each triad the fixation point was presented for 1000 milliseconds followed by the target being shown for 1500 milliseconds, after which the target image was joined by the two choice items. Presentation of each triad (after onset of the choice items) lasted for 75 seconds. Participants were asked to make their choice and then give a written response to “what sorts of things were you considering?” Rather than responding on the Superlab program as with the previous experimental work, participants were provided with response sheets that provided spaces for their choice and protocol (see

Appendix AC). The program ran through the SCO, DCO and PCO triads after which participants were debriefed and thanked for their participation.

Table 5.8

List of the Triads Presented in Set A and Set B.

Set	Triad type		
	SCO	DCO	PCO
A	Pencil	Fax machine	Axe
	Glass	Screwdriver	Baseball bat
	Spatula	Drink bottle	USB
	Pin	Rifle	Present
	Ketchup	Book	Nut
B	Orange	Computer	Clarinet
	DVD player	Calculator	Cocktail shaker
	Bed	Paperclip	Gun
	Leaflet	Deodorant	Peppermill
	Spade	Knife	Handbag

5.6 Results

5.6.1 Choice Analysis

The participants' responses were coded and the mean percentage of action choices selected were calculated for each of the triad sets. The results are shown below in Tables 5.9 and 5.10. As can be seen, the standard triad pattern found in Experiment 2 has been replicated here where the DCO triads have led to the lowest levels of the action choice selected, however, the pattern is much stronger with set A than set B. In addition, overall mean selections was higher in set A (M = .62) than in set B (M = .49). Therefore, the action scores were analysed individually for each set rather than pooling the data together. For each analysis a 3x2 repeated measures ANOVA was conducted using triad type as a within-subjects variable and context as a between-subjects variable.

The analysis on the mean percentage of action scores for set A revealed that the main effect of context was significant, F (1, 107) = 45.44, p < .001, η^2 = .30, with higher action scores in the context-rich (M = .72) than the context-lean condition (M = .53). The main effect of triad type was also significant using the Greenhouse Geisser adjustment[42], F (1.82, 194.60) = 22.27, p < .001, η^2 = .17. Post hoc analysis using the Bonferroni adjustment showed that the mean action scores were significantly higher in the SCO triads compared to both the DCO (p <.001) and the PCO (p < .001) triads. The difference between the PCO triads and the DCO triads approached significance but did not cross the alpha threshold (p = .065). The interaction effect between context and triad type was also significant using the Greenhouse Geisser adjustment, F (1.82, 194.60) = 12.25, p < .001, η^2 = .10. Within the context-lean condition, the mean percentage of action scores was significantly higher in the SCO triads compared to the DCO (p < .001) and the PCO triads (p < .001), but no difference was found between the latter (p = .94). A different pattern was found in the context-rich condition where the SCO triads were significantly higher than the DCO (p = .016), but not the PCO triads (p = .51). Post hoc analysis using the Bonferroni adjustment showed that context had a significant increase in action choices between the lean and rich conditions for the DCO (p < .001) and the PCO triads (p < .001), but not for the SCO triads (p = .25).

Table 5.9

Mean Percentage of Action Choices Selected on Triad Set A.

Context	Triad type		
	DCO	SCO	PCO
Lean	.44 (.26)	.71 (.18)	.44 (.23)
Rich	.63 (.26)	.76 (.19)	.78 (.18)

The analysis on the mean percentage of action scores for set B revealed a similar pattern to that of set A. The main effect of context was again significant, F (1, 142) = 10.19, p = .002, η^2 = .07, with higher action scores in the context-rich (M = .52) than the context-lean condition (M = .45). The main effect of triad type was also significant, F (2, 284) = 55.66, p < .001, η^2 = .28. However, unlike set A, post hoc analysis using the Bonferroni adjustment revealed no difference between the SCO and PCO triads (p = .60), but both were significantly higher than the DCO triads

[42] Mauchly's test of Sphericity was significant; χ^2 (2) = 11.13, p = .004, and therefore the Greenhouse-Geisser adjustment was used; ε = .91.

(SCO-DCO: $p < .001$, PCO-DCO: $p < .001$). The interaction effect between context and triad type was also significant, F (2, 284) = 5.81, $p = .003$, $\eta^2 = .04$. Within the context-lean condition the mean percentage of action scores was significantly higher in the SCO triads compared to the DCO ($p < .001$) but not the PCO triads ($p = .17$). The PCO triads were also significantly higher than the DCO triads ($p < .001$). In the context-rich condition the SCO triads were significantly higher than the DCO ($p < .001$), but lower than the PCO triads ($p < .001$). Between the contexts, post hoc analysis using the Bonferroni adjustment showed that the context had a significant increase between the lean and rich conditions for the PCO triads ($p < .001$), but not for the SCO triads ($p = .86$) or DCO triads ($p = .37$).

The data on both triad sets was further analysed for the effects of gender using a 3x2x2 mixed ANOVA with both context and gender as between-subject factors. The results on the main effects of triad and context, and the interaction effect between the two, remained the same as the previous analysis. Of main interest, was that a borderline significant main effect of gender was found on the data from set A, F (1, 105) = 3.78, $p = .055$, $\eta^2 = .04$, showing that the percentage of action choices selected was higher for the males (69%) than for the females (61%). However, this effect was only found in set A and not replicated in set B, F (1, 1040) = 2.65, $p = .11$, $\eta^2 = .02$. In neither set did gender significantly interact with context, nor was the three-way interaction effect significant (for both sets, $F < 1$). Additionally, no effect if age was found after removing those participants greater than two SD's above the mean.

Table 5.10

Mean Percentage of Action Choices Selected on Triad Set B.

Context	Triad type		
	DCO	SCO	PCO
Lean	.32 (.21)	.54 (.17)	.49 (.22)
Rich	.36 (.26)	.55 (.20)	.66 (.17)

5.6.2 Protocol Analysis

The protocols were analysed by the author and two independent coders. The coders read through the reasons from the participants and, using thematic analysis, categorised it using a coding system. The coding system itself was developed prior to the analysis using common themes in categorising objects such as functional, thematic, action, perceptual and categorical reasoning. Additional reasons were also developed using a bottom-up approach during the initial stages of the analysis whereby the coding took place simultaneously by all three coders. The final set consisted of fifteen codes:

1. Functional
2. Action
3. Perceptual
4. Thematic
5. Mediating link (the two objects are bound by a third, often non-presented item).
6. Same category
7. Same material
8. Personal
9. Motion
10. One can be the other
11. Word feature
12. Simile
13. Autobiographical
14. Biological
15. Other (used to classify any reasons which did not fall into the above categories).

All participants responded to fifteen triads and so the complete set of protocols consisted of 3795 protocols. The protocols were then subdivided into part protocols separating by the reasons given which is seen to provide a more accurate analysis and understanding of the cognitive processes involved during decision making (Bettman & Park, 1980; Ericsson & Simon, 1993; Kuusela & Paul, 2000). For example, if a participant selected *banana* with *orange* because “they are both fruit and both need to be peeled”, then this was divided into two separate protocols under the codes *same category* and *action*. In order to agree the application of the codes, the first 250 protocols were analysed by the three coders simultaneously and the bottom-up coding scheme was developed. The coders were then given the protocols in packs and independently went through each protocol separating it into part protocols when necessary and assigning a code to the reason given by the participants. The final coding assigned to a part protocol was done so when at least two (of the three) coders assigned it with the same coding. On occasions where the coders gave all different reasons the disagreements were discussed until agreement was reached between the coders. If an agreement could not be reached, the protocol was removed from the final analysis. In order to ensure that the coders all agreed in their codings the next 250 codings were subjected to a reliability analysis and an alpha of .95 was achieved showing that there was high agreement between the coders.

Overall, the results showed that functional (27.27%), perceptual (18.83%), action (11.43%) and thematic reasons (10.25%) accounted for the majority of the protocols. The coded protocols were identified as relating to an action choice or selection of the competitor for the purposes of comparison. The results below are separated into two stages. First, the percentage of protocols for the SCO, DCO and PCO triads were calculated overall. Second, the percentage of protocols for each individual triad was calculated to look at the main reasons given each choice, and to look at those triads where action was most influential[43].

Figures 5.5, 5.6 and 5.7[44] show the overall percentage of reported reasons for all of the protocols. It can be seen that on the DCO triads when participants selected the taxonomic choice participants were most likely to report functional, thematic and category reasons for making their choice. When participants selected the action choice they were most likely to report action, functional and perceptual reasons. While it was predicted that participants would report perceptual reasons for selecting the action choice (given that objects that share an action invariably share ergonomic and perceptual characteristics) it was not predicted that participants would give function as a reason for the action choice given that these pairs of objects do not share taxonomic information and are therefore not designed for the same use. However, this is discussed later with reference to the finding that participants would

[43] However the data from the individual triads is not presented here in the main body, but can be found in Appendix AD.

[44] Across all of the triad types, not all of the possible codes significantly contributed to the overall reasons used. Figures 5.5, 5.6 and 5.7 therefore only focus on those codes accounting for more than 10% of the protocols given (except for the case of the 'same category' codings on the SCO triads which were left in for theoretical reasons).

often give goal related reasons (e.g. a rifle and a water pistol go together because they "shoot"). On the SCO triads when participants selected the taxonomic choice they were most likely to report functional, perceptual and thematic reasons[45]. However, when participants selected the action choice they were most likely to report action, functional and perceptual reasons. Selection of the choices on the PCO triads varied but the main results do comply with the design format of the triads in that they reported perceptual reasons for selecting the perceptual choice and action reasons for selecting the action choice.

5.6.3 Protocols on the DCO Triads

Figure 5.5 below shows the codings reported by participants, which accounted for more than 10% of the protocols in at least one condition on the DCO triads. As can be seen the majority of protocols reported functional reasons for making their choices. While this is not surprising for the taxonomic choice, given that by definition the taxonomic choices share some functional information, this is more surprising for the action choice. This will be discussed later as to the difference between the specific object 'inter-action' and the general 'goal' of the objects. When participants selected the taxonomic choice they were more likely to report 'thematic' as well as 'same category' reasons for doing so. Few protocols on the action choice gave a thematic reason for doing so. This goes some way to alleviating any concern that participants were selecting the action choice because of shared thematic relations given research that has suggested that actions are thematic associations since we only use objects in specific situations (Kalénine et al., 2009; Tsagkaridis et al., 2014). Figure 5.5 further shows that when participants selected the action choice they gave a high percentage of 'action' and 'perceptual' protocols. This supports the prior notion that objects which share an action will invariably share perceptual characteristics and hence becomes influential in the triad task.

The analysis of the individual triads (see Appendix AD) shows that across the majority of triads participants reported the shared actions as a reason for selecting the

[45] The terms "reasons' and 'strategies' could potentially be used interchangeably here given that they are reporting their reasons for making their choice based on specific strategies (e.g. functional, perceptual, action). However, the term 'strategies' implies that the participants are fully able to introspect on their decision, rather than making post hoc justifications as suggested by Nisbett and Wilson (1977). Given the nature of this debate (outlined above) the term 'reasons' is used here.

action choice. However, there were three examples whereby selection of the action choice was not accompanied with action-based protocols. On the *fax machine, calculator* and *knife* triads participants rarely (if at all) reported action as being a primary reason for selecting the action choice. Rather, participants favoured alternative reasons and selection was coincidental. On both the *fax machine* and the *knife* triads participants favoured functional reasons for making their choice. On the *calculator* triad some participants did report action when selecting *mobile phone* in the context-rich condition only (13.90%). However, this is relatively low given that the majority of participants selected *mobile phone* because "a mobile phone has a calculator on it" (47.22%) and the action protocols were not consistent given that participants did not report such when selecting *mobile-phone* in the context-lean condition.

5.6.4 Protocols on the SCO Triads

The results below in Figure 5.6 show the percentage of codings given on the SCO triads. As can be seen, when participants selected both the taxonomic and the action choice they were highly likely to report using functional and perceptual reasons for doing so. Again, this is not surprising given that the objects all shared a taxonomic link with the target object, which includes both functional and perceptual information. Action reasons were reported when participants selected the action choice, but as can be seen action reasons were reported with lower frequencies compared to on the DCO triads. A small percentage of participants (7.44%) reported action reasons when selecting the taxonomic choice in the context-rich condition. These comments were action based, but not with the strict definition used here in the thesis and were related to grasping movements such as "I can pick them up with one hand". Such reasons were classified as 'action'. As can also be seen, participants reported thematic reasons for making their choices, but in relatively low quantities. In addition, very few participants reported using a 'same category' strategy despite the objects sharing category membership with each other.

The analysis of the individual triads (see Appendix AD) shows that, across the majority of triads, participants reported the shared actions as a strategy for selecting the action choice. However, there were three examples where selection of the action choice was not accompanied with action-based protocols. On the *spatula,* *spade* and *ketchup* triads participants rarely (if at all) reported action as being a primary reason for selecting the action choice. Rather participants favoured alternative strategies and selection was coincidental. In the *DVD player* triad also, participants used action reasoning to select the action choice in the context-lean condition, but not in the context-rich. This suggests that in this example, context does not increase the saliency of the shared action, but increases the saliency of other properties (functional and mediating links). These four triads were removed from subsequent analysis.

The *bed* and *leaflet* triads showed the opposite effect where action was rarely used within the context-lean condition, but became a primary reason in the context-rich condition (reported with a high percentage of action protocols). This supports the notion that the context increases the saliency of action and is more likely to be used when presented in context (but only on certain examples). The 'best' triads appear to be the *pin* and *orange* triad as participants relied heavily on action in both the lean and the rich contexts and both triad types resulted in a high percentage of action protocols reported.

For the *pencil* and *glass* triads it appears that participants did report the shared action to select the action item, however, these were not the primary reason for doing so in that participants favoured alternative reasons such as functional and perceptual. However, this does show that participants do recognise the shared action between the objects, and may use action as a supplementary reason for categorising the objects. Indeed, in both triad sets participants would often report action as being supplementary to other features. For example, participants would report that pencils and paintbrushes are "used to draw things by picking them up and grasping in their fingers". Therefore the shared actions would be used to support the pre-existing relations between the objects, supporting the designed notion that the objects share both an action and a taxonomic relation and further supporting the "additive" effect that action has in category decisions.

5.6.5 Protocols on the PCO Triads

The data below in Figure 5.7 shows the percentage of each coding type given on the PCO triads. As can be seen, when participants selected the action choice, they were most likely to report action reasons for doing so. In addition, when they selected the perceptual choice they reported perceptual reasons for doing so. Some participants also reported 'motion' reasons for selecting the action choice. These were limited to comments particularly on the *axe* and *baseball bat* triads where participants talked about the strength one would need in order to swing the objects. An interesting finding here as well is that some participants did report functional reasons for selecting both the action and the perceptual choice. This is a little surprising given that the triads were designed without taxonomic information. However, these comments were not centered on standard object functions, but were comments around overall goals that could be achieved with the objects. For example, participants selected *mace* with *baseball bat* because "they can both be used as weapons", and participants selected *car key* with *nut* because "they both make cars work".

The analysis of the individual triads (see Appendix AD) shows that across the majority of triads participants reported the shared actions as a strategy for selecting the action choice. However, there were four examples whereby selection of the action choice was not accompanied with action-based protocols. On the *gun, handbag, USB* and *present* triads participants rarely (if at all) reported action as being a primary reason for selecting the action choice. Rather, participants favoured alternative strategies and selection was coincidental. This was particularly the reason in the case for the *gun, handbag* and *present* triads where participants used alternative strategies for selecting the action choice and when participants did use action it was not consistent. The *USB* triad is to be removed because it does not conform to the design format of the PCO triads. Participants would impose a superordinate category to the items and therefore this item is to be removed from the data pool prior to re-analysis.

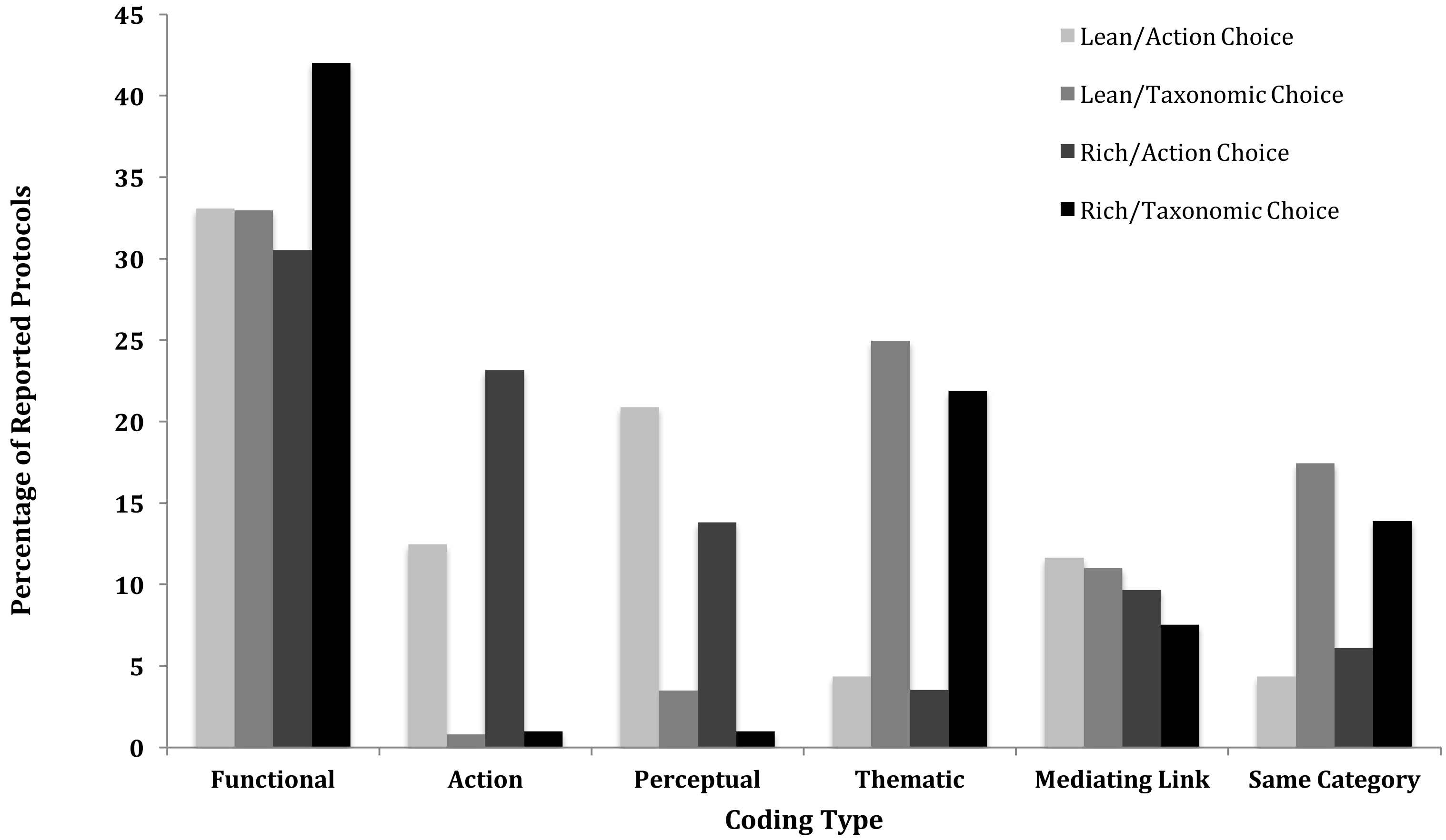

Figure 5.5. The percentage of reported protocols in the DCO triads.

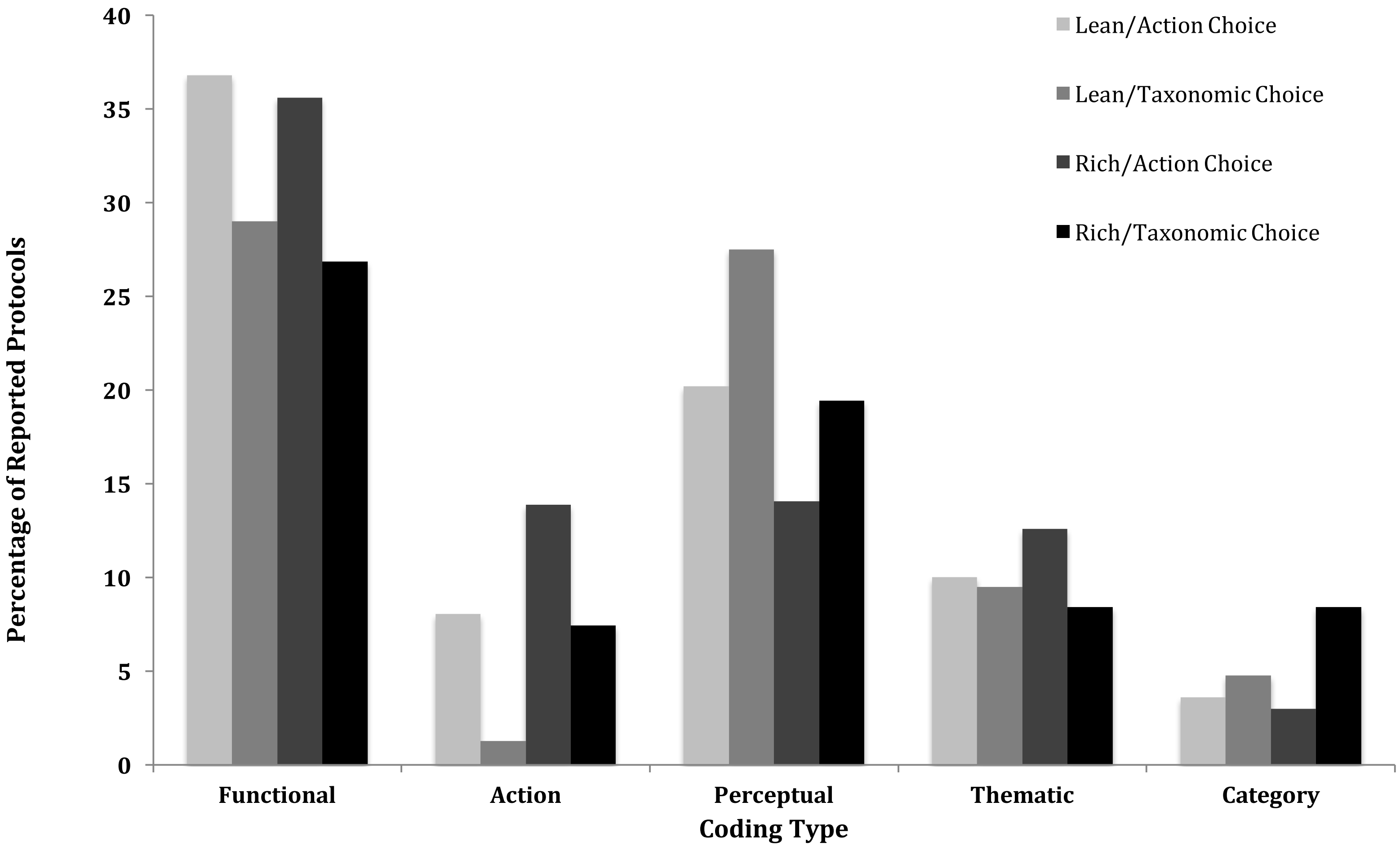

Figure 5.6. The percentage of reported protocols in the SCO triads.

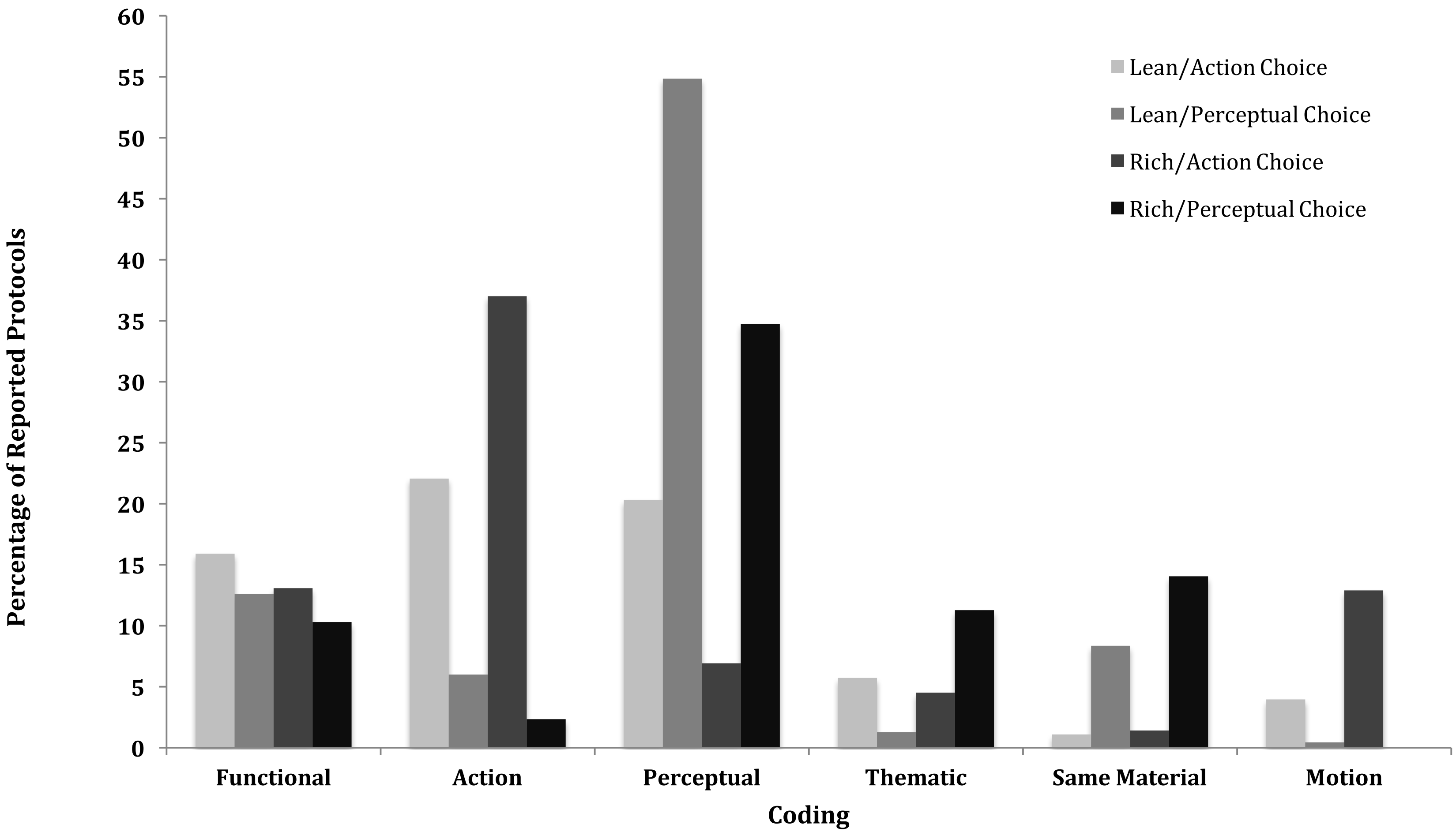

Figure 5.7. The percentage of reported protocols in the PCO triads.

5.6.6 Choice Data Re-analysed

The previous section identified the ‘non-action reported’ items that may confound the interpretation of the data. The aim of the next section was to re-analyse the choice data from the current experiment after such items have been removed. This was done in two steps: first, the original data from Experiment 2 was re-analysed following the removal of the ‘weak’ items and second, the choice data here from the current experiment was re-analysed in the same manner. Figure 5.8 below shows the results from Experiment 2. As can be seen the same pattern across the triads as was found in the original experiment is evident.

The lowest action scores were on the DCO triads (Lean = .19, Rich = .43) and similar means were seen between the SCO (Lean = .50, Rich = .66) and the PCO triads (Lean = .49, Rich = .68). A repeated measures ANOVA on the mean percentage of action scores showed that the main effect of context was once again significant with higher action scores in the context-rich condition, F (1, 48) = 32.36, $p < .001$, $\eta^2 = .40$. The main effect of triad was also again significant, F (2, 96) = 37.95, $p < .001$, $\eta^2 = .44$, with post hoc examination using the Bonferroni Adjustment showed that the DCO triads was significantly lower then both the SCO ($p < .001$) and the PCO triads ($p < .001$). No difference was found between the SCO and PCO triads ($p = 1.0$). As with the original analysis the interaction effect was not found to be significant, $F < 1$, suggesting that the context effect was consistent across all the triad types.

Figures 5.9 and 5.10 below show the mean percentage of action choices analysed from the current experiment following the removal of the ‘poor’ items as identified from the protocol analysis. As with the previous analysis the data sets were analysed separately because the results showed different patterns between them. Both data sets were analysed using repeated measures ANOVA’s using triad type as the within-subjects factor and using context as the between-subjects factor. Figure 5.9 shows the means for set A, and shows a very similar pattern to what has been seen previously from Experiment 2 (see Figure 5.8). The results showed that the main effect of context was significant with higher action choices in the context-rich condition, F (1, 107) = 30.30, $p < .001$, $\eta^2 = .22$. The main effect of triad type was also significant using the Greenhouse Geisser adjustment[46], F (1.74, 186.91) = 25.70, $p < .001$, $\eta^2 = .19$. Post hoc analysis using the Bonferroni adjustment showed that the DCO triads were significantly lower than the SCO ($p < .001$) and the PCO triads ($p < .001$), and the latter also significantly lower than the SCO triads ($p = .036$). Unlike the previous analysis in Experiment 2, the interaction effect was significant, F (1.74, 186.91) = 7.35, $p = .001$, $\eta^2 = .06$. Post hoc analysis revealed that the mean percentage of action scores was significantly higher in the context-rich compared to context-lean condition for both the DCO ($p < .001$) and the PCO triads ($p = .001$). However, there was no difference in the SCO triads between the two contexts ($p = .46$). This only partially replicates the data found previously where context was significantly increased on all three triad types.

Figure 5.10 shows that the data for set B followed a similar pattern, however, overall scores were lower compared to set A (as found in the previous analysis). A repeated measures ANOVA found the same pattern of data as with set A where the main effects of context, F (1, 142) = 15.60, $p < .001$, $\eta^2 = .10$, the main effect of triad type, F (2, 284) = 49.50, $p < .001$, $\eta^2 = .26$, and the interaction effect, F (1, 107) = 7.17, $p = .001$, $\eta^2 = .05$, were all significant. However, there was a difference found on the interaction effect seen between the two data sets. For set B only the mean percentage of action choices on the PCO triads were significantly increased by context ($p < .001$). No differences were found between the contexts for the SCO ($p = .21$) and the DCO triads ($p = .30$). This again only partially replicates the context pattern found between in Experiment 2.

46 Mauchly's test of Sphericity was significant; χ^2 (2) = 16.60, $p < .001$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .87$.

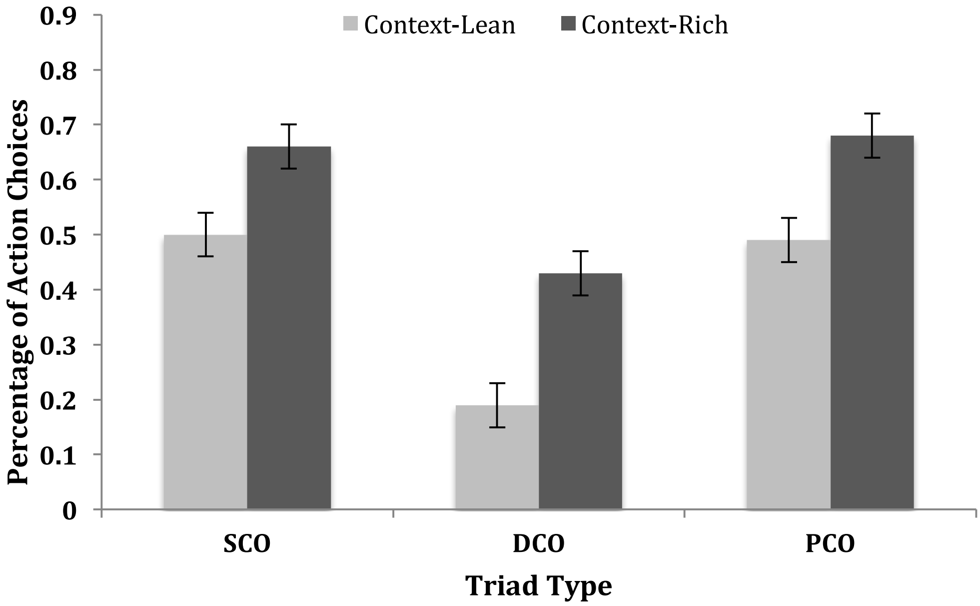

Figure 5.8. The percentage of action choices across triad type and context from Experiment 2 following removal of the 'non-action reported' items. Error bars present the standard error of the mean.

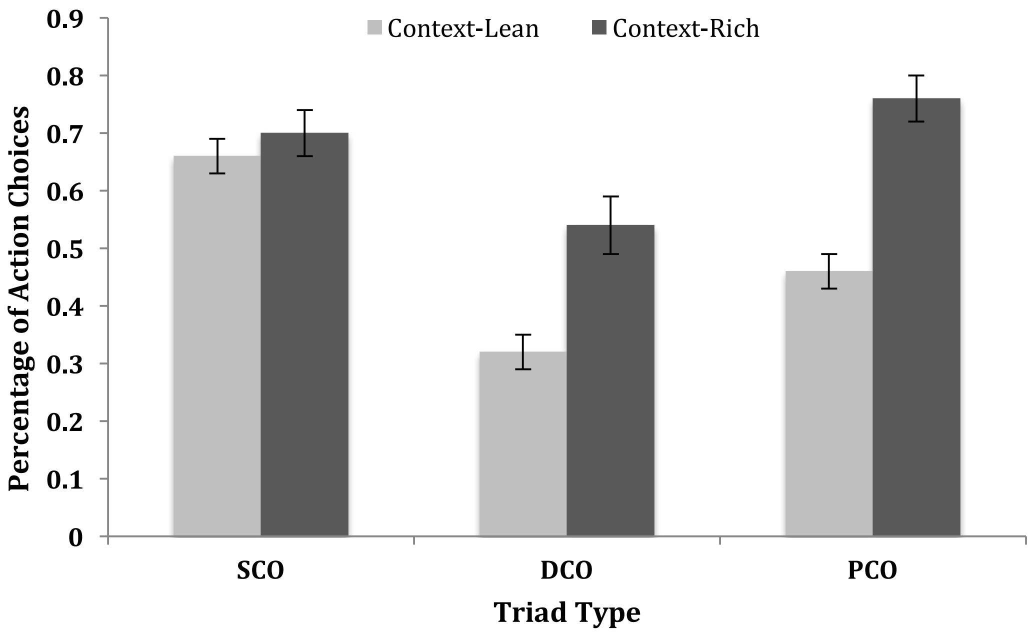

Figure 5.9. The percentage of action choices across triad type and context from Experiment 8 (set A) following removal of the 'non-action reported' items. Error bars present the standard error of the mean.

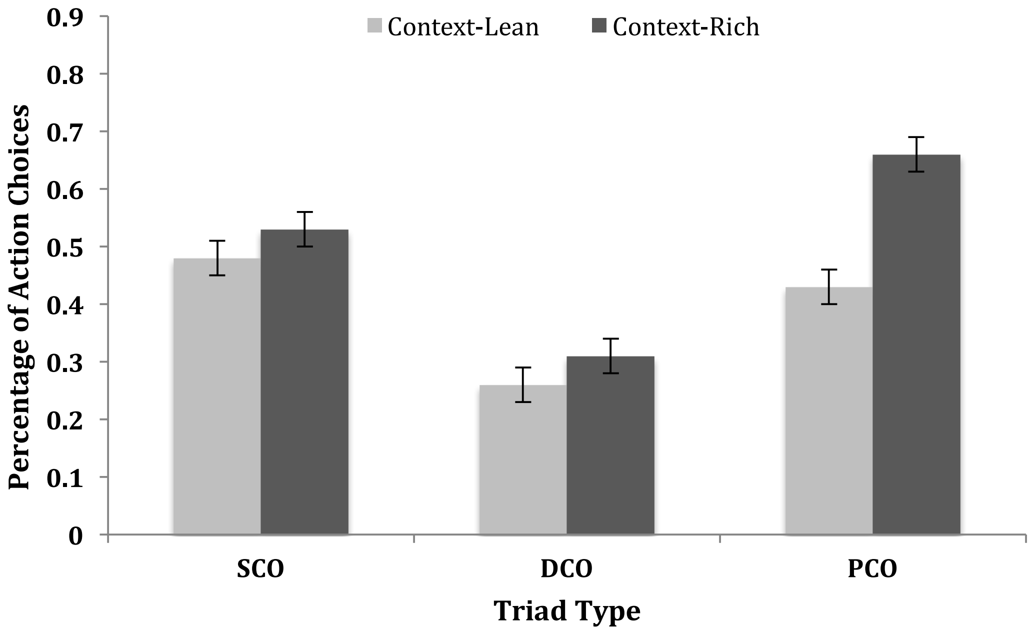

Figure 5.10. The percentage of action choices across triad type and context from Experiment 8 (Set B) following removal of the 'non-action reported' items. Error bars present the standard error of the mean.

5.6.4 Comparing the Protocols with the Choice Proportions

In the following section the protocol data found in Experiment 8 was matched up with the data reanalysed in Section 5.2. This includes the data on those triads where action choices were significantly greater than chance, and where action choices were significantly increased by context. The data is presented below in Table 5.11[47]. As can be seen below, in only two examples (*orange* and *clarinet*) were the action choices significantly higher than chance and significantly increased by context. These might be considered as the optimal triads to encourage selection of the action choice. A further five triads (*paperclip, bed, pencil, baseball bat* and *cocktail shaker*) were significantly higher than chance, but not increased by context. This might suggest that these triads were already highly salient in encouraging selection of the action choice. Eight of the triads (*computer, deodorant, rifle, screwdriver, glass, leaflet, pin* and *axe*) showed a significant increase in context, but were no different to chance. These triads show that the context led to increased saliency in selection of the action choice, but were also influenced overall by other

[47] The data presented in Table 5.11 does not include those triads that were identified in Experiment 8 as selecting the action choice, but not reporting the shared actions as a reason for doing so.

reasons in addition to the shared actions. This is primarily on the SCO and DCO triads where there is potentially more variation for other features to be used. For the PCO triads this is not as much the case since the items share less additional features in common. Additionally, in only four triads (*book, drink bottle, nut* and *peppermill*) were the action choices not different to chance, and not increased by context. While the protocol data does show that when participants are selecting the action choice they are doing so because of the shared actions, it might show that such triads are not "action favourable" and that participants favour the alternative choice based on alternative strategies.

Table 5.11

The Individual Triads Matched Against the Protocol Data and Reanalysis of Section 5.2.

Triad	Triad Type	Action choices significantly greater than chance?	Action choices significantly increased by context?	Actions reported in protocols?
Book	**DCO**	X	X	☆
Computer		X	☆	☆
Deodorant		X	☆	☆
Drink bottle		X	X	☆
Paperclip		☆	X	☆
Rifle		X	☆	☆
Screwdriver		X	☆	☆
Bed	**SCO**	☆	X	☆
Glass		X	☆	☆
Leaflet		X	☆	☆
Orange		☆	☆	☆
Pencil		☆	X	☆
Pin		X	☆	☆
Axe	**PCO**	X	☆	☆
Baseball bat		☆	X	☆
Clarinet		☆	☆	☆
Cocktail shaker		☆	X	☆
Nut		X	X	☆
Peppermill		X	X	☆

5.7 Discussion

The aim of Experiment 8 was to examine participants' reported reasons for their choices in the triads using protocol analysis. The analysis showed that in the case of certain triads, when participants selected the action choice, they reported reasons other than action for doing so. However, for the remainder of the triads participants did report the shared actions between the objects as being a potential reason for selecting the action choice. Those items where participants reported using alternative strategies were removed from the data pool and the choices were re-analysed for both the current experiment and the original experiment (Experiment 2). The same pattern was found again in the data set. Participants were always less likely to select the action choice on the DCO triads in favour of selecting the taxonomic choice. Participants were more likely to select the action choice on the SCO triads where the action choice already shared a taxonomic relation with the target.

The effect of context has not been as consistent between the previous and current experimental work. The results from Experiment 2 showed a clear main effect of context, where the percentage of action scores on all three triad types was significantly increased by context. The current data showed that this effect was limited to only the DCO and PCO triads, and that no contextual increase on the selection of the action choice was seen in the SCO triads. This may be because the triads removed from the SCO set (as explained above because participants reported other reasons for selecting the action choice) were those most influenced by context. In particular, Table 5.5 above shows that the *DVD player* triad was the only SCO example where the action choices were significantly increased by context in both Experiments 2 and 4. Therefore, it might be possible that context is less influential on selecting the action choice as previously thought, particularly on the SCO triads.

The results from the current experiment show how categorisation is both 'rich' and 'fluid'. Rather than participants using more traditional methods to group objects in the triads (e.g. taxonomic/perceptual strategies) participants reported having used a wide range of reasons for selecting the objects. In addition, such reasons were not consistent. The more traditional views of categorisation would predict that participants should be relatively consistent in their strategies used and this is supported by research showing that while there are individual differences, participants are relatively consistent in the strategies they use (Lin & Murphy, 2001; Simmons & Estes, 2008). However, this is not what was seen here.

While it would be predicted that participants should be consistent within each triad type for example, participants used various methods not only across the triad types (predictable, given differences between the triads types and how they were designed), but also within each triad set. For a lot of the triads participants reported using the same strategy for choosing the action item in both contexts. However, in certain cases the use of the two contexts produced a between-context effect since it is clear that even on the same triad participants use different strategies for categorisation. For example, when participants selected *mobile phone* to go with *calculator* in the context-lean condition they mainly reported using perceptual strategies that the two objects look similar. However, in the context-rich condition participants were most likely to report that 'one can be the other' given that mobile phones have a calculator on them. Given that the effect of context was significant, this is in line with the notion that context increases the saliency of the shared actions, as well as other features, between the objects. In addition, even within the same triad sets participants used varying strategies to select the action or the competitor choice. For example, on the SCO triads while functional and perceptual strategies were fairly consistent through the triads action was only reported in seven (of ten) triads and there were examples of other strategies such as thematic, personal, autobiographical and the materials of the object which were used, but not consistently.

Experiment 8 showed that participants used a variety of strategies in grouping objects together on the triads. This represents clear item effects since participants use such variety of strategies and have arisen because of the nature of how the triads were designed. Manipulating the design format of the objects would clearly impact on selection of the action choice. For example, in the *rifle* triad participants selected the taxonomic choice of *sword* because of the shared category link between the objects. However, both *rifle* and *sword* are highly typical and good examples of the category of weapons (Rosch, 1975). It would be predicted that the action choice would be more likely selected if the competitor was less typical of the category such as *missile*, *tear gas* or *hatchet*[48].

What should be kept in mind here, is the argument from Nisbett and Wilson (1977), that the protocols given do not reflect their actual processes, but post hoc

[48] Examples taken from Rosch, 1975, as less typical examples of weapons compared to both sword and rifle.

justifications. There are, however, good reasons to have confidence that the protocols do genuinely reflect at least part of the cognitive process involved in making the item choice. This is particularly based on the short-nature of the experiment, and that participants are asked to generate their protocol immediately after making their choice. Ericsson and Simon (1980, 1993) suggest that what is key in producing protocols is that (i) subjects report contents straight from short-term memory (STM), and (ii) what is produced is phonetic in nature. They also suggest that protocols are more accurate in reflecting the cognitive processes involved, as opposed to fabrication and post hoc justifications, when the task itself does not place a heavy burden on short-term memory. Given that the triad task is a relatively simply one, not exhausting the demands of STM with the protocols being produced immediately after making their decision (i.e. from STM), it is suggested here that the protocols generated do reflect the cognitive processes involved during the decision making rather than being post hoc justifications. Furthermore, the participants were not aware of the design manipulation and would not be able to form a priori justifications (in line with the argument of Smith & Miller, 1978). However, it is still likely that the protocols provide only a partial account of their choice and that subconscious influences could not be reported. The argument here is not that participants have complete access to their cognitive processes, but that the protocols can be used as an empirical check in support of the action choice data.

Experiment 8 shows that participants not only selected the action choice on the triads, but also then frequently reported the shared actions as the reason for having done so. However, what should also be kept in mind here is that not all participants reported the shared actions and this was not the case for every triad example. For those triads where participants reported the actions, it is possible that action was made more salient, and therefore more obvious, in the context-rich condition. The data further shows that many participants in the context-lean conditions also reported the shared actions between the objects, though the frequency of such was lower than in the context-rich condition. Therefore, just as participants are able to recognise the shared functional and thematic links between the items they are also able to recognise the shared actions. However, as stated above this was not the case for all participants, and for many items the frequency of reported actions was insufficient to result in a clear ‘advantage’ over the competitor.

5.8 General Discussion

The work reported within this chapter has sought to address item differences among the triads. This was completed through (1) reanalysing the triad data from the previous experiments, and (2) using protocol analysis to assess the strategies used when participants engaged in the triad task. The overall findings are outlined below.

5.8.1 Reanalysing the Triads

The triads used in the previous experiments have shown a wide variation on whether or not the participants selected the action choice. The choice data from Experiments 2 and 4 was reanalysed focusing on the selection of the action choice against the competitor, and the selection of the action choice in both the context-lean and context-rich condition. For certain items, participants were consistently more likely to select the action choice over the competitor. Only a few items showed that participants were consistently more likely to select the competitor choice over the action item. For a number of items there was no difference between selection of the action and the competitor choice using a binomial distribution. This would imply that both options where chosen with a (roughly) 50/50 ratio which would therefore suggest that, under these circumstances, action information is equally likely to be drawn upon for categorisation as taxonomic or perceptual information.

The proportion of action choices from the previous experiments was reanalysed after removing those items that did not differ, or led to a higher competitor choice, and showed a similar pattern of data compared to the previous analysis. However, after removing such items the context effect (lean vs rich) was limited to only the DCO and PCO triads (see Fig. 2 and 3). This would suggest that the context effect is strongest when the action choice does not present as a clear 'winner', but when shown in context the action is made more salient and hence more likely to be selected in the task.

The use of the context images here is very important and is a crucial factor in determining whether or not participants selected the action choice. The context images were collected with the intention that they reflected a visual scene of the objects being used, but there was some variation in the images used in terms of what they 'contained'. All of the images showed the objects being used for their functional purpose. The criterion in selecting these images was that the context reflected a natural scenario and included an agent. However, some of the images showed only a hand holding the objects while others showed a whole person in the scene (see Appendix N, O and P). In addition, the objects varied in size and therefore confining the images to include specific elements (such as the body and the face of the agent) would result in perceptual variations, e.g. a USB stick would look smaller in the image compared to a piano). As such, there are wide variations in the images used and how they demonstrate the object being used.

Part of the analysis above in Section 5.2.2 examined this by coding the images used as to whether the target, action choice and the competitor contained a whole agent (including the arms, face and body) or just showed the hands on objects. Figure 5.3 showed that participants were more likely to select the action choice when the action item was shown with a full agent where the body and face were clearly visible. Perhaps this is because including a full agent includes more visual clues of the scene and emphasising the function, the action and the goal of the situation. This in itself suggests a very specific context, which encourages participants to simulate an event (either the specific event suggested or a similar one) where they are also using the objects. Hence the context increases the saliency of the shared actions between the objects and the participants should be more likely to select the action choice. Though it should be noted that this was not deterministic and even on cases where only a hand was shown, some participants were still likely to select the action choice. It is possible that selection of the action choice is not just determined by simulating the action, but simulating a specific scenario in which the objects are used for their functional purpose and as such would naturally include simulating how to use the object.

5.8.2 Categorisation Strategies

The aim of Experiment 8 was to investigate the reasons participants would give for their selection of the items in the triads. These protocols were collected immediately after the participants made their choice on each of the triads. The protocol analysis revealed that for a few of the triads, participants were reliably selecting the action choice but not reporting the shared actions as their reason for doing so. It had been previously assumed that participants were selecting the choice items because of the shared action between them (as inferred from the manipulation). The protocol analysis supports this for the majority of the triads used (see Sections 5.6.3 to 5.6.5), but does show that other factors were involved in participants' reasoning for making their choices. On such items where participants did not report the shared actions they used alternative strategies for making their selection. However, this was only the case in less than one-third of the triads. On the remaining triads participants both selected the action choice on the triad and reported the actions as the reason for doing so, though it should be noted that the majority of participants reported multiple reasons for selecting their choice. For example, one participant selected *banana* with *orange* because “both are fruit and need to be peeled to eat them”. This seems to be an example of the ‘additive effect’ seen in the SCO triads, discussed in Chapter 2. That is to say that where both choice items share category membership with the target, the one that also shares an action is more likely to be chosen. Given the findings above we can be reasonably confident that the protocols shed some light on the strategies used during the task, and that participants were drawing upon action information as a source of commonality for categorisation.

The work presented thus far has shown that, under certain circumstances, action does have an influence on how participants make categorical decisions. It therefore stands to reason that if action can influence categorisation, then it might also influence other tasks that draw on categorical processes. The aim of Chapter 6 was to test this premise using the same stimuli as in the previous chapters, but using a different task. There is a close relationship between categorisation and similarity (Goldstone, 1994; Rips, 1989) and as such, Experiment 9 used a similarity judgement task different to that used in Experiment 4 (where similarity instructions were used on a forced task). Given the relationship that exists between the two processes, it was predicted that action should influence similarity in a similar manner as to how it has been demonstrated to influence categorisation.

Chapter 6

Rifle Goes with Sword but is More Similar to Water Pistol: Assessing Action-Based Dissociations in Categorisation and Similarity

The previous chapters have demonstrated how action information has an additive effect in categorisation judgements. Objects are more likely to be categorised together when they share both an action and a taxonomic relation (e.g. *orange* and *banana*) as opposed to just sharing a taxonomic relation (e.g. *orange* and *strawberry*). However, action is less likely to base category membership on its own when objects share an action but not taxonomic information (e.g. *rifle* and *water pistol*). Action choices overall were also shown to be higher when presented in the context-rich than context-lean condition. Furthermore, action influenced choices on the triad using the instructions to select the object that is “most similar” to the target. However, it is possible that the influence of action in similarity judgements is inflated by the “forced-choice” nature of the triad task. The aim of the present chapter was to assess how action influences similarity judgements using a standard rating scale, which are more commonly used in similarity research. The results showed an additive effect on judging similarity, as was previously found on the triad task. But unlike the previous findings, no main effect of context was found. In addition, the pairs developed from the PCO triads showed low similarity ratings for the items sharing only action information. The results are discussed in light of how sources of commonality are ‘weighted’ in similarity judgments, and how the format of the triads result in different sources weighted as more salient than others.

6. Experiment 9
The Role of Action in Assessments of Object Similarity

6.1 Introduction

Similarity is often seen as playing a key role in categorisation (Brooks, 1978; Goldstone, 1994; Hampton, 1995; Rosch & Mervis, 1975). Specific theories on categorisation view items in the world as belonging to a category based on how similar they are to an exemplar/base item. For example, the prototype theory of concepts (Rosch & Mervis, 1975; Rosch et al., 1976) suggests that details are abstracted from experience with objects to form a 'prototypical' case. New items are judged as being a member of the category based on how similar they are to the prototype, the more similar it is then the more likely it is that they will be judged as a member of the category. The details of the prototype are abstracted from the other category instances and therefore, form an amodal representation (Barsalou, 2003) focused only on the central tendencies/common features of the category. Such a view posits a "feature list" view where concepts are decontextualised and represented outside of the modalities in which they were experienced. Exemplar models (Brooks, 1978, Medin & Schaffer, 1978) differ because they use specific category instances in order to judge membership to the category, but are also based on how similar the new instance is to the generated exemplar (see Murphy, 2016, for an argument against exemplar theories).

It can be argued that similarity between entities does play a key role in categorisation because otherwise all members of a category would have equal status in terms of how 'good' an example they are. Rosch and Mervis (1975) showed that concepts have a 'graded structure' and that some category members are better members of the category than others. In support of the prototype theory they collected measures of 'family resemblance'. They showed that some examples are rated as better members of the category than others, e.g. a *robin* is a better example of a bird than *ostrich.* However, similarity cannot be used to explain all concepts and there are examples where similarity cannot be used to assess new members of the category. Two clear examples support this; ad hoc, and mathematical concepts.

Ad hoc concepts (Barsalou, 1983) are those that are developed in response to a specific goal such as *things to take on holiday*. Items within this category share very little in common except that they can be used to serve the relevant goal. For example, *passport* and *sun lotion* share no functional or perceptual properties and are only linked by the goal (see Estes et al., 2009, for an explanation of why ad hoc categories can be argued to differ from thematic categories). While you could argue that these items are similar in one specific dimension (passports and sun lotion are both good items to take on holiday) similarity cannot explain how the category in constructed and cannot explain how items are assessed as belonging to the category or not (Hampton, 1995, 1997).

Mathematical concepts also are also cases when similarity cannot be used to define and categorise new stimuli. Rather such elements are governed by explicit rules. For example, a *triangle* is governed by the explicit rule that it must have three sides where the internal angles add up to 180^{o}. While certain triangles might be more similar to each other this is not used in the categorisation of such a shape, rather it must meet the defining criteria. *Prime numbers* are another example, where similarity plays no rule in defining it. They are governed by the specific criteria of being divisible by 1 and itself. While the number 2 might be more similar to 3 than to 997, this is not taken into account when defining such as numbers as being a prime or not.

Overall, this shows that while similarity might play a key role in category construction, it cannot be used to explain all concepts. Goldstone (1994) has argued that similarity may ground some categories, but not all. From an evolutionary perspective, Franks and Braisby (1997) have argued that similarity is a spandrel, or "by-product", and has little use in cognition. They have argued that concepts have developed for the purpose of guiding potential actions and that this is their primary purpose. While similarity plays a role on how concepts are formed they argue that it has no role outside of concept formation. If similarity were an adaptation to the environment, then it would play a strong role on its own, which in their view it does not. Therefore, it is simply a by-product of concept formation and serves no other purpose.

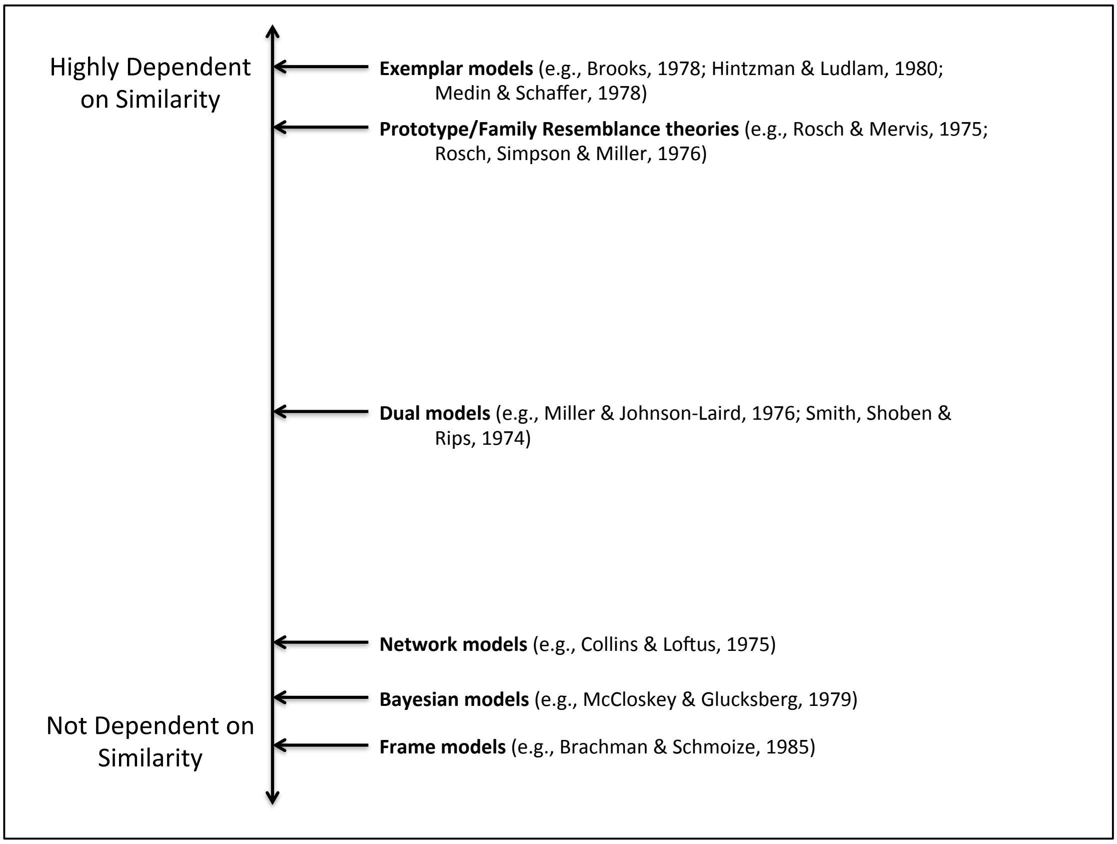

Figure 6.1. Models of categorisation organised by their dependence on similarity (taken from Rips, 1989).

As can be seen in Figure 6.1, models of categorisation vary in their dependence on similarity. If it is the case that categorisation is dependent on the judgment of how two objects are similar, then this would predict a monotonic relationship between the two (Braisby, 2004). As similarity between two objects increases then so should the likelihood of them being categorised together. However, tasks using the same stimuli for categorisation and similarity tasks do not always track each other and such dissociations between the two show that there is more to categorisation than similarity. For example, Medin, Goldstone and Gentner (1993) report an experiment where participants rated *Doberman Pinscher* as being more similar to a *raccoon* than a *shark*. However, they were more likely to be put into the group [bear, lion, shark] than [bear, lion, raccoon]. This is because of the ferocious nature of the former triplet that emerges as a salient property in the context of the animals presented. Rips (1989, Experiment 1) has demonstrated one of the clearest dissociations between the two processes where he demonstrated that some objects are more likely to be categorised with item X, but more similar to item Y (see Chapter 2).

In an additional experiment, Rips further showed this dissociation when participants were told about a bird-like animal that had gone through a physical change after an environmental accident and now looked more insect-like. When asked to make judgments of similarity and categorisation, participants viewed the creature as more similar to an insect, but more likely to be a bird. This shows clear evidence that tasks of similarity and categorisation do not always track each other, and that there is more to categorical decisions than assessing how similar the items are as participants were using rules to govern categorisation. It is now more generally accepted that categorisation can be both similarity based (this is a dog because it is similar to other dogs) and theory based (this is a fruit because it contains seeds).

An interesting distinction in similarity research is the difference between features that are necessary for categorisation, and those that are characteristic of the object, but not necessary. Smith and Sloman (1994) have argued that the dissociation occurred in Rips' experiment because the descriptions (Experiment 1) contained the necessary feature obstructing the fixed over the variable category, but this feature was not characteristic of either category. They distinguish between the necessary-feature hypothesis where categorisation is made by rules in the absence of any characteristic information encouraging a rule-based strategy, and the characteristic-feature hypothesis where necessary features included alongside shared characteristics would encourage a similarity-based categorisation strategy.

Smith and Sloman (1994) showed that, under certain circumstances, participants do use both strategies to categorise objects. They used the same task as Rips (1989), only presented participants with sparse object descriptions (as used by Rips, 1989) and rich descriptions. The sparse descriptions encouraged participants to select the variable category by definition that the target item could not be a member of the fixed category based on size (e.g. a round, three-inch cannot be a quarter). For the rich descriptions, a characteristic of the fixed variable was also included to test the characteristic-feature hypothesis (e.g. *circular object with an X-inch diameter that is silver coloured*). The necessary-feature hypothesis would predict that if participants only categorise by rules then they should always favour the variable category. If, however, they do take characteristics features into account and categorise the objects by a similarity-based strategy then they should be less likely to select the variable category with the rich descriptions. The results of Experiment 1 supported the latter prediction as the participants were more likely to select the fixed category with the rich descriptions which does not fall in line with the ‘rule’ imposed by the objects, suggesting that they relied on the characteristics of the object and engaged in a similarity-based categorisation strategy. Most interesting in their results was the finding that sparse descriptions (the same as used in Rips, 1989) failed to replicate the categorisation/similarity dissociation. In both tasks participants showed close to a 50/50 distribution in selecting the fixed and the variable category. The authors suggest that this was because they inhibited participants from talking out loud as they had done in Rips’ experiment. Therefore, in their second experiment, they encouraged participants to talk out loud and recorded verbal protocols while participants engaged in both tasks. Only under these conditions did they replicate the findings of Rips (1989). Participants given the sparse descriptions were more likely to select the variable (rule) category in the categorisation task than they were in the similarity task[49]. In addition, the same pattern was found as in Experiment 1 where the proportion of selecting the variable category (which they should do if using rules to categorise the objects) was overall very low, suggesting that they engaged in a similarity-based strategy. The results therefore show, that not only do participants show evidence in engaging in both rule and similarity-based strategies for categorisation, but also that the dissociation between the two is not well replicated. Thibaut, Dupont and Anselme (2002) have further supported this, showing that participants are more likely to base categorisation on deep, necessary features where similarity judgments are based more on characteristic features.

Braisby (2004) also argued that such dissociations are not easily replicated and can be reduced if participants are given a specific context in which to frame their similarity judgments. Using a similar method to that used by Thibaut et al., Braisby (Experiment 1, 2004) presented statements to participants regarding natural objects that varied in their appearance (characteristic) and genetic (necessary) factors. For example, an apple which after genetic modification had either retained/lost its genetic properties and retained/lost its appearance/taste. Therefore, the statements could either be congruent (A+G+, A-G-) or incongruent (A+G-, A-G+). Participants first judged the category membership of the objects and then judged the typicality of the exemplars relative to the category label. A double dissociation was found between the

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[49] However the dissociation was not as strong as previously. Rips (1989): $M_{categorisation}$ = .63, $M_{similarity}$ = .31; Smith & Sloman (1994): $M_{categorisation}$ = .67, $M_{similarity}$ = .50.

A+G- and A-G+ items on the tasks. Participants used the necessary features when judging category membership and judged the items sharing genetic, but not appearance, properties as more likely to be a member of that category than those which did not share genetic properties. In contrast, participants used the characteristic features when judging typicality and found that those that shared an appearance, but not genetic properties, were more typical of the category than those that did not share an appearance. Therefore, the double dissociation found by Rips (1989) in judging categorisation and similarity was replicated using natural stimuli that differed in their necessary and characteristic features.

Braisby (2004) further showed, in two additional experiments, that the double dissociation could be reduced and that such judgements are context-dependent. The same procedure as in Experiment 1 was repeated, only participants were either asked to “imagine being a sculptor” (increasing attention to the appearance properties of the items, Experiment 2) or to “imagine being a biologist” (increasing attention to the genetic properties, Experiment 3). In both Experiments 2 and 3, the double dissociation was not found between the incongruent pairs and only a difference was found for the A+G- items where typicality ratings were higher than the categorisation scores. Overall, Braisby demonstrated that judgements of categorisation and similarity of natural objects do dissociate, but that the dissociations are context/perspective-dependent. Braisby further argues that “similarity-based models should be seen as models of categorisation-in-context” (Braisby, 2004, p. 155), and that categorisation models should first explain “categorisation-in-context” before explaining judgments of categorisation that are “context-free”. However, it should be noted that the situated simulation view would take that stance that “context-free” categorisation does not exist. The context in which stimuli is provided can be limited, similar to the context-lean condition used in the previous chapters, but thinking about objects is never devoid of any context. Rather, participants’ instantiate their own context on the objects based on the prior knowledge and previous experience with the concepts.

To date, little research has focused on how similarity judgments are affected by action knowledge. However, further dissociations between categorisation and similarity have also been shown by Iachini, Borghi and Senese (2008) by demonstrating how action is recruited and used in such tasks. Iachini et al. (Experiment 1) presented participants with an array of cups that differed in their shape, size and grip (had a handle or not). Participants were shown the cups on a table and performed both a sorting task and a similarity task, where pairs were shown and participants verbally rated similarity on a scale of 1 to 7. The results showed that the grip of the object was used more in sorting the objects but the size of the objects was most prominent for similarity judgments. This pattern was also seen in Experiment 2 where novel objects (boxes with intact or broken handles) were shown to participants and again varied in their shape, size and grip. The results showed that the sorting task was most influenced by the shape and grip of the objects where the similarity task was most influenced by the shape only. Across both experiments the same results were shown depending on whether participants physically interacted with the objects, looked at the objects only, or watched the experimenter interact with the objects (mirror-neuron condition). This shows that the properties used in categorisation and similarity differ according to the goal, but that in line with the embodied view of cognition, categorisation is grounded within, and aimed towards, action.

However, according to Iachini et al., while this might be true of categorisation the same cannot be said for assessments of similarity. The results previously found here in Experiment 4, following the manipulation of task instructions on the triad task (to either pick the item 'most similar' or that 'goes best to form a category'), showed that participants were less likely to pick the action choice when using the similarity instructions. However, despite this, selection of the action choice using the similarity instructions was fairly high (over 50%) under certain conditions, particularly when shown within the context-rich condition. In the context-lean condition the similarity instruction led to high action choice on the SCO triads when the items also shared taxonomic, and arguably perceptual, information with the target (*pencil* and *paintbrush*). Action choices were lowest on the PCO triads where participants were more likely to select the perceptual choice (*cocktail shaker* and *vase*) than the action choice (*cocktail shaker* and *maracas*). This would support the findings of Iachini et al. who found that similarity is based more on perceptual features and that knowledge of action has little influence in such a task.

The aims of the present experiment were to use the same stimuli as in Experiment 2 to further assess how actions are used in judging similarity, and whether the same context effects can be replicated here. Iachini et al. (2008) showed how action is used in categorisation but not in the assessment of similarity using a *within-category* paradigm, since the only objects they used were various cups. Therefore, it is possible that action might not be used to judge similarity between items within the same category. Such similarity judgments might be more dependent on the visual characteristics (size and shape) to distinguish between such category exemplars. Using the same stimuli as the triad task of Experiment 2 it is possible to gauge how participants use similarity in a *between-category* paradigm. Therefore, the primary aim here was to use the same stimuli as the triad task to see if participants would use action as the basis for judgments of similarity. Furthermore, studies into similarity more commonly use rating scales rather than a forced-choice task, which arguably allows for a finer grain of measurement.

A potential criticism of Experiment 4 is that it might be the case that the forced-choice paradigm biases participants to select one item which they might not feel is as similar to the item as the results imply. For example, in the *pencil/elastic band/paintbrush* example participants might think that overall similarity between the *pencil* and *paintbrush* is low, but still more similar than between the *pencil and* the *elastic band* and hence they do not select it. Therefore, while the results would show that participants picked the action choice the design of the task might be inflating what is actually already quite low.

Given the findings of Iachini et al. (2008), along with what was found in Experiment 4 and the previous work showing a dissociation between similarity and categorisation (Braisby, 2004; Rips, 1989; Roberson, Davidoff & Braisby, 1999; Smith and Sloman, 1994; Thibaut et al., 2002), it was predicted that action will not be as influential on the similarity ratings as it was in the triad task. However, given that similarity is dynamic and subject to context effects (Braisby, 2004; Goldstone, 1994; Goldstone, Medin & Halberstadt, 1997; Medin et al., 1993), it was predicted that a main effect of context would be found with higher overall similarity ratings for the context-rich than context-lean conditions.

6.2 Method

6.2.1 Participants

Forty undergraduate Psychology (26 females) students from the University of Hertfordshire took part in the experiment in return for course credit with a mean age of 23.74 (*SD* = 5.82, age range: 18-37). The sample size was calculated following an a priori power analysis using G*Power. Assuming $\alpha = .05$ and $1 - \beta = .80$, the a priori power analysis indicated that a similar effect size to that found in Experiment 1 would be detected using a sample of 26 participants.

6.2.2 Design

The experiment utilised a similarity judgment task presented in a 2x5 mixed design. All participants saw five types of pairings (within-subjects factor) drawn from the triads used in Experiment 2. The pairings therefore shared, either taxonomic membership (*rifle* + *sword*), action relations (*rifle* + *water pistol*), taxonomic membership and action relations (*pencil* + *paintbrush*), action relations but no perceptual properties (*clarinet* + *balloon*) or perceptual properties but no action relations (*clarinet* + *wooden spoon*). This led to the construction of sixty pairings that were presented between-subjects, either as images of the objects on a white background (context-lean condition) or as images of the objects being used in a functional context (context-rich condition). The images were the same as that used to construct the triads in the previous experiments. The dependent variable of interest was the rating of similarity for the paired items.

6.2.3 Materials

The pairs were constructed from the triads used in Experiment 2. A test booklet was constructed in which each page showed a target picture at the top, and, beneath, the two choice options from the triads (see Appendix AG and AH). Each choice option was presented with a scale from 1-7. For example, *rifle* was seen at the top of the page and beneath was *sword* with a 1-7 scale, and *water pistol* lied beneath that again with its own 1-7 scale. With the scale the instructions were written in the form of "on a scale of 1-7, how similar is *rifle* to *sword*". The test booklet consisted of 60 object-pairs across 30 pages. Based on the design of the SCO, DCO and PCO triads there were 20 pairs sharing a taxonomic membership (SCO and DCO), 10 sharing an action relation (DCO), 10 sharing an action relation and taxonomic membership (SCO), 10 sharing perceptual properties but no action relation (PCO) and 10 sharing an action relation but no perceptual properties (PCO). There were more taxonomic membership pairs since both the SCO and the DCO triads contained a target and a match based on taxonomic membership only, such as *rifle*/*sword* and *pencil*/*elastic band*. Two sets of the test booklet were created; in one booklet, participants saw the items as pictures solely on a white background (context-lean condition). The remaining participants saw the items as being used by an agent in a functional based scenario (context-rich condition). The booklets were counterbalanced for the order of the triads (SCO, DCO and PCO) and the presentation of the choice items presented in reverse order to half of the participants.

6.2.4 Procedure

Participants were instructed that they would see a booklet consisting of 60 pairings for which they had to indicate on a scale of 1-7 (where 7 would indicate high similarity and 1 high dissimilarity) how similar they were. Participants were told to work through at their own pace and the experiment lasted for approximately 10-15 minutes. At the end of the experiment the participants were thanked for their participation and debriefed.

6.3 Results

The mean similarity ratings are reported in Table 6.1. The data from two participants was removed from analysis due to printing errors in the booklets. The highest ratings were given to the pairs sharing both an action and taxonomic similarity in both the context-lean (M = 4.45, SD = .58) and the context-rich (M = 4.55, SD = 1.02) conditions. Ratings were lowest in the context-lean condition when the pairs shared perceptual but no action (P-NA) similarity (M = 1.91, SD = .68), but lowest in the context-rich condition when the pairs shared an action but no perceptual (A-NP) similarity (M = 2.08, SD = .50).

A 2x5 mixed ANOVA was conducted on the mean similarity ratings using the item pairs as a within-subjects factor and context as a between-subjects factor[50]. The analysis revealed a non-significant main effect of context as participants tended to give the same similarity ratings whether the items were shown in context-lean or context-rich condition, $F < 1$. The main effect of pairing type was significant using the Greenhouse-Geisser adjustment[51], F (2.87, 103.4) = 102.93, $p < .001$, $\eta^2 = .74$. Post hoc analysis using the Bonferroni adjustment revealed that the taxonomic + action pairs had the highest mean and were significantly higher than all other pair types (for all comparisons $p < .001$). No difference was found between the action pairs and the taxonomic pairs (p = .81). However both the A-NP and the P-NA pairs

[50] For the purpose of this analysis the means for the taxonomic pairs from the SCO and DCO triads were combined for an overall ‘taxonomic only’ similarity pair and therefore the data arose from twice as many items (20) than the other pairs (10).
[51] Mauchly’s test of Sphericity was found to be significant; χ^2 (9) = 28.66, p = .001, and therefore the Greenhouse-Geisser adjustment was used; ε = .72.

were found to be significantly lower than all other pairs ($p < .001$) but no difference was found between them ($p = 1.00$). The paring type factor had a large influence accounting for three quarters of the explained variance in the data. The interaction effect between condition and pairing type was found to be significant using the Greenhouse-Geisser adjustment, F (2.87, 103.4) = 6.77, $p < .001$, $\eta^2 = .16$. Post hoc tests using the Bonferroni adjustment showed that similarity ratings were significantly higher for the A-NP pairs compared to the P-NA pairs in the context-rich condition ($p = .02$) while the reverse was found in the context-lean condition with higher similarity ratings for the P-NA pairs than A-NP ($p = .006$). No effect was found for the taxonomic, action or the taxonomic + action pairs.

Table 6.1.

Mean Similarity Ratings (Standard Deviations) From 1 (Lowest) To 7 (Highest) On The Matched Pairings.

Condition	N	Mean similarity ratings (SD)				
		Taxonomic + action	Taxonomic	Action	Action – no perceptual (A-NP)	Perceptual – no action (P-NA)
Context-lean	19	4.46 (1.02)	3.39 (.99)	3.54 (.80)	2.08 (.68)	2.53 (1.05)
Context-rich	19	4.55 (.58)	3.35 (.84)	3.81 (.97)	2.77 (.77)	1.91 (.50)

The purpose of the second analysis was to look at the competition effect of the action related pairs in the SCO and DCO triads against the taxonomic only pairs. When engaging in the triad task participants are effectively comparing the two choice objects to see which is the ‘better’ match. Participants in the similarity task might be engaging in a similar process given that both choice items were presented on the same page to simulate the process of the triad task. This was tested by separating the means for the taxonomic only pairs for each the SCO and the DCO triads and analysing these separately (the PCO triads were not included in this analysis). A 4x2 mixed ANOVA was conducted on the mean similarity ratings for the SCO and DCO triads using similarity pairs as a within-subjects factor and context as a between-subjects factor.

The main effect of pairs was significant using the Greenhouse-Geisser adjustment[52], F (1.62, 58.24) = 35.36, $p < .001$, $\eta^2 = .50$ (see Figure 6.2). Post hoc analysis showed that the taxonomic + action pairs were significantly higher than all other pairs (for all comparisons, $p < .001$). In particular, there was a significant difference found between the taxonomic only pairs on the SCO and DCO triads with those on the SCO triads significantly higher ($p < .001$). The taxonomic only pairs on the DCO triads were also significantly lower than the action only pairs ($p = .04$). No difference was found between the action only pairs and the taxonomic only (SCO) pairs ($p = 1.$). This shows overall that for the DCO pairs, the action only pairs were rated as more similar to the target than the taxonomic only. The analysis further showed that there was no significant main effect of context, $F < 1$, nor a significant interaction effect between context and similarity pairs, $F < 1$.

52 Mauchly's test of Sphericity was found to be significant; χ^2 (5) = 46.66, $p < .001$, and therefore the Greenhouse-Geisser adjustment was used; $\varepsilon = .54$.

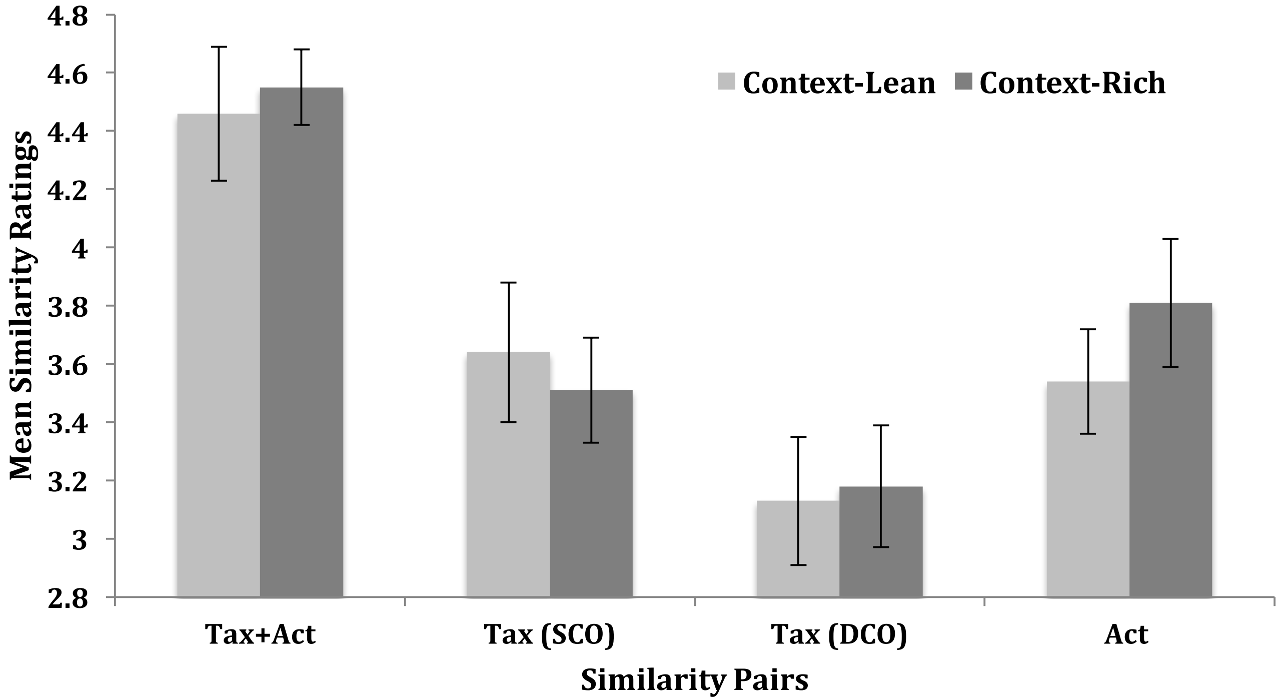

Figure 6.2. Mean similarity ratings on the SCO and DCO pairs across contexts. Error bars represent the standard error of the mean.

6.4 Discussion

The results of Experiment 9 suggest that the more sources of similarity that items have in common, the greater their rated similarity. Similarity ratings were highest when the items shared an action with taxonomic information (and presumably perceptual information), than when taxonomic or action similarities were present independently. This is in line with previous work suggesting that similarity judgments involve a comparison of the stimuli and judged more similar when they have more commonalities between them[53] (Tversky, 1977; Wisniewski & Bassok, 1999[54]). The overall means from the initial analysis showed that there was no difference between the pairs that were matched on taxonomic information only and action only. The data in the second analysis from the competition effects on the pairs developed from the SCO triads shows that the taxonomic + action pairs were rated significantly more similar than the taxonomic pairs. Therefore, action has again been shown to have an additive effect in increasing similarity between items that share both an action and a taxonomic relation.

The ratings from the DCO triads show that the action only items were rated as more similar to the target than the taxonomic only items. This would support the conclusion that action is more likely to be used in judging similarity than taxonomic information. However, this claim is not supported given the results of the pairs developed from the PCO triads. The similarity scores on the action-no perceptual (A-NP) pairs was overall very low showing that action plays very little role on its own when judging similarity. If it was the case that participants were rating the action pairs based on action, then in the A-NP pairs developed from the PCO triads they should give higher similarity ratings than were seen in the data. In addition, given that the overall means on the action only items were fairly low (M = 3.68, out of 7), this might indicate that action on its own does not form a strong assessment of similarity.

However, it is also clear that perceptual properties are not the driving factor here in making similarity judgments as the ratings on the perceptual-no action (P-NA) pairs was also very low. Such scores should be high if similarity judgments were primarily a perceptual process. It is most likely the case that judging similarity

[53] These commonalities may not all be of the same type, e.g. shared perceptual properties or shared themes or, as it seems to be the case here, shared actions.

[54] However, while Tversky (1977) and Wisniewski and Bassok (1999) found that items are rated more similar when they have more respects in common, it should be noted that action, as defined in this thesis, was not manipulated in these tasks nor considered to be a relevant source of similarity.

depends on the weighting of multiple commonalities used and perhaps a difficulty within research, is to assess which features have the strongest influence. It is clear that not all sources of commonality between objects would be 'weighed' the same. Those sources of commonality between objects that present as being more salient given the context and goal of the situation would be weighted as more important. Hence, such sources with stronger weightings are more likely to influence similarity judgements. In the current task, taxonomic information was weighted quite strongly as a source of commonality and was influential in the task. Those items sharing both a taxonomic and an action received the highest similarity rating because the shared action was also weighed in the context of the task. The shared action was identified as a source of commonality and this produces the additive effect seen on the SCO triads. The A-NP pairs share only action which, on its own, does not produce a strong weighting and hence similarity judgements were low.

Within the current research, it is difficult to establish whether the high ratings on the action pairs (e.g. *rifle* and *water pistol*) were due to the shared action or perceptual characteristics. The most plausible explanations are that (i) the objects were weighed as being similar based on both action and perceptual characteristics, or that (ii) the objects were aligned on a third dimension outside of those proposed. Both explanations are plausible, however the former explanation is most likely true because participants were assessing the objects based on both action and perceptual characteristics. If participants were rating them solely on perceptual characteristics then the means would be similar to those of the perceptual-no action (P-NA) pairs. Equally, if participants were rating them based only on action then the ratings would be similar to the A-NP pairs. Neither case is true, and the ratings for the action only pairs were significantly higher than the PCO pairs.

As discussed in Chapter 2, the ideal method in which to test the action/perception distinction would be to have pairs that shared a taxonomic and perceptual relation but no action, and pairs sharing a taxonomic and an action relation but no perceptual properties. While the former is possible the latter is not, especially not with artefacts. This is because items in the world are designed to work within the ergonomics of the human body and therefore items operated in the same manner will invariably share perceptual properties. However, what is evident here is that judging similarity is not based on unitary properties but the combination of several similarity sources together including the shared actions between the objects. The pairs rated the highest were those that had the highest level of combination between similarity sources, and those that were the lowest had only a single shared source amongst them. Taxonomic information seems to be more salient given that the pairs sharing only a taxonomic relation were rated more similar compared to those sharing only an action (A-NP) and only perceptual features (P-NA). However, in a similar manner found on the categorisation task, it does appear that action has a weaker influence as a source of similarity when on its own, but does have a strong additive effect.

Analysis of the competition effects of the pairs formed from the SCO and DCO triads also showed that the taxonomic pairs from the DCO pairs were rated as less similar to each other compared to the SCO pairs. This is an interesting finding since theoretically speaking there should be no difference between these as they share the same relation. What is evident is that the inclusion of the opposing choice (the taxonomic + action pairs from the SCO triads, and the action pairs from the DCO triads) modulated their similarity response, hence creating a 'framing' effect. In the task, all three items from the triad were presented on a single page with the target at the top, and the two choice options beneath accompanied by the rating scale (see Appendix AG and AH). The similarity ratings were higher for the taxonomic pairs when the other choice on the page was a taxonomic + action pair. It might be the case that on such pages an overall taxonomic category becomes more salient for the participant given that all three items come from the same category and is weighted more as a strong source of similarity. Such presentation might automatically increase the viewed similarity between the items. Hence, participants find all the items more similar, and the taxonomic + action choice becomes even more so given that it shares additional sources with the target.

However, on the DCO pairs the overall category is not as salient as it is in the SCO pairs, and the taxonomic only pair is judged as similar without category membership being such a salient factor as it is on the SCO pairs. Therefore, the taxonomic only pairs from the DCO triads were understandably rated as less similar than those from the SCO triads when presented in such a context. This supports the idea raised in Chapter 2 that the design manipulation of the triads modulates task response and that participants are using different processes for different triads. What the SCO triads encourages is a more 'global' strategy focusing on and using the shared category membership between all the items where as the DCO triads encourage more of an 'individualised' (local) strategy weighting the salient features of each choice item against each other. This is in line with previous research suggesting that variations of material presentation modulates task response (Braisby, 2004; Goldstone, et al., 1997; Medin et al., 1993). As such, this demonstrates how judgments of similarity are sensitive to all aspects of the 'context' of the design manipulation. While it is possible here that the saliency of the shared category membership is increased on the SCO pairs, it should also be noted that the overall similarity ratings were fairly low with the Tax+Act pairs receiving the highest mean (M = 4.61, out of a maximum of 7). The data further show that the shared category membership is based more on functional information than perceptual, given that the P-NA pairs received very low similarity ratings.

It is possible that the similarity ratings on the A-NP and P-NA pairs were low because participants were assessing similarity on the PCO pairs based on ad hoc categories (Barsalou, 1983), but assessing similarity on the SCO and DCO pairs based on taxonomic categories. This might also explain why the similarity ratings for the PCO pairs were the lowest given that Barsalou (1982) found that members of common categories were rated as more similar to each other than members of ad hoc categories. Given that such categories of "things that you shake" are not very salient or concrete, this might explain why the similarity ratings between such pairs are low. This supports the notion that participants are using different strategies on each trial, and that there are variations both with and between categorisation and similarity.

An unexpected finding here in the current experiment was the absence of a significant main effect of context. Across the pairs a main effect of context was not found suggesting that context, as defined by the parameters of the thesis, does not increase similarity ratings. This is surprising given the results reported in Experiments 2 and 4 and given the notion that previous research suggests that similarity ratings are dynamic and influenced by context (Braisby, 2004; Goldstone, 1994; Goldstone et al., 1997; Medin et al., 1993). As such it appears that context (as defined within this experimental work) is not salient enough to increase the overall similarity between the pairs and that showing the items in context activates no further information that was not already activated by the context-lean condition. As posited previously, one possibility here is that such differences have been found because of the way in which 'context' has been operationalised. For the purpose of the presented experimental work, context is operationalised in terms of images showing scenes of the objects being used by an agent. In contrast, Braisby (2004) altered context in terms of giving participants a different 'perspective' from which to think about their choice. Barsalou (1982) showed that providing a contextual category heading decreased differences in similarity ratings between common and ad hoc categories. Alternatively, Goldstone et al. (1997) altered context in terms of how a range of stimuli (faces in Experiment 2A and 2B) shared a varying number of features with a target. It could be that the 'context' of the design manipulation does influence similarity judgments, but manipulating the visual context (context-lean vs context-rich) does not. However, it is also possible that the context does increase the saliency of the shared actions between the items but that this is not used in the context of already present taxonomic and perceptual information.

However, despite the fact that the main effect of context was non-significant, what is interesting is that the interaction between context and pair type was found to be significant. Dissociations were found between the A-NP and P-NA pairs when presented in context. In the context-lean condition the similarity ratings were significantly higher for the P-NA pairs while the A-NP pairs were rated as significantly more similar in the context-rich condition. The data from the similarity ratings here is consistent with, and does track, the data from Experiment 4 where participants performed the triad task with the "most similar" instructions. In Experiment 4 participants were more likely to select the perceptual choice (e.g. *vase*) on the PCO triads in the context-lean condition, indicating that they found it more similar than the action choice. In the context-rich condition, participants were more likely to select the action choice (e.g. *maracas*). This pattern is reflected in the similarity ratings where the perceptual choice was more similar in the context-lean condition, and the action choice was more similar in the context-rich condition. This would therefore suggest that context increased the saliency of the shared actions between the objects on the PCO triads. If this were the case, then this would result in a context-based increase, as found in the data, but does not explain why the perceptual related pairs (*cocktail shaker* and *vase*) decreased in similarity. However, the latter can be explained by the use of perceptual information in making such judgments in the absence of taxonomic information. In the context-lean condition the objects are very clear in the sense that they are presented on a white background and as such any visual similarities are very clear. However, in the context-rich condition the same cannot be said due to the agent in the image. It is possible that the agent holding the items are partially obscuring elements of the objects, which impacts on the shared perceptual qualities between them. As the participants cannot see all aspects of the objects then this decreases the shared perceptual characteristics of the objects and as such decreases overall similarity with the target object. It seems that shared action is more likely to influence similarity between these items when presented in context, given the differences found in context on the A-NP pairs. However, the similarity ratings for such items were still very low and close to floor effects. Therefore, similarity judgments are more likely to rely on shared taxonomic properties. The findings from this task, compared to the triad task, fall in line with Iachini et al., (along with the data from Experiments 2 and 4) that action is more likely to influence categorisation than rated similarity judgements of the same items.

Overall, the results from the current experiment show how similarity judgements are influenced by action knowledge, having an additive effect when presented alongside taxonomic information. However, action does not appear to be as influential when it is the only shared relation between items. Pairs developed from the PCO triads showed that while action may serve on its own as some source of similarity, it is not very influential and such ratings are low and close to floor effects. This shows that potential sources of similarity are differentially weighted in the similarity judgment and that some sources are more influential than others. In addition, against strong predictions that it would, context seemed to have little influence on judging similarity of the items. However, it does appear that on such judgements of similarity what is most influential is not the between context manipulation (comparing visually rich compared to lean stimuli) but the design manipulation of the stimuli used from each triad type and how the pairs are visually presented against each other.

Chapter 7

The Influence of Action Knowledge

The aim of the thesis was to assess (some of) the circumstances under which action is used in complex categories on an action-irrelevant task. The research has demonstrated that action is most likely to be used for categorisation when (i) it is presented in conjunction with taxonomic information as in SCO triads, (ii) it is presented with a context, and (iii) when participants are first asked to physically interact with the objects. In addition, action has been shown to be influential in judging similarity as it has been in categorisation. Across both tasks, action has shown to have a strong additive effect when combined with taxonomic information, but a weaker influence when presented on its own.

Chapter 7 discusses the experimental results in light of Simulation Theory (Barsalou, 1999, 2003, 2008) and how different sources of commonality are 'weighed' in conceptual tasks. The effect of context is discussed in terms of how the images 'narrow' the possible range of simulations that could be generated, which raises the saliency of the shared actions between the objects. In addition, the 'time' elapsed during the simulation is discussed as a potential factor for increasing likelihood of using action as a salient source for categorisation.

Also addressed, is the importance of different actions. The triad task was originally designed with the assumption that different actions are 'equal' in their contribution to concept knowledge. The suggestion made here is that this is not the case, and that different actions will vary in their relative importance based on various factors including time, goals, physical effort and familiarity. Proposals for methodological improvements are presented along with suggestions for future research.

7. Challenging Traditional Categorisation

Chapter 7 discusses the experimental research presented within this thesis in light of Simulation Theory (Barsalou, 1999, 2003, 2008). The work discussed here has been broken down into the following sections:

(i). Research Findings
(ii). The Additive Effect of Action
(iii). Action in Context
(iv). Physical Object Interaction
(v). Judging Actions as Similar
(vi). Are All Actions Equal?
(vii). Task Specificity
(viii). 7.4 Critiquing Simulation Theory
(ix). Potential Methodological Improvements
(x). Empirical Contributions
(xi). Future Work
(xii). Conclusions

7.1 Research Findings

It seems uncontroversial to claim that the brain organises experience in memory in such a way that it can be informative in supporting our ability to successfully negotiate our environment. In the case of experiences of objects, the organisation seems to take the form of categories that allow us to quickly identify aspects of the environment and make predictions about them. In the categorisation of objects, an important line of research has been the investigation of which 'features' of objects form the basis of a category. Traditional theories suggested that shared functional, perceptual and biological features play a strong role in explaining many categories (Rosch, 1975; Rosch & Mervis, 1975; Rosch, Mervis, Grey, Johnson & Boyes-Braem, 1976; Rosch, et al., 1976). For example, the category of 'weapons' develops around the functional property of being able (and having been designed) to inflict damage/injury. However, this is not to say that the categories comprise an "all or nothing" approach whereby the objects are either in or out of the category, possessing such a property or not, but rather they are probabilistic in nature (Medin & Smith, 1984; Smith & Medin, 1981). A challenge to this single notion of category coherence has arisen in the past 20 years following the evidence that thematic relations between items, that share few (if any) perceptual, functional or biological features, can influence category decisions by adults since participants have been shown to also group objects together by shared situational co-occurrence[55] (Kalénine et al., 2009; Lin & Murphy, 2001; Murphy, 2001; Simmons & Estes, 2009). Following the experimental work conducted through Chapters 2 to 6, the conclusion to be presented here is that, in addition to taxonomic and thematic relations, there is sufficient evidence to believe that an account of the role of action in categorisation is merited.

The aim of this programme of research was to use an action-irrelevant categorisation task to investigate the conditions under which action may influence categorisation performance (using a triad task). Additionally, the thesis investigated how action influences similarity judgements given the close relationship that exists between categorisation and similarity (Brooks, 1978; Goldstone, 1994; Hampton, 1995; Rosch & Mervis, 1975). While previous research has shown the influence of action on category decisions (Borghi et al., 2012; Kalénine et al., 2014), such research has done so using very broad classifications of objects such as 'natural' and 'man made' What the experimental work presented here has shown, is that action can influence decisions on more complex categories. The research has shown three main circumstances under which knowledge of action becomes influential in the triad task designed for the purpose of this research. In particular, the research has demonstrated that action is most likely to be used for categorisation when (i) it is presented in conjunction with taxonomic information as in the SCO triads, (ii) it is presented with a context, and (iii) when participants are first asked to physically interact with the objects.

7.1.1 The Additive Effect of Action

A consistent finding across the experiments using the triad task was that participants were significantly more likely to select the action choice on the Same Category Object (SCO) triads in comparison to the Different Category Object (DCO)

[55] The term feature/property is typically used to denote physical aspects of objects. For example, *metal* and *flat head* are both features of hammers. It could be argued that, theoretically, thematic relations such as *kept in a toolbox* is not a feature of hammers. However, as research has shown that participants who engage in property generation tasks do generate thematic properties (Wu & Barsalou, 2009) they are, for the purpose of the thesis, considered as a feature.

triads[56]. Therefore, knowledge of a shared action needed to use the objects seemed to enhance the attractiveness of the same category member as a suitable choice in this task. The objects already had a taxonomic relation and having an additional action relation made them a "better" match in the task. In comparison, when a shared action was directly pitted against a taxonomic relation in the DCO triads, participants were less inclined to make action-based categories. At face value, this would suggest that action is not as influential in this task as taxonomic relations. However, it should be noted that this effect was not consistent and for some triads the shared action alone was sufficient for participants to select it in the triad task (see Chapters 2 and 5). Therefore, action primarily gives rise to an additive effect in the triad task since it was more likely to be used in the SCO triads alongside taxonomic information. This is reminiscent of previous research from Wisniewski and Bassok (1999) who showed that thematic information had an additive effect in enhancing similarity, and to Tsagkaridis et al. (2014) who showed that action had an additive effect in thematic relations (see Chapter 1 for an explanation of how such research differs from the present experimental work). However, it should be noted that the use of the PCO triads in this work showed that under certain conditions action can act as the basis of category membership on its own. For example, on the *clarinet* triad participants showed a strong tendency to select the action related item (*balloon*) over the perceptual competitor (*wooden spoon*), which should, according to a traditional stance, be the preferred choice given the strong perceptual commonality in both objects. The fact that participants were more likely to choose *balloon* shows that under certain circumstances, action is sufficient to act as a basis for categorisation.

In the case of SCO triads, the possibility exists that participants were playing a 'numbers' game, and that selection of the action item occurred because it shared two sources of commonality (action and taxonomic characteristics) rather than the taxonomic choice sharing only a single source. This is believed not to be the case and there are multiple reasons to argue for such. First, if this were the case then participants should be more likely to select the action choice on the DCO triads where the action choice in many cases also shared (arguably) perceptual characteristics with the target. For example, *rifle* and *water pistol* share an action, but also perceptual

[56] The only exception to this was in Experiment 6 reported in Chapter 4 where no difference was found between the SCO and DCO triads and a potential explanation for this is discussed there.

characteristics. However, participant performance on the *rifle* triad, for example, showed that participants were most likely to select the taxonomic choice (*sword*), which would not be predicted in a 'numbers' game. Second, if this were the case then participants would consistently be more likely to select the action choice on the SCO triads. This was not the case, and there were wide variations in selection of the action choice across the triads; participants did not always select the action choice, which would be predicted in a 'numbers' game. Third, participant performance on the Perceptual Object Category (PCO) triads showed that participants were more likely to select the action choice over the perceptual choice, particularly when shown in the context-rich condition. In these triads, the choice items only shared action or perception with the target and thus performance could not be explained by selecting the choice with most sources of commonality. That said, on the PCO triads participants did show a tendency to select the action choice.

The results of the protocol analysis in Experiment 8 support the notion of action having an additive effect. Categorisation is both 'rich' and 'fluid' and participants can use a variety of strategies in order to group objects together. While it was a concern that participants were categorising the objects based on alternative reasons, the protocol analysis does show support that participants were consciously drawing upon action knowledge. For some of the triads, participants selected the action choice but did not report action as being the reason for doing so. However, for the majority of the triads, participants selected the action choice and reported the action as being a reason for doing so. In many cases, participants would report multiple reasons for doing so, which were broken down into part protocols. The action reason in many cases supported their choice. For example, participants selected *banana* with *orange* because "both are fruit and both have to be peeled". Despite the arguments against using protocol analysis (see Chapter 5 for details), there are good reasons to be confident that participants were drawing upon action knowledge to categorise the objects together.

Across the experiments, age and gender were tested to see if they had any confounding influence on the selection of the action choice. The results showed that age had no effect and that selection of the action choice was consistent irrespective of the participant's age. For the most part, gender appeared to have little to no effect. Only in a few instances across the experiments did gender have any influence on the scores. In these studies, it did appear that males were more likely to select the action choice than females. However, the results were highly inconsistent and not replicated across the experimental work. Therefore, it is possible that any increase in the action scores was not due to the gender of the participants, but additional factors outside of those measured here such as physical familiarity (Yee et al., 2013). While the gender results are inconsistent, this does highlight an interesting avenue of research.

7.1.2 Action in Context

The experimental work in Chapters 2, 4, and 5 consistently showed that participants were more likely to select the action choice when presented in a functional context. It seems that the shared actions between the objects were made more salient when shown in context. The theory of concept simulation (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006) has been drawn upon to explain this effect.

According to Barsalou (2003) objects are not simulated "context-free", but are always situated within a relevant scenario. Under this view, when participants see the objects in the context-lean condition, they can instantiate a wide variety of possible situations. Consider the *orange* and *banana* example. In the context-lean condition, no specific scenario is suggested and therefore participants could instantiate a wide variety of situations such as buying them, walking around a shopping market, eating them, putting the into a blender or even peeling them. As such, the simulations can be generated from a wide range of potential scenarios.

In contrast, the context-rich condition presents the participant with a specific scenario that should directly influence how participants simulate the objects. The simulations are 'guided' by the context and should mirror[57] that seen in the context images, which in turn should highlight the associated actions by showing them in use by an agent. Therefore, under such contextualised conditions, the simulations are more restricted and hence the action choice becomes more salient in the task[58].

[57] It is noted that the simulations would not be exactly the same as that indicated by the context, and should be based within the participants' own experience. While it is not exactly the same, the simulations should 'mirror' to an extent that they are very close in nature to that suggested by the images used.

[58] In presenting this work at the 2016 Annual Conference of the Cognitive Science Society, a suggestion was made that any context used would increase the action choices and not necessarily need to show the functional actions. Given the wide variety of possible situations in which objects occur it is believed that this is not the case. Objects shown in different contexts would make certain features more salient than others and hence might not focus on the shared actions. Such information would then not be as influential in the triad task used here. This is in line with previous research showing how certain object features become more salient under different contextualised conditions (Barsalou, 1982; Borghi et al., 2012).

However, what was not strictly controlled here was the exact nature of the context that participants saw in the triads. The images themselves varied and while they all showed the objects being used, some showed the agent in full using them while others only showed the agents' hands on the objects. Chapter 5 showed that differences in triad performance directly arose from the images used, and intimated that showing the agent in full led to a higher proportion of action choices on the triads. This will be discussed later in this chapter as future work needs to examine the effect of the context in which the objects are seen (either as just hands on the objects or as a full agent using the object for its function) more systematically in order to identify what it is about the provision of 'context' that seems to raise the salience of the actions.

An initial analysis of the results of Experiment 2 led to the inference that participants were particularly focusing not on the objects, but on the hands of the agent interacting with the objects. This was investigated in Experiment 5 using eye tracking, to investigate what aspects of the objects participants were looking at. The results showed that participants spent very little time looking at the individual hands interacting with the objects, but rather looked at the image as a whole. This would also support the notion of concepts being contextualised, in that participants were more likely to select the action item when viewed as a whole image. This might arise because the whole scene is included within the situation, not just the hands and the object. What this suggests is that viewing the scene as a whole and absorbing the additional information provided by the image, would be more likely to 'narrow' the simulation to guide a specific scenario. However, it should not be forgotten that a certain number of action choices were made in the absence of context.

7.1.3 Physical Object Interaction

Chapter 4 (Experiment 6) showed an interesting finding whereby participants were more likely to select the action choice after they had first used the objects for their functional purpose. This was compared against participants categorising the objects, or moving them around for a general purpose not related to their function. The explanation proposed in Chapter 4 is that the functional actions created a 'recency' effect on the contribution of action to their simulations. Simulation theory (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006) suggests that how recently we have interacted with objects directly influences the simulation created when thinking about them. As such, the functional action of the objects was simulated and therefore participants were more likely to select it in the triad task. However, as can be inferred from Experiment 6, it is important that actions performed by the participants should be directly related to the function of the object in order to increase likelihood of the action choice being selected. As discussed in Chapter 4, the possibility also stands that interacting with the objects results in long-term functional activations (Binkofski & Buxbaum, 2013; Buxbaum & Kalénine, 2010; Jax & Buxbaum, 2010). The long-term activation of the ventro-dorsal stream remains active during the triad task, which acts in a facilitatory effect when participants simulate the objects in the triads. The same effect does not happen when participants perform structural actions because activation of the dorso-dorsal stream rapidly degrades (see Chapter 4 for further details).

7.1.4 Judging Actions as Similar

In addition to using the triad task, the thesis also investigated how action knowledge is used in making similarity judgements. As outlined in Chapter 6, many traditional models of categorisation place a strong emphasis on similarity as a key component of categorisation (Medin & Schaffer, 1978; Rosch & Mervis; 1975; Rosch et al., 1976). Given that categorisation and similarity are often seen as related processes, with the former depending upon the latter, it is reasonable to hypothesise that factors affecting categorisation might also affect similarity. However, Iachini et al. (2008) showed that action information (how to grip the object) influences categorisation but not similarity judgements. In contrast, the research reported in this thesis demonstrated that action *can* exert an influence on similarity judgements.

Chapter 6 reported that the additive effect found on the triad task, was also found in similarity judgements. On the pairs developed from the SCO triads, those matched on both action and a taxonomic relation were rated as more similar than those matched only on taxonomic information, mirroring the predominant choice made on the triad task. The object most likely to be selected in the triad task was also the object rated as most similar. However, while higher similarity ratings on the SCO pairs reflected this additive effect, in the absence of any other relations, shared action was not a strong influence on similarity judgements. On the pairs developed from the PCO triads where they shared only an action, the similarity ratings were low and close to floor effects. This might seem to be inconsistent with the results from the instruction task. For example, on the PCO triads used in Experiment 4 participants were more likely to select the perceptual choice as being most similar. While this might suggest that the perceptual choice was most preferred, it is based on an experiment where participants were forced to make one choice over the other (see Section 7.3). In Experiment 9 where participants gave ratings of similarity, neither choice was rated as highly similar and ratings were, overall, exceptionally low. This would suggest that there is more to rating similarity than focusing on action or perceptual characteristics. Therefore, while action had an additive effect in judging similarity, taxonomic information was the main source for assessing similarity.

The process used to assess similarity could explain why action has an additive effect (SCO triads). In judging similarity, participants will ‘weigh’ the sources of commonality and base their assessment on those elements more salient. On the SCO triads, the objects already have a strong weighting given that the objects all share a taxonomic relation. Action is entered as another ‘source’ of similarity that is weighted into the judgement. The additive effect occurs because the shared actions are weighted alongside the taxonomic information and the action item becomes more ‘similar’ to the target than the taxonomic only choice.

There are numerous factors that will affect the importance of those sources of commonality that are drawn upon in assessing similarity, including context and recency. If it is the case that action information is weighed into the similarity judgement, then the type of goal the items (potentially) share should reflect the similarity ratings. For example, items from the SCO that share an action also come from the same category. As such, the functional goal of the objects is likely to highly related. For example, a pencil and a paintbrush could be used in creating art, and are therefore related to each other. This would lead to a high similarity rating. In contrast, the action related pairs from the PCO triads will share the same action, but are not related to a specific goal. While the items could potentially form an ad hoc category, the actions are less likely to be related to each other because such categories are not well defined. This would lead to low similarity ratings, as seen in the PCO triads.

What is not clear is why the action related items in the DCO pairs were higher than the action related pairs in the PCO pairs. Theoretically speaking, the ratings on both pair types should be close because they share the same rule (sharing only an action relation to the target). However, the higher similarity rating on the DCO pairs could be the result of two factors. First, the PCO items were designed so that the objects shared no perceptual characteristics, only a shared action. The perceptual characteristics of the DCO items was not systematically manipulated and therefore, the DCO pairs could be more similar because they are inflated by shared perceptual characteristics. Second, the presence of the competitor could have inflated similarity ratings. For example, the target/taxonomic item pairs in the DCO condition were rated as more similar than the PCO target/perceptual item pairs. This could have potentially inflated the score on the action item by acting as a "positive context", and led to participants giving it a higher similarity rating. It is believed that the former is a more likely explanation for the pattern seen in the data, but this could not be tested without developing new triads where the strength of the competitor is manipulated.

Also of interest was variation in performance within the triad types. This could be the result of the type of action performed in each pair, and of certain actions being more salient than others (see Section 7.2). Watson and Buxbaum (2014) have argued that the semantic similarity of tools is determined by the amount of 'featural overlap'. In their research, participants rated tools based on how they are used. Specifically, participants rated (i) the amount of arm used, (ii) the distance the arm travels, (iii) the amount of forced used, (iv) the surface area of the hand, and (v) the peripersonal direction of whether the objects are used towards or away from the body. Following Latent Semantic Analysis (Landauer & Dumais, 1997) and multidimensional scaling, Watson and Buxbaum showed that actions are judged as being similar based on the magnitude of the arm movement and the configuration of the hand. This offers a clear explanation for the differences found in the triad task between the objects, and between the different types of action. Objects that share the same functional actions would share high similarities on arm movement magnitude (AMM) and hand configuration (HC). However, there will be natural differences between objects that require different actions. Watson and Buxbaum did show that objects cluster together based on AMM and HC. Objects share actions based on how they cluster together within the "action space" of AMM and HC. Therefore, those that lie on the extremes of such dimensions might be rated as more salient, because they are most unique compared to how other objects cluster. Given that differences occur within the same action space, this can provide a clear explanation for why different actions within each triad type were rated as more/less similar than others.

Overall, the experimental work has shown that action has an additive effect in judgements of categorisation and similarity. However, differences arise between such when action is recruited on its own in both tasks. Action has been shown to, when presented in context, act on its own in making category judgements but seems to be a weaker source of similarity assessments. Therefore, the research has added to our understanding of the potential sources of information may enter into considerations of category membership and similarity.

7.2 Are All Actions Equal?

While traditional models of categorisation suggest that concepts are abstracted from context, the theoretical and experimental evidence outlined in Chapter 1 has shed light on how conceptual knowledge is contextualised. Simulation theory (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006) posits that concepts are simulated within a specific context by partially re-instantiating the neurons that were active at the initial encounter. As outlined above, the results here are explained in terms of simulation theory. Presenting the objects in context is believed to have guided the participants' simulations such that the shared action was made more salient. Such an explanation should predict that participants would always select the action choice, and that the effect of context should be consistent across all the triads. However, this was not the case. The reasons as to why participants vary in terms of selecting the action choice or not has been explored above. The simulations created are guided by the context, previous experience and individual differences, all of which play a role in the simulations. It is a decision made which could be based on various aspects of the simulation. Therefore, it is possible that participants simulate the actions but may still weigh other factors as more influential in categorising the objects.

Two relevant questions to address here are (i) why the effect of context is not consistent across all of the triads, and (ii) why some triads are "better" than others in terms of high selection of the action choice[59]. What has not been discussed previously, and could explain both of the above questions, is the 'temporal nature' of the simulation and what is included. Research would suggest that participants are quick to simulate (Barsalou et al., 2008; Simmons et al., 2008; Santos et al., 2008) but does not suggest how long the simulation might last for, nor the internal content of the simulation and how much 'time' in the event is covered. For example, in simulating

[59] It should be noted that these two questions are interconnected. For many examples of the triads, the effect of context was more consistent when they were "better" examples.

the *water pistol* participants might simulate only grasping and squeezing the trigger, or the full sequence from filling it up with water to pulling the trigger and the consequences of such an action. To the best of the author's knowledge, this has not been discussed and it is assumed that the simulations contain the actions, but has not specified how much more additional information is also simulated. Furthermore, some actions take longer to perform than others. For example, the action of typing on a computer or playing a piano[60] arguably takes a lot longer in both real time and (presumably) 'simulation time', than turning a key or pushing a plug into a socket. If this is reflected in how participants simulate the objects, then the simulations should vary in 'temporal length' according to how long it takes to perform them.

What is argued here, is that both factors influence the simulations and hence how action may exert its influence in the triad task. It is suggested that participants not only simply simulate the initial interaction with the objects (as originally anticipated when designing the triads) but also simulate the *ongoing sequence* of events. Therefore, participants may not only simulate the specific agent/object interaction but also the goal that leads the action to be initiated. The variation of the influence of action between the triads may be linked to the length of the action sequence, and the time the action itself takes to perform, with the prediction that the longer this mental simulation takes the more likely it is that the shared actions become a salient feature used in the triad task. As the simulation-time duration increases, participants might be more likely to select the action choice in the triads. Though it should be noted that there is no suggestion that participants simulate in real time, particularly given how simulations are rapidly instantiated (Barsalou et al., 2008; Simmons et al., 2008; Santos et al., 2008).

The explanation above might be difficult to test experimentally, especially in the context of the triad task. Since simulation-time duration could not physically be measured externally, only an estimate could be requested from the participant, which in itself would not be an accurate measure. As suggested above, simulations are quick to instantiate (Barsalou et al., 2008; Simmons et al., 2008; Santos et al., 2008), which is also reflected by fast reaction times on the triad task. Within the time it would take for participants to potentially describe their simulations (assuming that participants

[60] Depressing a single key would be a very quick action for both typing and playing a piano. It is assumed that when people simulate both actions they do not simulate depressing a single key (as this is less reflective of real life), but simulate a longer action of 'typing' and 'playing'.

could do this with some level of accuracy), they may have already chosen their preferred object in the task. In addition, the act of describing the simulation might cause participants to change their mind. Participants might decide that the alternative is a better match for some reason, or even select the same object but using a different strategy to do so compared with their initial decision. Designing a new set of triads in which the 'action length' is systematically manipulated would theoretically help to address this issue. For example, designing new triads (both DCO and SCO) where the actions are longer for one set than the other. However, such a triad set would be difficult to design given the complications in perceptual, action and taxonomic relations already outlined in previous chapters (see Chapter 2 for further details).

It is suggested above that the longer the simulation, the more likely it is that action is chosen in the triad task. However, it is possible that with potentially long simulations the action choice is actually made less salient. Consider the following example. First, a participant simulates peeling a banana (taking a few seconds to do) and eating it. Since the simulation only contains two elements, peeling and eating, the shared action becomes a salient aspect of the simulation (comprising of approximately 50%[61]). Second, a participant simulates making a smoothie by peeling a banana, adding it to a blender, adding other fruit, and pushing the *on* button. In this example, the *peeling* action would be less salient in favour of the overall goal of the situation. Therefore, in the *orange/banana/strawberry* triad participants might be tempted to group those objects together which they prefer to make a smoothie. This might suggest that action has an 'optimum saliency level' where it might be under or overwhelmed by other elements in the simulation. However, this could be said of any potential categorical source where features of objects are made more salient given the context in which they are presented. Furthermore, a potentially long simulation might have multiple actions within it. For example, bananas and oranges require both peeling and eating. Therefore, while the initial action might present as more salient at the beginning of the simulation, this may be overridden by any subsequent actions that become more salient. The reverse is also possible, that when two objects require different actions then this may distinguish one object from the other that may be chosen given how distinct it is.

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[61] This is calculated based on the number of potential elements within the scenario. It is not suggested here that participants would spend the same amount of time peeling the banana as they would eating it.

The research outlined to this point, and the explanations for the triad choices, has made a critical assumption that should be addressed here. It has been assumed that all potential actions have the same level of importance in how conceptual knowledge is structured. For example, the ‘trigger’ action of the rifle is assumed to be just as important as the ‘shaking’ action of the cocktail shaker and the ‘inserting’ action of the plug. If this were the case, then the action effects should be consistent across all of the triads and that objects are either grouped by action or not. While this might be the case, the suggestion made here is that this is not so. This is based on several findings from both the present and the previous research. First, previous research has shown that there are differences in the planning and execution of different types of actions. Bub and Masson (and colleagues) have shown that functional actions are quicker to instantiate and take longer to dissipate compared to volumetric actions (Bub & Masson, 2006, 2010, 2012; Bub et al., 2008; Masson et al., 2008). Their argument, along with the arguments of others (Barsalou et al., 2005; Barton & Komatsu, 1989; Chaigneau & Barsalou, 2008; Chaigneau et al., 2004; Chaigneau et al., 2009; Keil, 1989), is that functional actions are more important in conceptual knowledge. This is certainly plausible given the notion that artefacts are designed, and conceptually stored, based on their function and not based on abstract and ‘potential’ volumetric actions. It is not plausible that the human conceptual system stores a long list of possible volumetric actions, but that such actions are guided by the fluid nature of current goals and situational information. Therefore, certain types of actions are more important than others. Second, certain real world categories put more emphasis on certain features than others. For example, fruits and vegetables are strongly based on biological features where tools are strongly based on functional and thematic features. Other features, besides action, vary in strength based on both the category and the context. It would be illogical to assume that the saliency of other properties varies across categories and context, but action does not[62].

While this variability has been attributed to numerous factors such as the context, how the triads were manipulated and the “strength” of the competitor, it is possible that this was because certain actions are simply more salient than others. In certain triad examples, selection of the action choice was not only high, but also consistent across the various experiments conducted in this thesis. In particular, as

[62] Chapters 2 and 5 have shown that the influence of action does vary across categories and context.

outlined in Chapter 5, the *orange* and the *clarinet* triads were most likely to encourage selection of the action choice. This could be linked to (i) the length of the simulation as outlined above, (ii) the strength/importance of the end goal, (iii) the amount of physical effort required to perform the action, or (iv) the familiarity the action. In particular, the frequency of the action could be most influential in leading to selection of the action choice. In a similar manner to how distinctive stimuli leads to better recall (McDaniel & Einstein, 1986), distinctive actions might stand out within a given scenario and hence be more salient in the simulation. Indeed, other triads that arguably require large amounts of energy to perform the associated actions showed high levels of action choices (e.g. *axe*, *baseball bat*, *cocktail shaker*). Therefore, based on the above points, it is believed that not all actions are 'equal' in how they contribute to conceptual representations. It was initially assumed that the effects seen within the triad sets would be homogenous, but clearly this is not the case and directly reflects the difficulty in developing a homogenous set of items in all the respects outlined above.

7.3 Task Specificity

Previous research has shown that shared actions can be influential in grouping objects together in an action-irrelevant task in which knowledge of shared actions is not necessary for task performance. Research has also shown that such action effects extend to other tasks such as free sorting tasks (Iachini et al., 2008), stimulus-response compatibility tasks (Bub & Masson, 2006, 2010, 2012; Bub et al., 2008; Tucker & Ellis, 1998, 2000, 2004) and object classification tasks (Borghi et al., 2012; Campanella & Shallice, 2012).

It has been suggested above, that the triad experiments reported in this thesis have not been as successful in demonstrating action effects on task performance as it has in previous research (Borghi et al., 2012; Bub & Masson, 2010, 2012; Iachini et al., 2008; Tucker & Ellis, 1998, 2001, 2004). For example, Iachini et al. found that participants consistently sorted objects together based on the grip/handle feature. In addition, Tucker and Ellis (1998, 2001) found that participants were influenced by the micro-affordances offered by the primed image. While the triad task has been successful in showing *some* of the circumstances under which action is used in categorisation, the effects have not always been consistent and there are clear individual differences in using such a task. The question that therefore must be addressed, is why action may be more influential in some tasks than others? A strict view of categorisation might suggest that if certain features are salient enough, then they should influence category decisions no matter the method used. For example, research has shown that functional information is important in categorisation and this has been demonstrated using a variety of tasks (Barsalou et al., 2005; Barton & Komatsu, 1989; Chaigneau & Barsalou, 2008; Chaigneau et al., 2004; Chaigneau et al., 2009; Keil, 1989, Rips, 1989). However, the context in which features are presented determines their saliency for use in task performance. Under certain conditions, different features are more salient than others. Therefore, a strict category view cannot be adopted here.

It is clear that while action may be influential in some tasks, it may not be as influential in others. The research outlined in Chapter 1 has outlined convincing results that action knowledge is automatically instantiated upon viewing objects (Borghi, 2004; Chao & Martin, 2000; Hauk et al., 2001; Jax & Buxbaum, 2010; Pulvermüller & Hauk, 2006). However, just because the information is instantiated, this does not necessarily mean that it will always be 'used' in task performance. It might be the case that participants are instantiating (and simulating) action information, but that it does not inevitably influence task performance even if instantiated for task performance. This is similar to the findings of Lin and Murphy (2001) where participants may recognise thematic relations but still prefer to choose a taxonomically related item. Particularly in the case of the triad task, other factors might be more salient or preferred when participants make their decisions. This is supported in Chapter 5 where participants reported using a wide variety of reasons to justify their performance.

The experimental work presented here has shown that action knowledge can influence decisions on more complex categories. However, performance was not consistent across participants nor across the triad types. Participants did not always select the action choice across all the triads, and participants selected the action choice more so in some triads than others. Previous research has tended to show very strong action based effects, where clear influences can be seen. Given that the current research has shown the influence of action to be task specific, it could be argued that the triad task used here has not demonstrated strong action-based effects in comparison to the previous research. It is possible that performance differs on the triad task in comparison to other tasks, because the triads require a different process compared to other tasks. In particular, it is suggested here that performance on the triad task reflects a two-step process and requires more conscious ‘effort’ than other tasks. Consider the following example. Participants, tasked with property verification, see the word (or a picture of) *calculator.* According to Barsalou and colleagues (Barsalou, 1999, 2003 2008; Santos et al., 2008; Simmons et al., 2008; Wu & Barsalou, 2009), the LASS system becomes active and participants begin to simulate the calculator. In doing so, conceptual information is accessed. The simulation itself is represented by a visual image that can be ‘inspected’ by participants to verify the property. Therefore, participants if given the property *buttons* can readily accept the property based on the visual representation created. Or the reverse, where given the property *wheels* participants can readily reject this because it is not present in the visual representation. Performance is therefore a ‘yes or no’ response based on whether or not they can see it and does not require any additional processes. This is not a difficult strategy and participants can answer fairly easily, though performance is not always perfect.

The triad task used here is different because while participants are simulating the object they cannot answer based solely on the representation created. The task does not require that participants make a yes or no response, but make a comparison between the three object simulations and select the one they feel “goes best” with the target. Participants are not only simulating the objects, but also performing a categorisation task in which a decision is made as to which is a “better” category match. The simulation generated then directly influences the categorisation/decision making process and this requires more cognitive effort than simply verifying the property of the object. Performance on the triad tasks used in this programme of research potentially demands use of a “dual-process” strategy in comparison to other, simpler conceptual tasks used in the reported literature. This dual-process occurs in two stages; first, participants simulate the objects and second, participants make a categorical decision based upon the simulations.

Property generation tasks might lie somewhere between triad and verification tasks. When generating properties participants have been shown to strongly rely on the visual imagery of the simulation (Santos et al., 2008; Simmons et al., 2008; Wu & Barsalou, 2009). This can be completed fairly easily by simply stating what they “see” on their mental representation. However, participants can report properties not directly derived from the simulation, which is why the task may be seen as being more difficult than property verification. In order to be successful on this task, participants are required to simulate a variety of situations to generate multiple properties which would require more cognitive effort compared to property verification. Properties could be generated from reporting what participants 'see' within the simulations, but do not make a categorical decision.

The results of Experiment 7 showed that performing a manual concurrent action while engaging in the triad task had no effect on task performance. All the objects in the triads were (mostly) selected as being objects that require hand actions to operate. Simulation theory suggests that the neurons active at the initial encounter with objects are (partially) re-instantiated when simulating the objects at a later date. Based on this, it was predicted that performing concurrent actions would 'block[63]' the simulation process and hence favour selection of the non-action choice in the triad task. The results did not show any difference between participants who performed concurrent actions, and those that did not. The dual-process theory outlined above could explain why no interference effect was found. If the triad task does reflect a dual-process, then performing concurrent actions should only interfere with the simulation phase, but not the decision phase. Given that participants are required to make a decision, which extends the amount of time in which the simulation system is in effect, any interference from the concurrent actions could diminish as participants progress through the task. While the concurrent actions may have initially interfered with the simulation process, this effect diminished with the simulation at "full strength" and had no impact on the choices made in the task. Therefore, it is suggested here that the triad task represents a dual-process task making the task different to other single-process strategies such as verification and generation tasks.

7.4 Critiquing Simulation Theory

The results have been interpreted based on Simulation theory because as argued in Chapter 1, it can at the very least, offer a more parsimonious explanation of how concepts include action information. This is in comparison to traditional (amodal) views which would suggest that action information is stored as 'features' of the objects. Chapter 1 has described how amodal views cannot offer an elegant explanation of action based on the varying definitions of action, the numerous

[63] Or potentially inflate; see Chapter 4 for more details.

possible types of actions that can be performed, and the notion of what is meant by 'intrinsic features'. It is, therefore, difficult for amodal views to capture an economic explanation of how action is incorporated into concept knowledge. In contrast, Simulation Theory can offer a stronger explanation of concept representation not by representing action as 'features', but by simulation and reactivation of the motor cortex. Therefore, Simulation theory can, it has been proposed, offer both an account of the data presented in this thesis, and a more elegant account of how concepts represent action knowledge.

While Simulation theory can offer a strong explanation of the data collected within this thesis, this is not to say that the explanation is flawless. Arguments against simulation theory relate to how it could be considered *too* situated. The theory suggests that when thinking about a concept, it is simulated within a situation based on personal factors relating to a persons' experience. However, participants can extract information from concepts that initially requires accessing a simulation, but over time would consist of common and lexically frequent features. For example, *cats* and *dogs* are highly associated and often coincide without participants having to simulate cats and dogs together. Performance based on lexically frequent features are quickly generated and represent 'quick thinking' responses. This therefore shows that concepts can be accessed without accessing a simulation. Evidence from Santos et al. (2011) supports this with their findings that participants generate lexical properties before taxonomic or situational. Therefore, a strength of amodal theories is that they can explain how participants abstract information from concepts, thus lexical properties can be generated without simulating. However, while it is possible that some aspects of concepts can be accessed without simulating, it is doubtful that this includes action knowledge because (i) action cannot be comfortably considered a feature and (ii) its intrinsic association with the goals of the situation.

Evidence from patients with neurological disorders has also served as a further source of challenge to simulation theory. One example is apraxia in which patients have difficulties in using objects and making relevant gestures based on function. Embodied views of concepts suggest that thinking about a concept reactivates the motor cortex and that the two systems are highly intertwined. This therefore makes the prediction that damage to one system should impact on the other. In other words, *if* concepts are embodied then not being able to use an object should correlate with not being able to recognise them. However, this has not always been shown to be the case

(Garcea, Dombovy & Mahon, 2013; Garcea & Mahon, 2012; Machery, 2016; Negri et al., 2007). Negri et al. has demonstrated double dissociations between using and recognising objects/actions. In their experiment, apraxic patients showed patterns of not being able to use the objects, yet still able to name them with high levels of accuracy. This does present a problem for embodied views since they would not predict this pattern to occur. Machery (2016) has built upon this to suggest the 'Offloading Hypothesis'. In his view, concepts are primarily amodal, but the conceptual system can "offload the solution of tasks onto the perceptual and motor systems" (Machery, 2016, pg.1094). Hence, the perceptual and motor systems work as 'slave systems' to an amodal representation of concepts. Given that not all tasks can be solved by perceptual or motor simulation, the amodal system itself can be used for task completion.

Barsalou (2016a) has counter-argued, and offered further criticism to both the offloading hypothesis, and the amodal approach. He has argued that the amodal approach is often see as being the default explanation of concepts, that when data arises that cannot be accounted for by the embodied approach, then concepts must be amodal. However, this view is taken despite the fact that there is no empirical evidence for symbols. Their adoption by other researchers simply reflects that such theories have been around the longest and that it is not necessary to prove that amodal representations exist, but to cite evidence disproving the embodied view. Barsalou further argues that descriptions of amodal theories are often vague and ill-defined. It is therefore difficult to use amodal theories as a basis for concept representation, when it cannot be agreed on what exactly they represent. The reason why concepts may still exist in lesioned patients, may be because of conjunctive brain areas that can account for conceptual processing, but this does not necessarily mean that concepts are amodal. Performance on tasks that do not appear to utilise perceptual and motor processes, occur because the conceptual system is specialised in abstracting information (not representing them as amodal symbols).

The value of adopting a theoretical stance of simulation regarding concepts will continue to be debated and tested. For the reasons given here it is felt that, overall, it accommodates evidence regarding the role of action more effectively than treating it as a new 'addition' to an amodal feature-list and so has been adopted as the main explanatory theory for the purpose of this thesis.

7.5 Potential Methodological Improvements

The research conducted in the thesis has used the forced-choice triad task as the primary research method. The triad task was selected as it could be easily manipulated to allow competition between choices matched with the target on specific criteria. Unlike other categorisation methods (e.g. card sorting tasks) the triad task allows for only two stimuli to enter into how the decision is made. Therefore, if manipulated correctly, inferences can be made based on the choices made. For example, if choice option A has feature X and choice option B has feature Y, then the choices made can be attributed to the feature that only one possesses. Furthermore, the triad task has been successfully used to show how participants categorise using taxonomic and thematic information (Lin & Murphy, 2001). Based on such reasoning, the triad was selected as an appropriate method with which to test how action could be used in categorisation. However, while the triad task has been successful in this respect, it is not without its drawbacks.

As discussed in Chapter 2, one issue relates to confounding influences in matching features between the objects. Objects that share actions will invariable share perceptual properties. For example, water pistols and rifles share a certain amount of perceptual characteristics that could have been the basis of participant's choices. The only way in which this could be further explored would be to design new triads and pull apart such confounding features. However, as intimated in Chapter 2, designing such triads could be near impossible. To pull these apart, new triads would need to be designed with the following remit based on sharing taxonomic, perceptual and action features:

- Choice A: Shares a taxonomic relation with the target, but no action and no perceptual characteristics (+T -A -P).
- Choice B: Shares a taxonomic and an action relation with the target, but no perceptual characteristics (+T +A -P).
- Choice C: Shares taxonomic and perceptual characteristics with the target, but no action (+T -A +P).
- Choice D: Shares taxonomic, action and perceptual characteristics with the target (+T +A +P).

If participants are selecting the action choice because of the shared actions then selection of choices B and D should not differ. However, based on the close relation that exists between perception and action, it is not possible to design such triads using everyday objects. The ergonomics of the human body are always a primary concern when designing objects. If it is not easy for a person to use an object then it is difficult for it to fulfil its function. For example, a torch that was too big to hold would not be used. In such an example, the size of the torch is key in its design because it must fit within the hand and should also be lightweight enough to hold. Based on such, objects that are designed with a specific operating mechanism (e.g. pulling a trigger) will invariably share perceptual characteristics to confirm with ergonomic functionality. Furthermore, objects can (to an extent) share perceptual characteristics without sharing an action. For example, a pencil and a straw look similar but are not operated in the same manner. As such, objects from different categories can be combined in such a manner. This is complicated however, when taxonomic information is combined. Stationery objects such as pencils, pens and paintbrushes all share perceptual information, the direct result of the objects being designed around the same operating mechanism. Therefore, using the triad stimuli developed here, it is virtually impossible to systematically disentangle the influence of action and perception in categorisation when the objects are also linked by taxonomic information.

A further point of issue with the research might arise from the design format of the triads, given that the choice is dichotomous. The triad task is designed so that the participants select only a single item to "go with" the target. While this leads the participant to make a category based on these two items alone, it perhaps does not accurately reflect the richness of how numerous objects are categorised into the same group. For example, the concept of *fruit* contains numerous members, many of which share specific features with each other. Therefore, tasks that include many items (such as sorting tasks) might be more suitable in demonstrating how action (or other features) is used in categorising a richer set of stimuli[64]. A question that therefore arises is whether or not action only becomes a salient feature in the context of such 'two-item' pairings or would be used in free sorting tasks. Iachini et al. (2008) used a free sorting task and showed that action *is* influential in categorisation. However, this

[64] Pilot work for the PhD program was conducted as part of the author's MSc thesis using a free sorting task. The task used objects (both novel and everyday) that could be sorted based on shared actions or taxonomic relations. Part of the justification for not using the free sorting tasks here was that participants only sorted the objects using action when given several trials to sort the objects and instructed to use a different method each time. Action was not the primary categorisation strategy used.

has not been investigated using objects designed in the format used in the present triad task.

The dichotomous choice and the fact that the triad task is forced choice might bias the participant to make a category decision where they might not naturally do so. This might particularly be a problem on the PCO triads. For example, the results of Experiment 2 showed that participants were more likely to group *clarinet* with *balloon* over *wooden spoon*. It might be possible that participants viewed neither object as being a good object to pair with the target, particularly given that there are few real world scenarios that would involve such items together. Given that the task demands that participants must make a response, participants select the "best" alternative. Despite selecting such, it may still not be a good match. In this case participants select the *balloon* not because they feel it matches the target object well, but simply that it is a better choice than *wooden spoon*. Under such forced conditions, participants' action scores might be inflated and, again, not reflect a natural categorisation strategy. Evidence for this could be seen in the similarity scores on the PCO objects. In Experiment 4, the action choice was selected in the context-rich condition on 63% of trials when using the "most similar". This would indicate that the action choice was the better choice under such conditions. However, in Experiment 9 using the similarity ratings the action choice was given a very low rating (2.77 out of a maximum of 7) which would therefore suggest that participants do not see such objects as being similar to each other. This demonstrates the point made above that while participants selected it in the triad task, such selection was simply the result of a "weaker" competitor and participants' did not view the items as being very similar/going together in a category. The way in which the task could be manipulated to get around this issue would be to introduce a 'no choice' option. Under such conditions, it could be made clear to the participants that if they feel that no option goes well with the target then they are free to not select any option. It should be noted that this is not standard practice with the use of the triad task, and to date no known research has introduced this option into the format of the triad task.

A further potential criticism of the triad task used here relates to the design format and presentation of the triads. First, the manipulation of context was not consistent across all of the triads. Different images use different scenarios (this cannot be avoided unless the objects used all come from the same functional context) and different elements in the pictures. For example, as discussed in Chapter 5, some of the pictures show only a hand on the objects while others include more of the agent. This arose because (i) it was important to ensure that the images used reflected a natural context and (ii) because variations in the size of the objects would lead to perceptual inaccuracies. For example, rifles are large objects and to show a full agent using the rifle would mean that the rifle itself would dominate a large portion of the image used. In contrast, a USB pen is very small and therefore to manipulate the image to include a full agent would lead to a small object within the whole image. It was felt that this might increase the saliency of other features of the scenario rather than the action element but the decision led to other different inconsistencies. In Chapter 5, it was suggested that the variations in the presence of a hand or full agent led to variations in the use of action in categorisation. As it stands however, this is based on speculation since the triads were not manipulated based on such a feature. Therefore, a possible avenue for future research would be to test this hypothesis and manipulate the context based on such considerations. For example, the type of context (functional or not) in which the objects are presented could be manipulated. The objects could be presented within a context that shows the objects being handled, but not used for their functional purpose. Such a context would offer more information than the context-lean condition, and may show how functional and volumetric (structural) actions are differentially influential in making categorical decisions.

The potential issues outlined above raises an important, and valid, question on whether it would, for future research, be “better” to use a different task. The most widely used tasks in measuring conceptual knowledge include property verification, property generation/feature listing, sorting tasks and triad tasks. For example, rather than using the triad task the experimental work could have employed a sorting task or property verification task. The aim of the thesis was to investigate how action was used making categorical decisions, particularly when compared against taxonomic information. Property verification and property generation tasks assess conceptual representations by focusing on the features used to organise objects together. Such tasks are more likely to use familiar than novel objects. Having no prior experience with the objects, participants would be more likely to rely on perceptual characteristics rather than accessing conceptual knowledge. Previous research has already shown that action information is produced during such tasks and under different contexts in which the items are imagined (Borghi, 2004; McRae, Cree, Seidenberg & McNorgan, 2005; Riordan & Jones, 2011; Vinson & Vigliocco, 2008).

However, the aims of the thesis was to establish whether or not participants use action in a categorisation task, and whether this is used over taxonomic information. While property verification/generation tasks measure conceptual representations, they do not reflect an ‘online’ categorisation process. Therefore, using such tasks would not have been appropriate for the aims of the thesis. Free sorting and triad tasks reflect a more direct measure of categorisation, as they require participants to categorise familiar and novel objects for on-going task performance. Iachini et al. (2008) showed that action is an influential property when sorting objects together. They manipulated objects based on sharing perceptual or action-based properties, namely the grip, size and shape of the objects. However, the objects were not manipulated based on sharing taxonomic information, but came from the same category (Experiment 1 consisted of using cups). Previous pilot work conducted outside of the thesis (see Footnote No.58) showed that when participants could sort objects based on either shared actions or shared taxonomic relations, they were more likely to use the latter. In order for the sorting task to successfully show that action is used to categorise objects together, the shared actions must be recognised across various objects (across different taxonomic categories). If it is the case that action information is not made salient enough under such conditions, then participants are not likely to use action to group the objects together. Rather, shared taxonomic categories and functional information, which is already salient in categorisation tasks, is likely to be exerted to categorise the objects. The triad task was used because it required participants to recognise the shared actions between only two objects. If participants cannot recognise and categorise the shared actions between two objects, then they would be unlikely to do so using multiple objects. Therefore, the triad task was selected in order that action and taxonomic information could be directly pitted against each other.

7.6 Empirical Contributions

As research into categorisation has advanced, the understanding of how objects are mentally grouped together has progressed. For example, categorisation has progressed from the ‘Roschian’ notion of categories stored amodally as decontextualised feature lists (Rosch, 1975; Rosch & Mervis, 1975; Rosch et al., 1976; Rosch et al., 1976), to the notion of categories being grounded across the modal systems in which they were first encountered (Barsalou, 1999, 2003, 2008; Yeh & Barsalou, 2006). However, it should be noted that the amodal/grounded debate still exists with particular emphasis on patients with apraxia as evidence for an amodal representation (Barsalou, 2016a; Machery, 2016; Mahon & Caramazza, 2008; Yee & Thompson-Schill, 2016). Behavioural and neuropsychological evidence has further shown how semantic knowledge is distributed across neural topography (see Chapter 1). The development of such modal views of categorisation has encouraged researchers to move away from the more traditional view. In generating properties, amodal views suggest that participants would access these abstract feature lists and simply report those features available. The features most commonly reported are often related to the typicality of the objects (Rosch & Mervis, 1975; Rosch et al., 1976), and both lexical and statistical co-occurrence across difference category instances (Taylor, Devereux, Acres, Randall & Tyler, 2012).

Simulation theory would suggest that participants report the features available from directly simulating the referent object in context. The LASS theory suggests that participants make use of both a simulation and a lexical strategy in task performance. Additional research has also supported prototype theory suggesting that new examples are judged as being members of the category based on similarity to an overall prototype (Hampton, 1995). Therefore, the view taken here is not that grounded views should replace amodal views. Rather, the conceptual system *can* make use of both strategies in line with the Offloading Hypothesis (Machery, 2016).

Both the grounded and amodal view of categorisation both share the idea, that various sources of information can be drawn upon for categorisation. What differs between the views is the strategy in how such information is accessed. Typically, amodal views refer to ‘features’ of objects used to categorise them including biological, functional and perceptual properties. The term ‘features’ is usually used to refer to physical elements of objects. The suggestion is not being made here that action is one of such ‘features’ used in categorisation. Irrespective of whether action could be considered a ‘feature’, it does provide an additional source of information by which objects can be categorised. The research conducted here as part of the thesis has shown that action is another source of information used in making complex categorisations in an action-irrelevant task. While simulation theory has dominated the interpretation of the data throughout the thesis, there is no argument for the redundancy of amodal representations. The research here adds to the literature in identifying action as a categorical source that can be used in such tasks. However, as demonstrated using the triad task, the use of action as a 'feature' for categorisation is context (and task) dependent.

Barsalou (1982) demonstrated that conceptual knowledge contains both context-dependent and independent properties. For example, the notion that skunks smell is a context-independent as such knowledge can be quickly accessed in contexts where the 'smell' property is irrelevant to the situation. In contrast, the notion that a basketball can float is context-dependent as such knowledge is only accessed in contexts where a basketball is seen to float. However, the development of situated simulation theory (Barsalou, 1999, 2003, 2008) might suggest that context-independent properties do not exist. Simulation theory suggests that in thinking about objects, the conceptual system automatically instantiates a context. No object properties will be instantiated in the absence of a context. Those properties which are more common are those that are occur in multiple contexts. Therefore, those properties which are "context-dependent", simply occur in fewer contexts. This does imply that action information should be a common property of objects given that the objects are used in the same manner, irrespective of the context. This is in line with the previous research (Borghi, 2004; Borghi et al., 2012; Iachini et al., 2009; Kalénine et al., 2009), along with that reported here, of the importance of action information in categorisation.

7.7 Future Work

The experimental research within this thesis has reported (some of) the circumstances under which action is an influential source in making complex categorical decisions. Throughout the reported chapters, suggestions have been made as how the triad task developed here can be adapted. In addition to this, the research has led to various avenues that should be the focus of future research within this field.

One factor that has been identified as increasing the saliency of action being used to categorise objects together is context. Chapter 5 alluded to the fact that action is more likely to be used in categorisation when the context shows a full agent using the objects. However, as outlined above the context was not systematically manipulated within this thesis. What the area should focus on is a more systematic identification of how context can increase the saliency of action. In addition, the goal of the task should also be identified as to how this can be used to predict maximum influence of action knowledge, with particular emphasis on reflecting real life goals.

The research outlined above has shown that, under certain conditions, participants are likely to categorise *rifle* with *water pistol.* A sensible question is the extent to which this would reflect a real life category. It is difficult to imagine a real life scenario in which participants would need to categorise these objects together. Participants in the triad task carry no specific goal outside of the goal of completing the experiment. A suggestion that has been made above is that the goal of the task would influence how different sources of commonality would be weighted in the decision. For example, a fork would be useful with the goal of eating food, but not with the goal of hammering in a nail. Therefore, in the same way that the function of an object is determined by the goal, so is the saliency of the action. However, for many objects the method used to operate the objects is the same across context and goals. Since the goals of the situation can vary greatly, research should seek to identify the type of goal related to the objects that can 'maximise' the saliency of the actions.

An additional avenue for future work is to assess the factors behind why some actions might be more 'important' than others. In section 7.2 it was suggested that not all actions are equal, and that shaking a cocktail shaker might be more salient than inserting a plug. Several factors have been suggested as to why this might be the case including time, task goals, physical effort and familiarity. The latter would be the most difficult to assess. The others can be measured accurately, however familiarity with using an object would be difficult given the participants understanding of what might entail being 'familiar' with an object. Yee et al. (2013) asked participants to rate on a scale of one to ten how familiar they were with using objects. However, for many objects a person might not be physically familiar with using it, but familiar in the sense that if they came across one, they might know how to use it. For example, film and television influence could mean that a person is aware of the basic 'trigger' action of a rifle and how to use one, without having direct physical experience of doing so. In addition, if it is the case that actions are more salient following a longer time duration and greater physical effort, then perhaps a person might be just as familiar with mowing the garden once a fortnight compared to plugging an object into a socket everyday. The suggestion that not all actions are equal has a direct influence on how objects are conceptually represented as well as predicting performance under task conditions.

The empirical findings within this thesis have been discussed within the framework of simulation theory. The results are arguably consistent with the theory and research should focus on establishing such. Suggestions have been made based on the process that participants use while engaged within the triad task. Specifically, the notion of time has been suggested as to why certain actions are more salient in such tasks as well as the notion of a 'dual-process' strategy. Future empirical work perhaps using neuroimaging techniques could be used to support the role of simulations when engaged in the triad task.

7.8 Conclusions

The present research has sought to investigate the circumstances under which action is used to categorise objects together in an action-irrelevant task. The main findings are that action is used when it is combined with taxonomic information, and shown within a functional context. The research has added to the literature by identifying additional sources, and the circumstances surrounding such, that influence decisions on complex categories. Knowledge of action plays an important role in cognition across a variety of methodologies including the triad task. Knowing what the function of a lamp and what one looks like is important for object identification, but without knowledge of how to interact with one it becomes difficult (and near impossible) to navigate the environment. Therefore, it is important for the conceptual system to include such functional, perceptual, thematic *and* action based information. The research presented here has supported this in showing that action is an additional source with which to categorise objects. Navigating the environment cannot take place by assessing affordances alone. To do so successfully, it is not enough to know what an object looks like and does, but also to know how to use and manipulate objects. Concepts support the agent in acting in the environment and in line with the view of Franks and Braisby (1997), develop in the service of guiding actions.

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Appendices

Appendix A: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

Appendix B: Pilot questionnaire on category membership (only page 1 included because the questionnaire was exactly the same as that in Appendix A with the exception of the instructions).

Appendix C: Information sheet used in Experiment 1.

Appendix D: Consent form used in Experiment 1.

Appendix E: Debrief sheet used in Experiment 1.

Appendix F: List of triads used in Experiment 1.

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

Appendix H: Animal foils used in Experiment 1.

Appendix I: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

Appendix J: Pilot questionnaire on shared perceptual properties (only page 1 included because the questionnaire was exactly the same as that in Appendix J with the exception of the instructions).

Appendix K: Information sheet used in Experiment 2.

Appendix L: Debrief sheet used in Experiment 2.

Appendix M: List of triads used in Experiments 2-8.

Appendix N: SCO triads used in Experiments 2-8.

Appendix O: DCO triads used in Experiments 2-8.

Appendix P: PCO triads used in Experiments 2-8.

Appendix Q: Information sheet used in Experiment 3.

Appendix R: Consent form used in Experiments 3-9.

Appendix S: Debrief sheet used in Experiment 3.

Appendix T: Information sheet used in Experiment 4.

Appendix U: Debrief sheet used in Experiment 4.

Appendix V: Information sheet used in Experiment 5.

Appendix W: Debrief sheet used in Experiment 5.

Appendix X: Information sheet used in Experiment 6.

Appendix Y: Debrief sheet used in Experiment 6.

Appendix Z: The ‘checklist’ task used in the action priming condition of Experiment 6.

Appendix A: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

Information Sheet

I am a PhD student from the University of Hertfordshire undertaking a study into semantic knowledge.

If you agree to take part, you will be asked to complete a short questionnaire, which should take no longer than 10 minutes.

As a participant you will be asked not to discuss the study with others until the study is completed in May 2011.

You will have an opportunity to ask questions now and at the end of the experiment.

Please note that any information you may supply today will only be used for the purposes outlined here. You may withdraw your assistance from this study at any time.

You may use the contact email address below, should any queries or concerns arise in the future.

Thank you for your participation.

Name of researcher: Nicholas Shipp

Email address: n.j.shipp@herts.ac.uk

Ethics protocol number: PSY/04/11/NS

Appendix A: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

CONSENT FORM

I ______________________________ (please type name) give my full consent to take part in the following research investigation with the full understanding that I may withdraw at any time without giving any reason.

If I withdraw from the study, the data that I have submitted will also be withdrawn at my request. I have received an information sheet explaining what the experiment entails and what will be expected from me.

I understand that the information that I will submit will be confidential and completely anonymous and used only for this study. I have read and understand the above information.

I agree/do not agree to participate in the study.

Signed:

Date:

Appendix A: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

Action Questionnaire

You are about to see a list of 30 triads. Please circle which two of the three objects share the same action, i.e. how we use them. If you feel that all three items share the same action then please circle all three.

1.	orange	apple	onion
2.	fax machine	telephone	photocopier
3.	screwdriver	key	hammer
4.	drink bottle	mug	jam jar
5.	pencil	paintbrush	pen
6.	boat	airplane	car
7.	rifle	sword	water pistol
8.	glass	jug	cup
9.	computer	piano	printer
10.	trumpet	violin	clarinet

11.	spatula	saucepan	grater
12.	calculator	mobile phone	set square
13.	teapot	coffee cup	milk jug
14.	book	iPod	wallet
15.	paperclip	clothes peg	ruler
16.	dice	playing card	bowling ball
17.	spade	trowel	shears
18.	pin	plug	screw
19.	cake	ice cream	pizza
20.	ketchup	mayonnaise	shower gel
21.	lawnmower	pram	shovel
22.	deodorant	hair gel	insect repellent

23.	scissors	stapler	selotape
24.	drum	triangle	trombone
25.	fork	spoon	skewer
26.	shoelace	sock	tie
27.	dvd player	cd player	television
28.	knife	ladle	saw
29.	bed	sofa	wardrobe
30.	leaflet	newspaper	poster

DEBRIEFING

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to see how you grouped the items together for use in a later experiment.

If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

Appendix B: Pilot questionnaire on category membership (only page 1 included because the questionnaire was exactly the same as that in Appendix A with the exception of the instructions

Category Questionnaire

You are about to see a list of 30 triads. Please circle which two of the three objects go together in the same category. If you feel that all three items belong in the same category then please circle all three

1.	orange	apple	onion
2.	fax machine	telephone	photocopier
3.	screwdriver	key	hammer
4.	drink bottle	mug	jam jar
5.	pencil	paintbrush	pen
6.	boat	airplane	car
7.	rifle	sword	water pistol
8.	glass	jug	cup
9.	computer	piano	printer
10.	trumpet	violin	clarinet

Appendix C: Information sheet used in Experiment 1.

INFORMATION SHEET

I am a PhD student from the University of Hertfordshire undertaking a study into semantic knowledge. Semantic knowledge is one form of long term memory which stores information regarding the world around us and objects which exist in that world.

If you agree to take part, you will be asked to complete a triad choice task. The whole task should take no longer than 15 minutes.

As a participant you will be asked not to discuss the study with others until the study is completed in March 2012.

You will have an opportunity to ask questions now and at the end of the experiment.

Please note that any information you may supply today will only be used for the purposes outlined here. You may withdraw your assistance from this study at any time.

You may use the contact email address below, should any queries or concerns arise in the future.

Thank you for your participation.

Name of researcher: Nicholas Shipp

Email address: n.j.shipp@herts.ac.uk

Ethics protocol number: PSY/04/11/NS

Appendix D: Consent form used in Experiment 1.

CONSENT FORM

I ____ (please type name) give my full consent to take part in the following research investigation with the full understanding that I may withdraw at any time without giving any reason.

If I withdraw from the study, the data that I have submitted will also be withdrawn at my request. I have received an information sheet explaining what the experiment entails and what will be expected from me.

I understand that the information that I will submit will be confidential and completely anonymous and used only for this study. I have read and understand the above information.

I agree/do not agree to participate in the study.

Signed:

Date:

DEBRIEFING

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate whether our semantic memory contains information related to actions associated with everyday objects. It further aimed to see whether people would select an item that shared the same action over its categorical function.

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

List of Triads Used (Experiment 1)

Table F1

List of the SCO Triads Used in Experiment 1.

Target	Taxonomic choice	Taxonomic + action choice
Bed	Wardrobe	Sofa
Cake	Ice cream	Pizza
DVD player	Television	CD player
Glass	Jug	Cup
Leaflet	Poster	Newspaper
Pencil	Elastic band	Paintbrush
Pin	Screw	Plug
Spade	Shears	Trowel
Spatula	Grater	Saucepan

Table F2

List of the DCO Triads Used in Experiment 1.

Target	Taxonomic choice	Action choice
Book	Ipod	Wallet
Calculator	Set square	Mobile phone
Computer	Printer	Piano
Deodorant	Hair gel	Insect repellent
Dice	Playing cards	Bowling ball
Drink bottle	Mug	Jam jar
Fax machine	Telephone	Photocopier
Ketchup	Mayonnaise	Shower gel
Knife	Ladle	Saw
Orange	Apple	Orange
Paperclip	Ruler	Clothes peg
Rifle	Sword	Water pistol
Screwdriver	Hammer	Key

Table F3

List of the Foils Used in Experiment 1.

Target	Choice Option 1	Choice Option 2
Ant	Spider	Centipede
Anteater	Armadillo	Raccoon
Camel	Sloth	Kangaroo
Cow	Duck	Pig
Crab	Lobster	Seahorse
Daffodil	Rose	Tulip
Dog	Rabbit	Cat
Donkey	Horse	Deer
Elephant	Giraffe	Lion
Fox	Hedgehog	Badger
Frog	Crocodile	Next
Goat	Sheep	Pony
Gorilla	Hippo	Chimpanzee
Iguana	Alligator	Llama
Monkey	Bear	Snake
Moth	Wasp	Butterfly
Mouse	Hamster	Rat
Oak tree	Willow tree	Maple tree
Owl	Hawk	Hummingbird
Ox	Gecko	Panda
Parrot	Koala	Macaw
Robin	Eagle	Bat
Seagull	Kestrel	Heron
Seal	Polar bear	Walrus
Snail	Worm	Scorpion
Tiger	Rhino	Panther
Tortoise	Lizard	Aadvark
Trout	Cod	Salmon
Turkey	Chicken	Goose
Whale	Shark	Dolphin

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

Figure G3. Format of the *bed* triad used in the context-lean condition (Experiment 1).

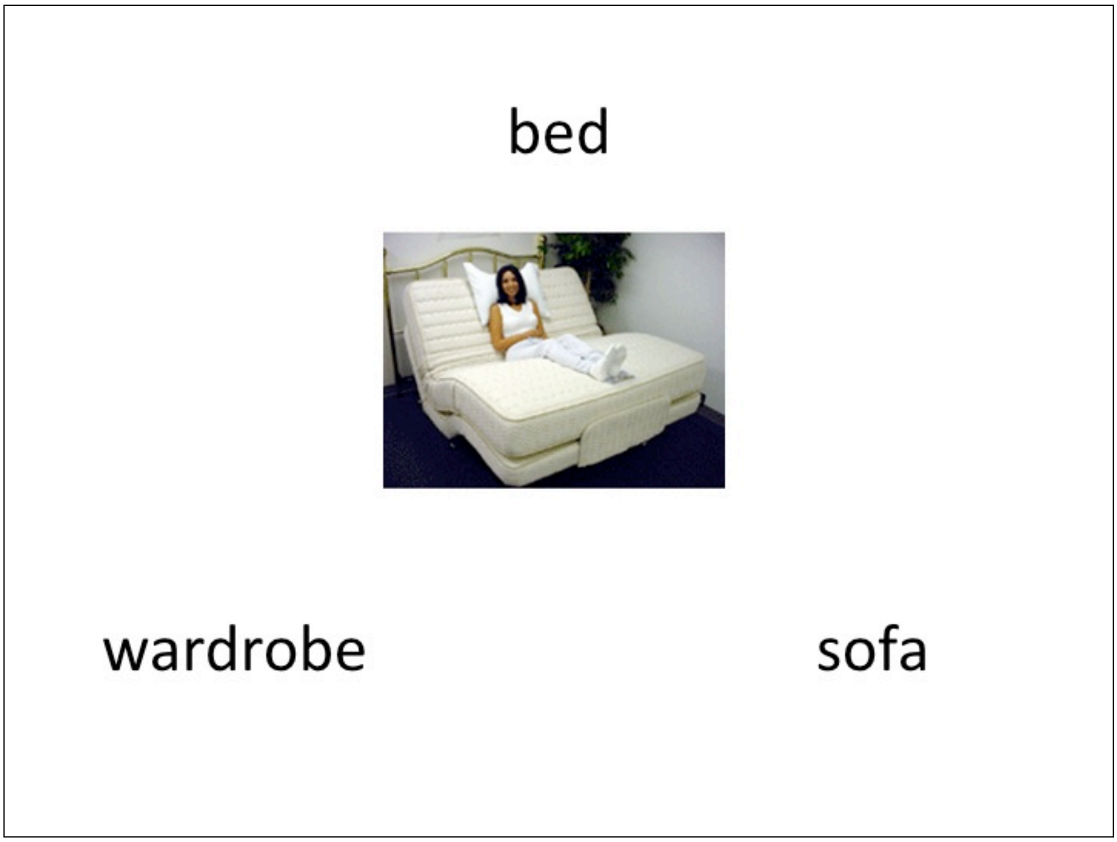


Figure G4. Format of the *bed* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

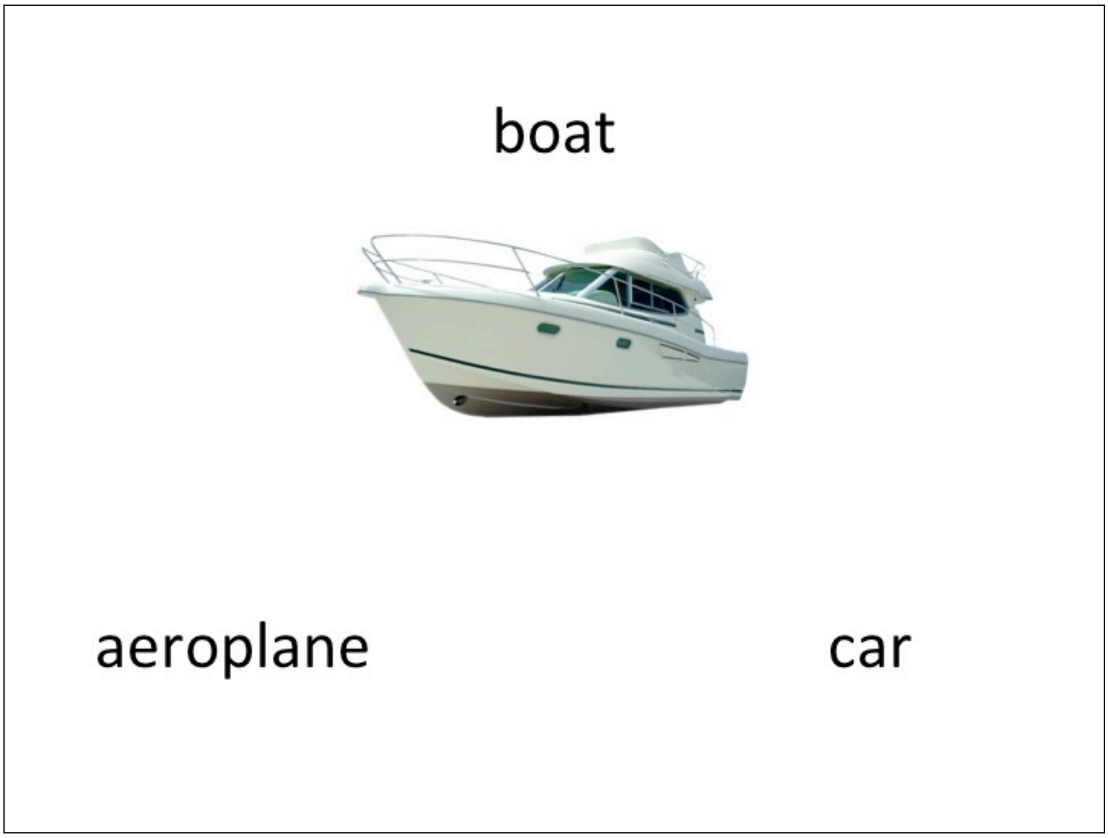


Figure G5. Format of the *boat* triad used in the context-lean condition (Experiment 1).

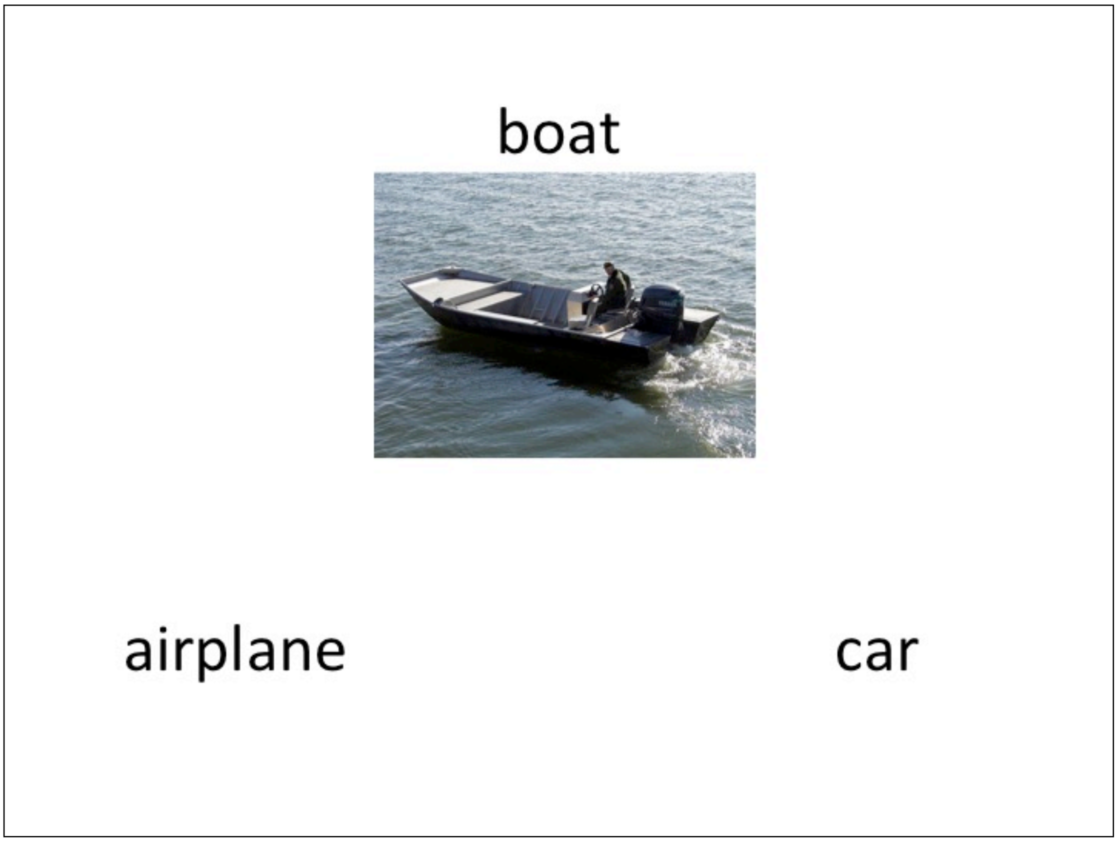


Figure G6. Format of the *boat* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

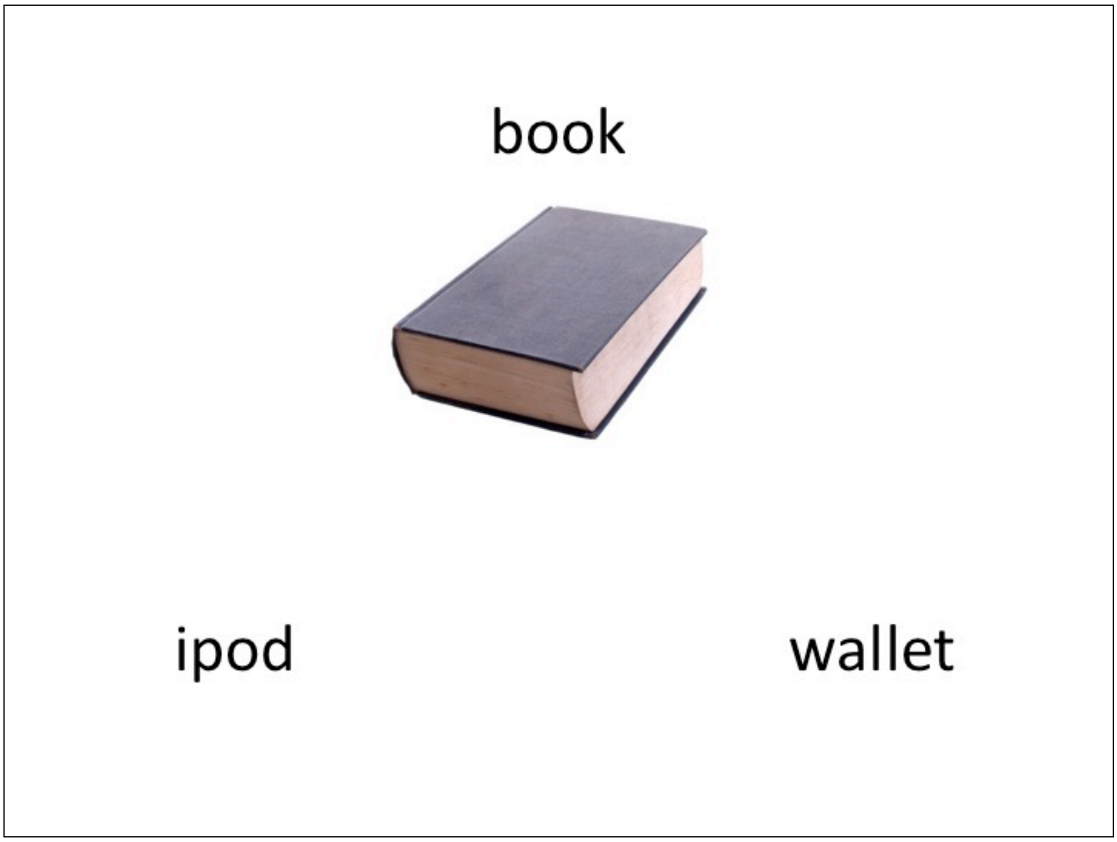


Figure G7. Format of the *book* triad used in the context-lean condition (Experiment 1).

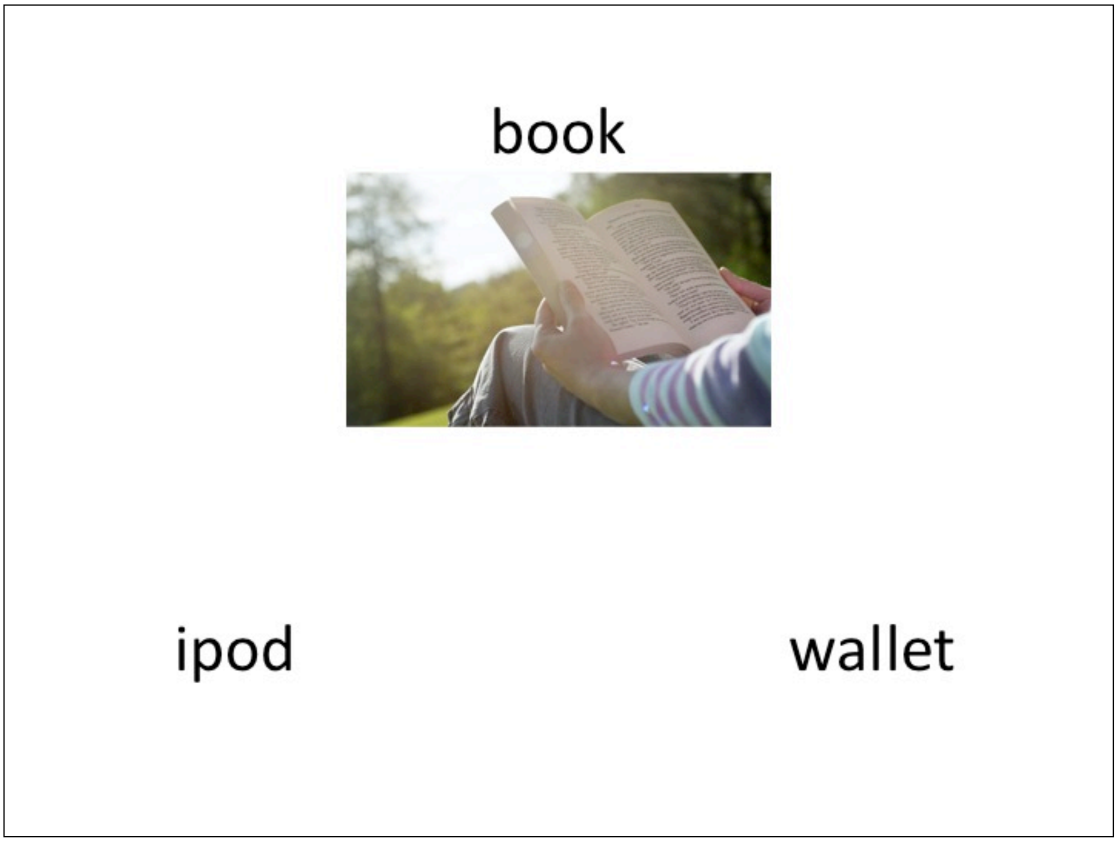


Figure G8. Format of the *book* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

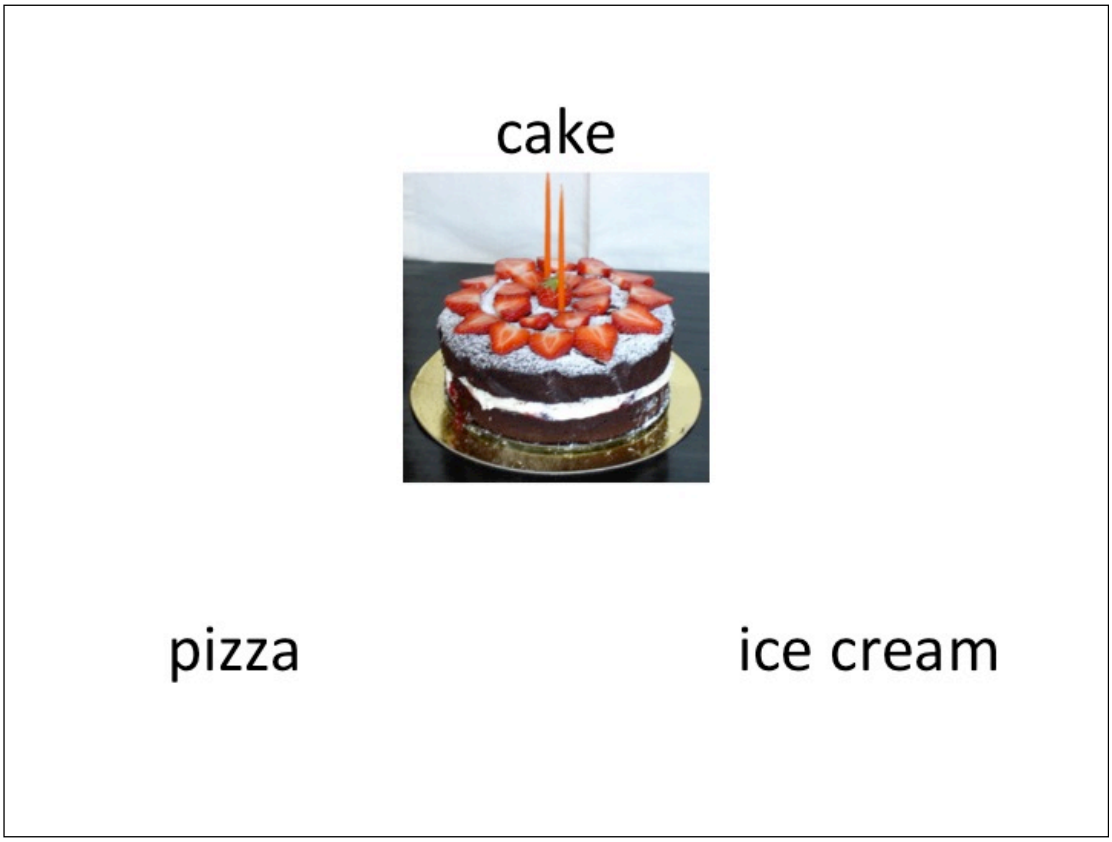


Figure G9. Format of the *cake* triad used in the context-lean condition (Experiment 1).

Figure G10. Format of the *cake* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

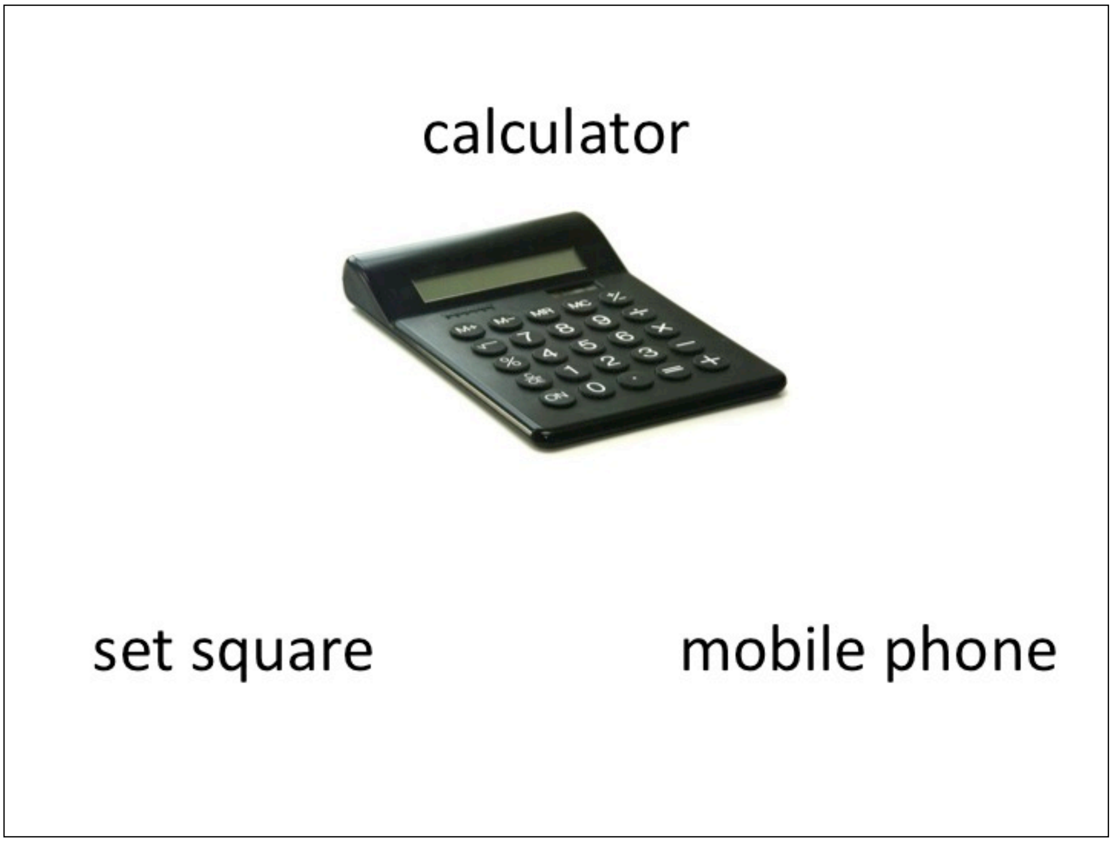


Figure G11. Format of the *calculator* triad used in the context-rich condition (Experiment1).

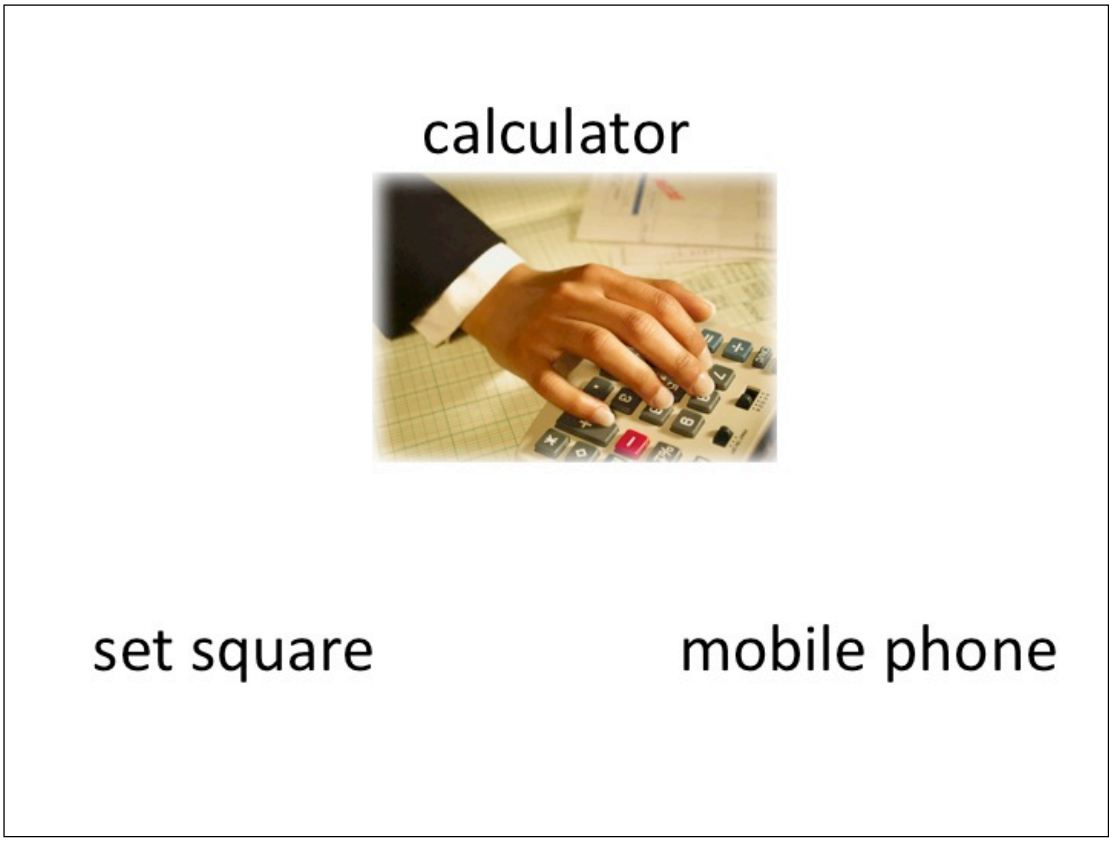


Figure G12. Format of the *calculator* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

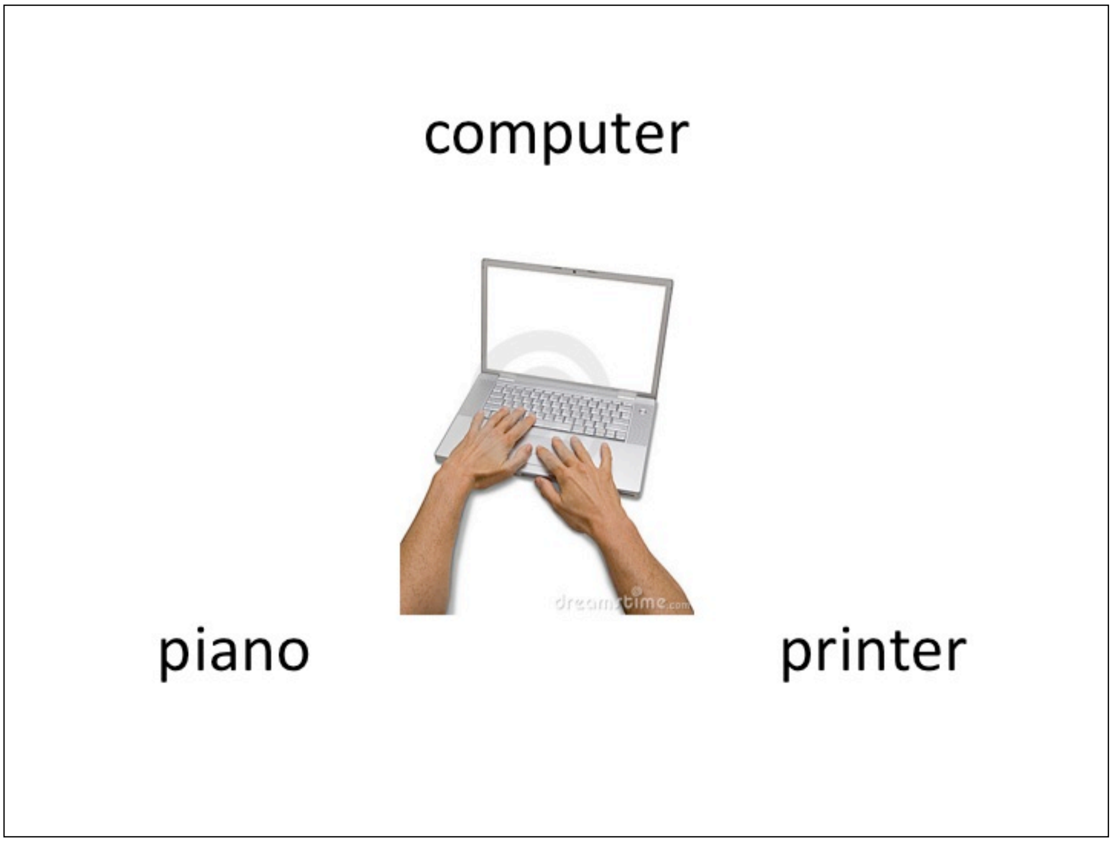


Figure G13. Format of the *computer* triad used in the context-lean condition (Experiment 1).

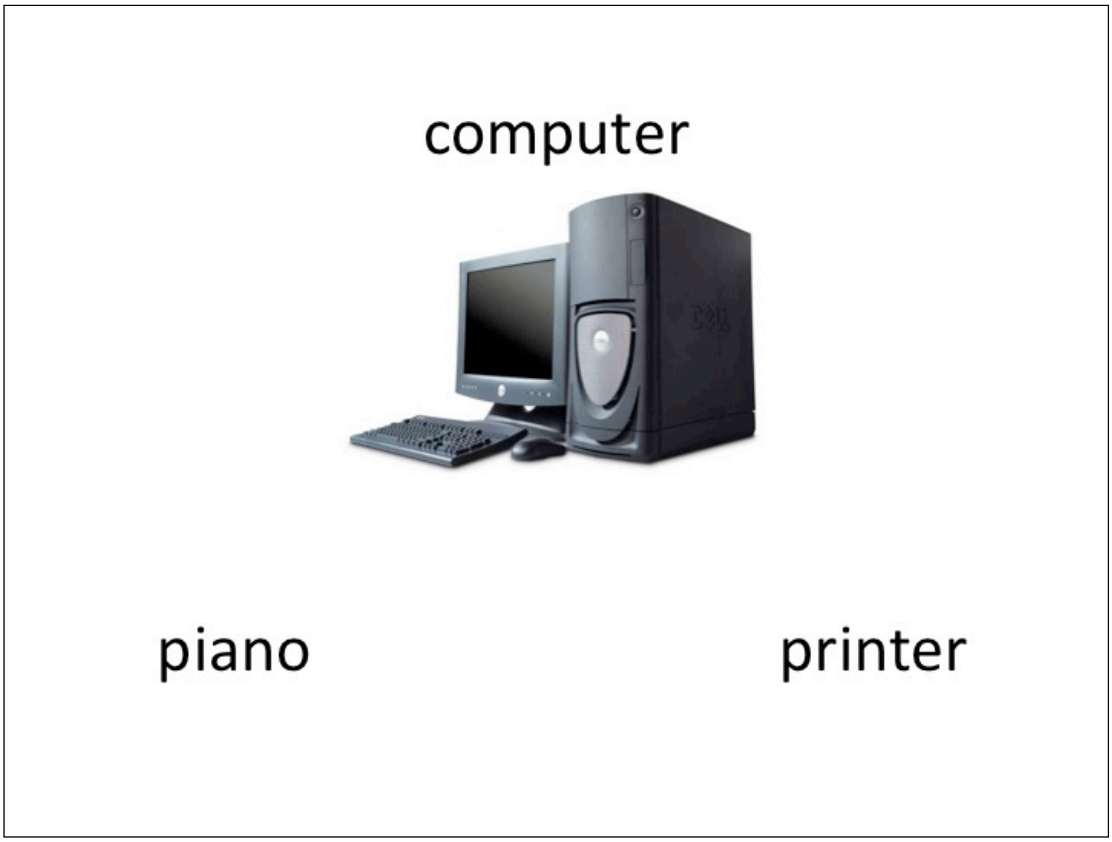


Figure G14. Format of the *computer* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

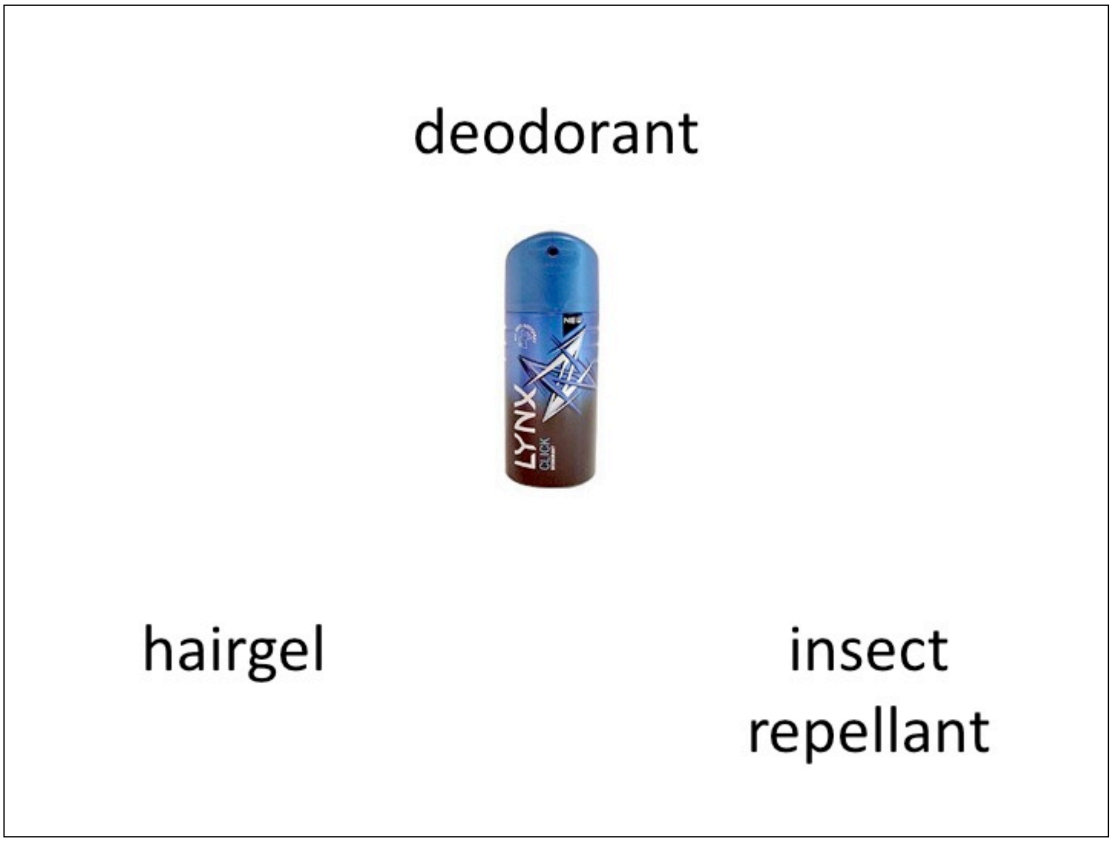


Figure G15. Format of the *deodorant* triad used in the context-lean condition (Experiment 1).

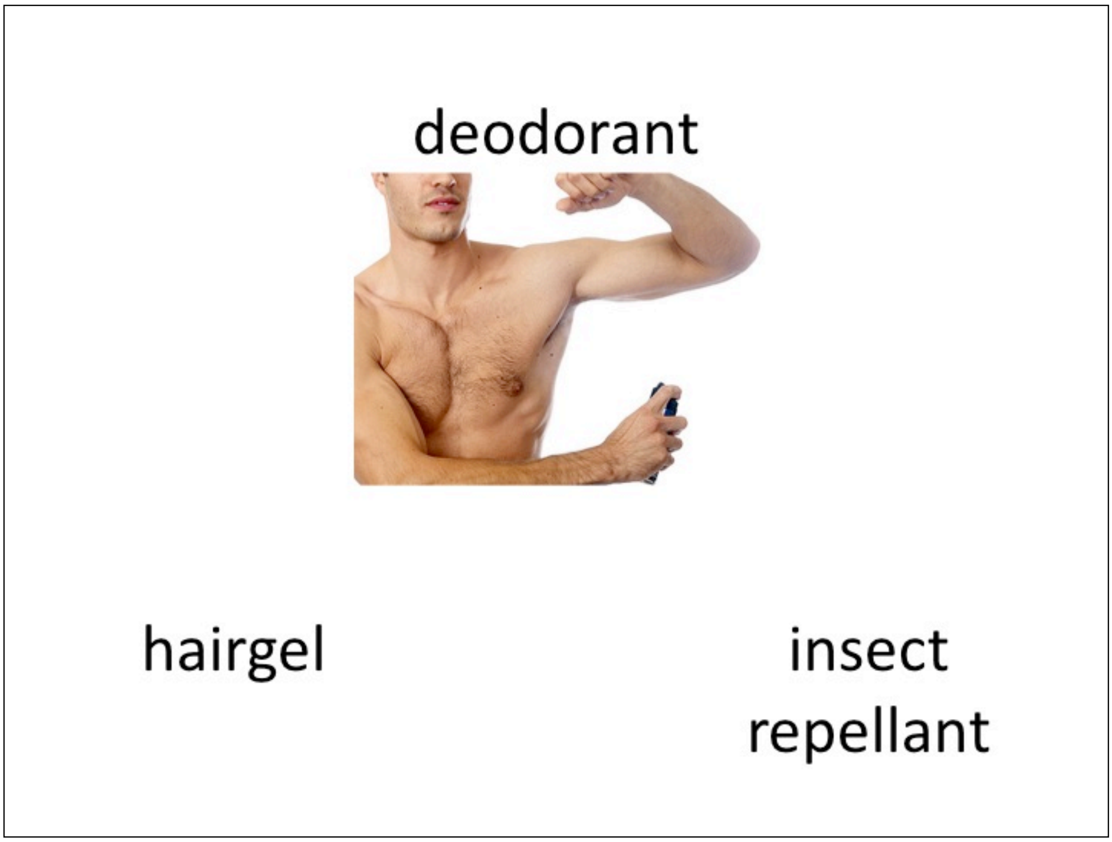


Figure G16. Format of the *deodorant* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

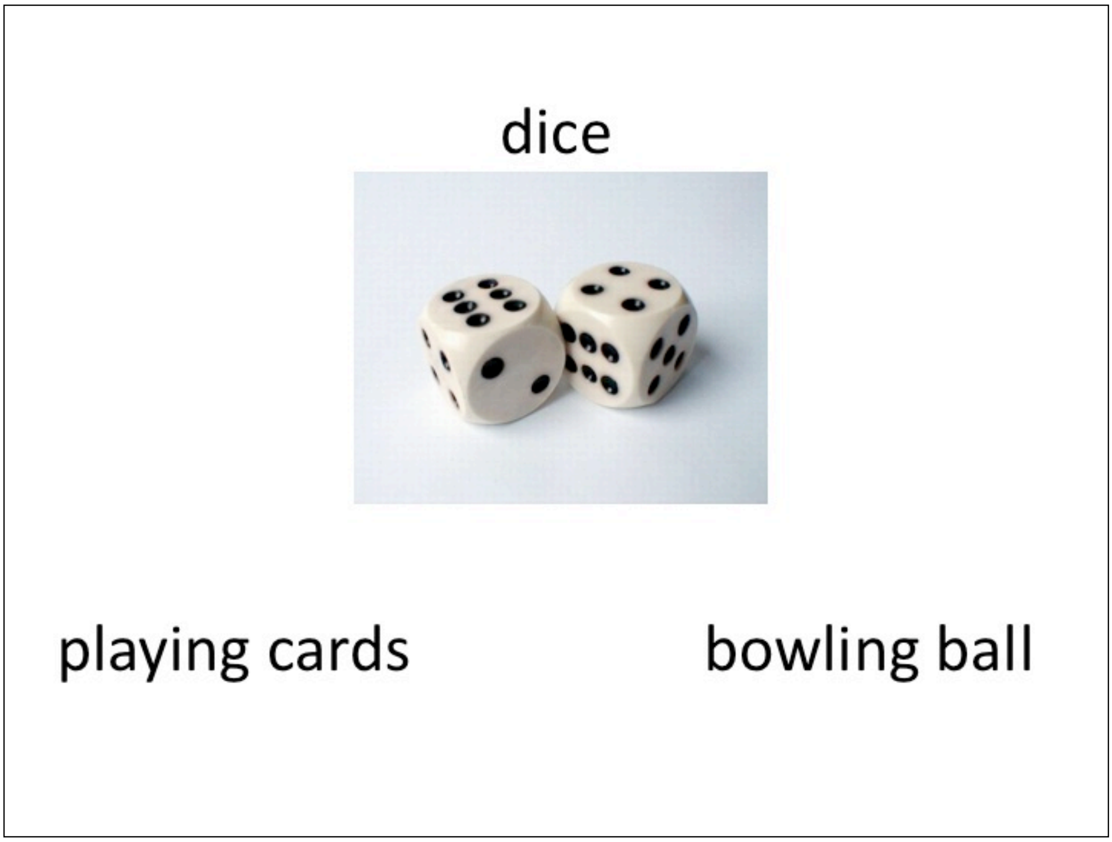


Figure G17. Format of the *dice* triad used in the context-lean condition (Experiment 1).

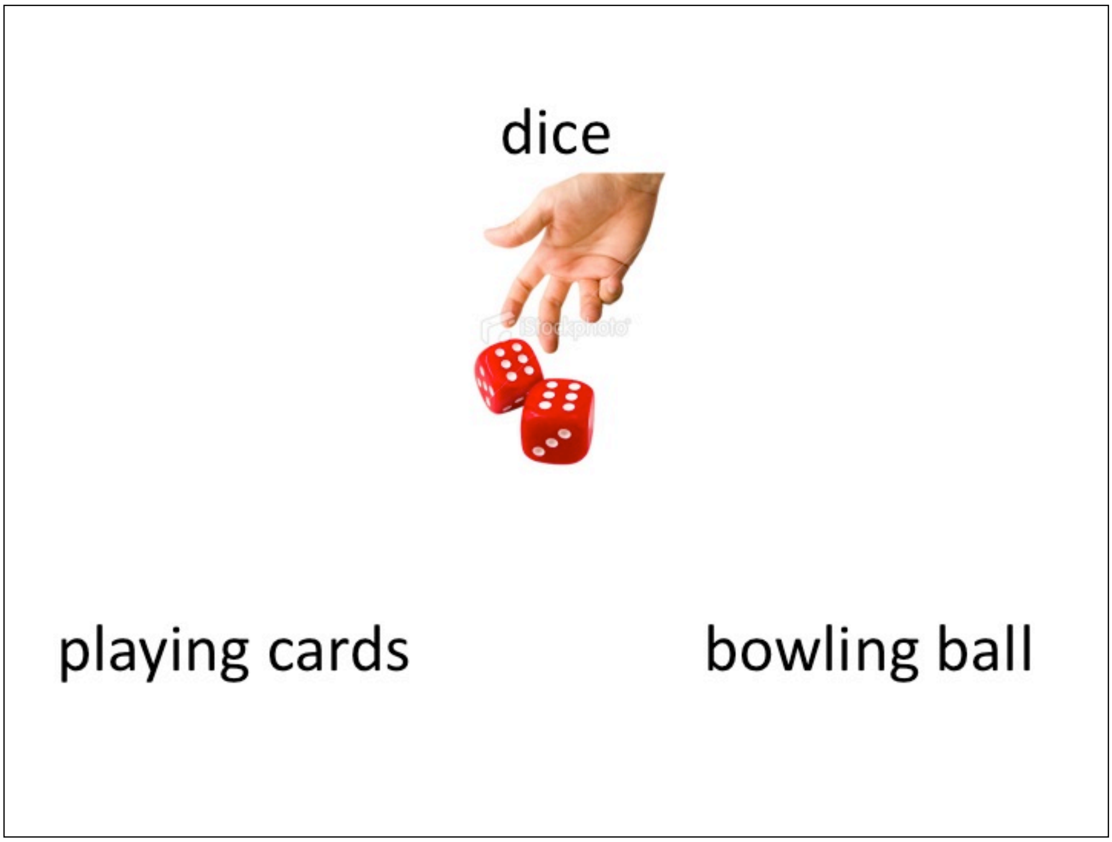


Figure G18. Format of the *dice* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

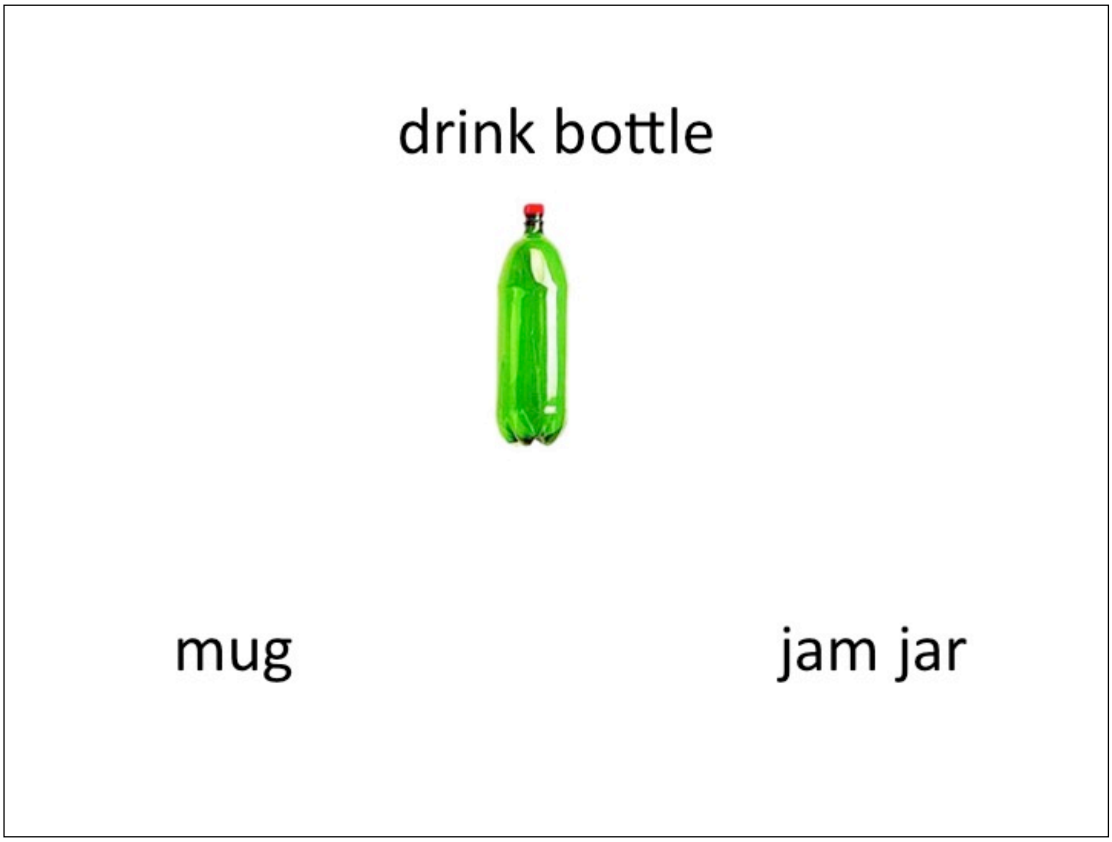


Figure G19. Format of the *drink bottle* triad used in the context-lean condition (Experiment 1).

Figure G20. Format of the *drink bottle* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

Figure G21. Format of the *drum* triad used in the context-lean condition (Experiment 1).

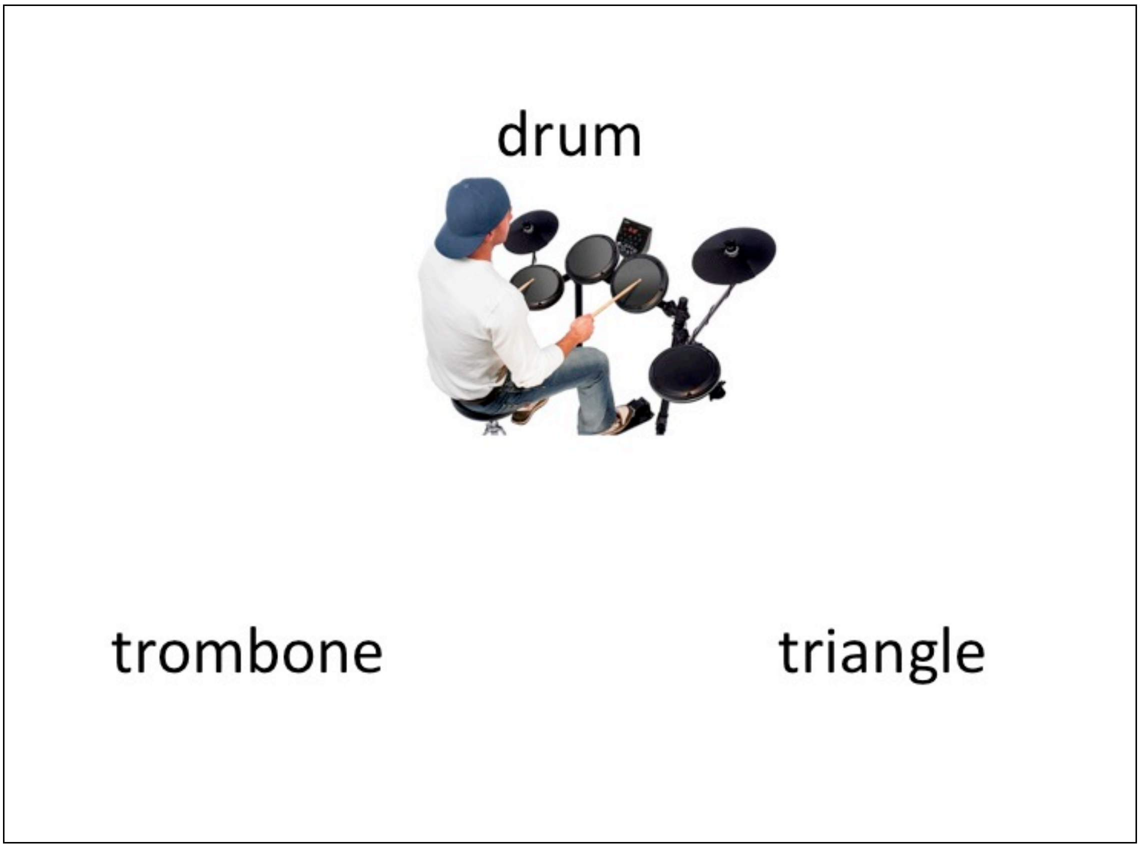


Figure G22. Format of the *drum* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

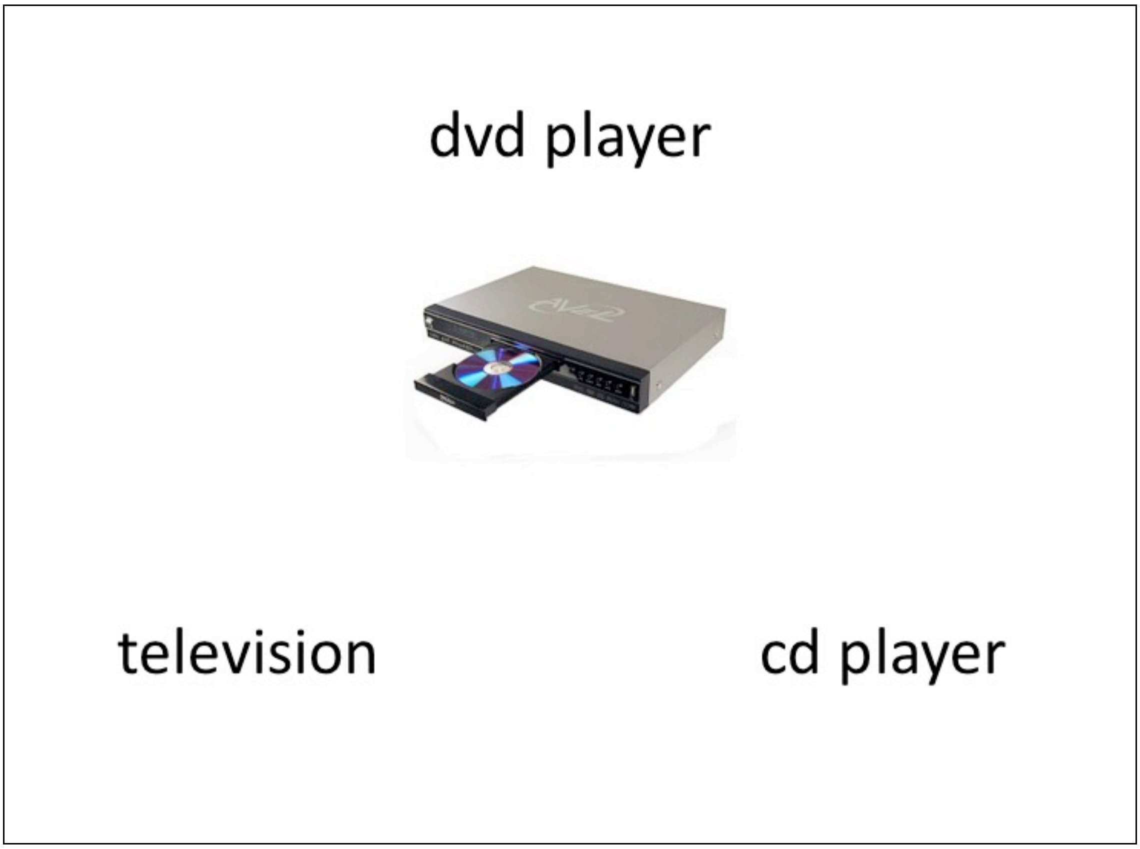


Figure G23. Format of the *dvd player* triad used in the context-lean condition (Experiment 1).

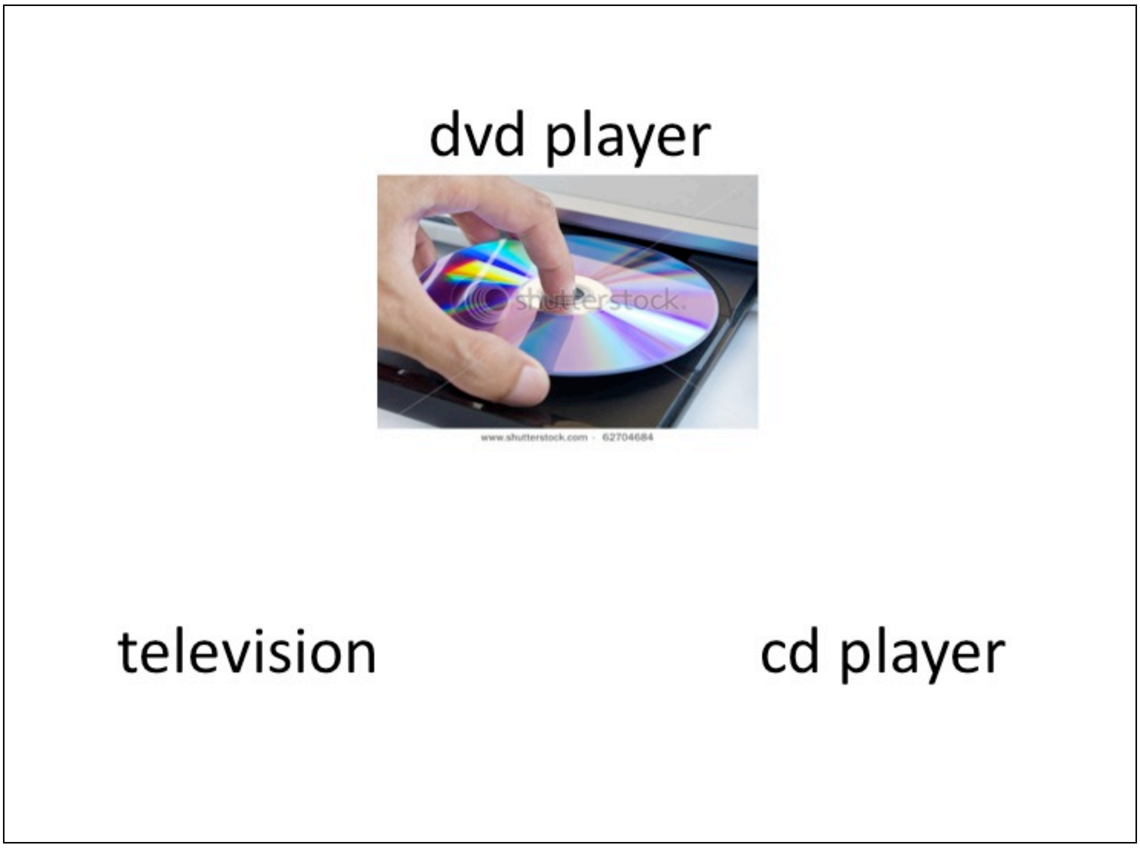


Figure G24. Format of the *dvd player* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

Figure G25. Format of the *fax machine* triad used in the context-lean condition (Experiment 1).

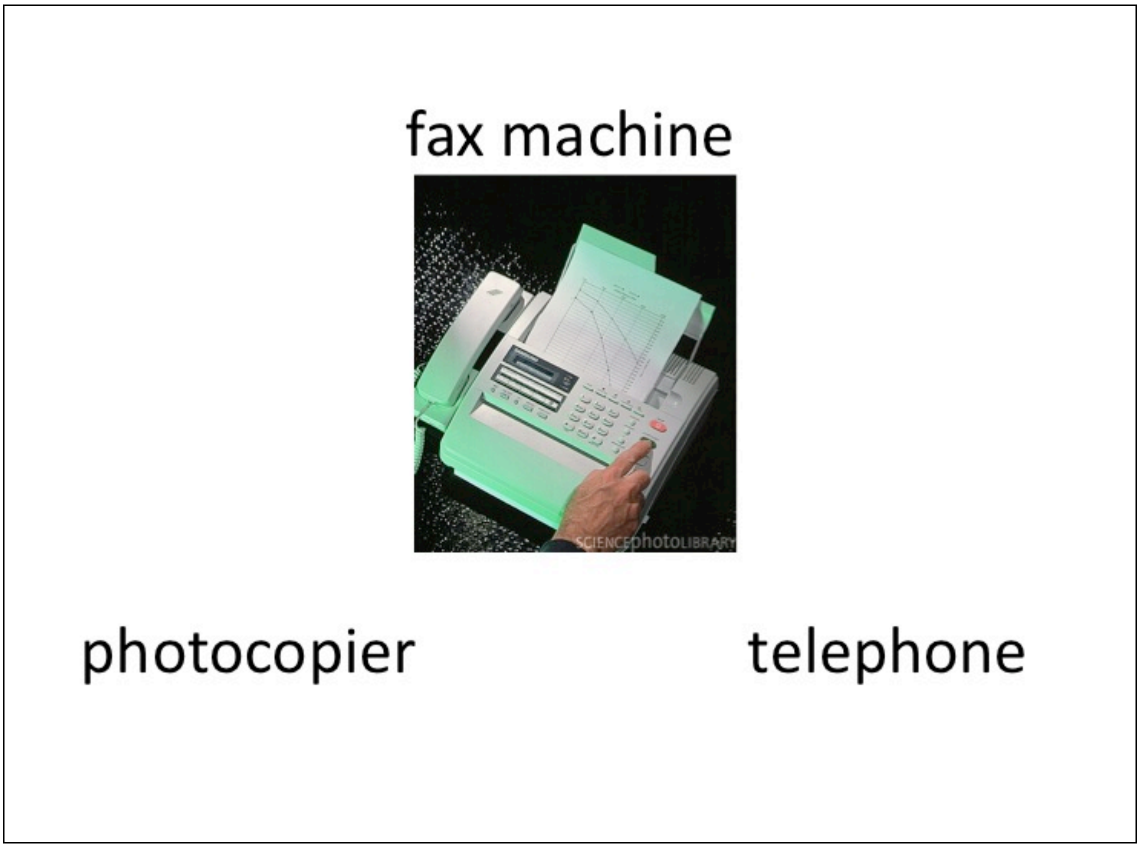


Figure G26. Format of the *fax machine* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

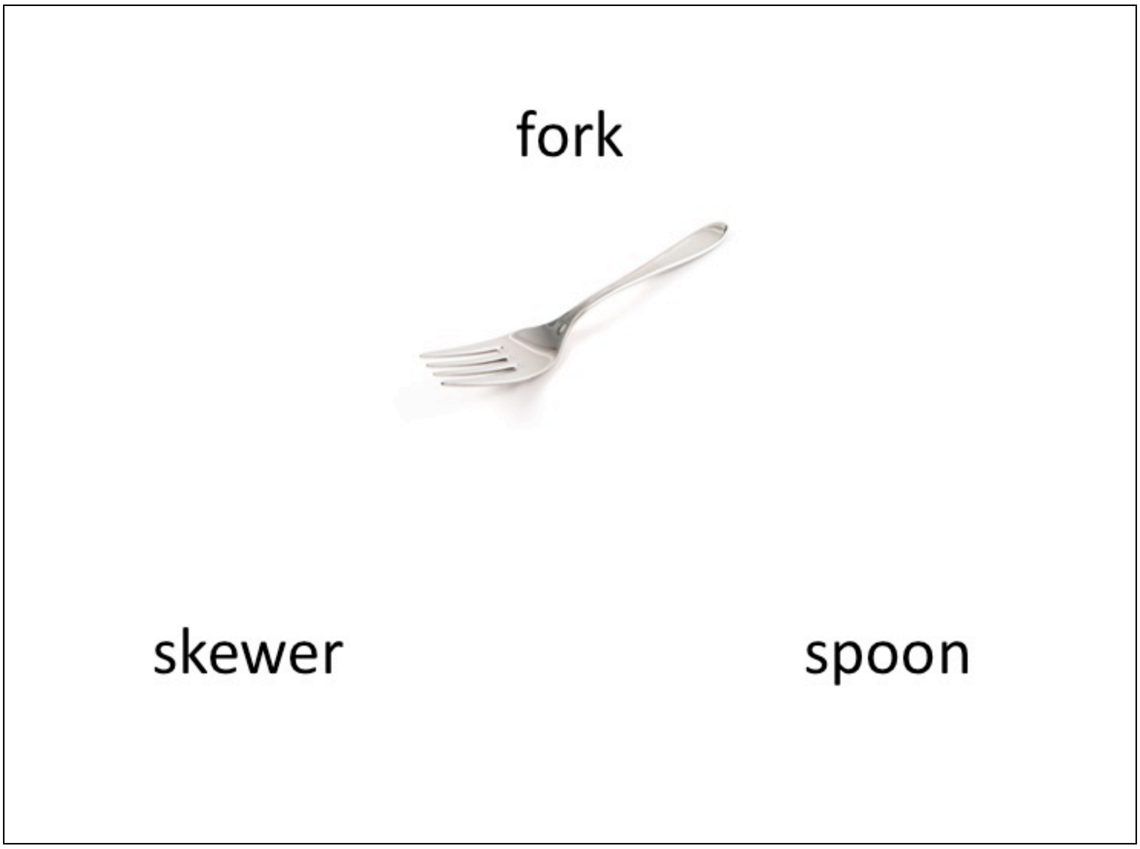


Figure G27. Format of the *fork* triad used in the context-lean condition (Experiment 1).

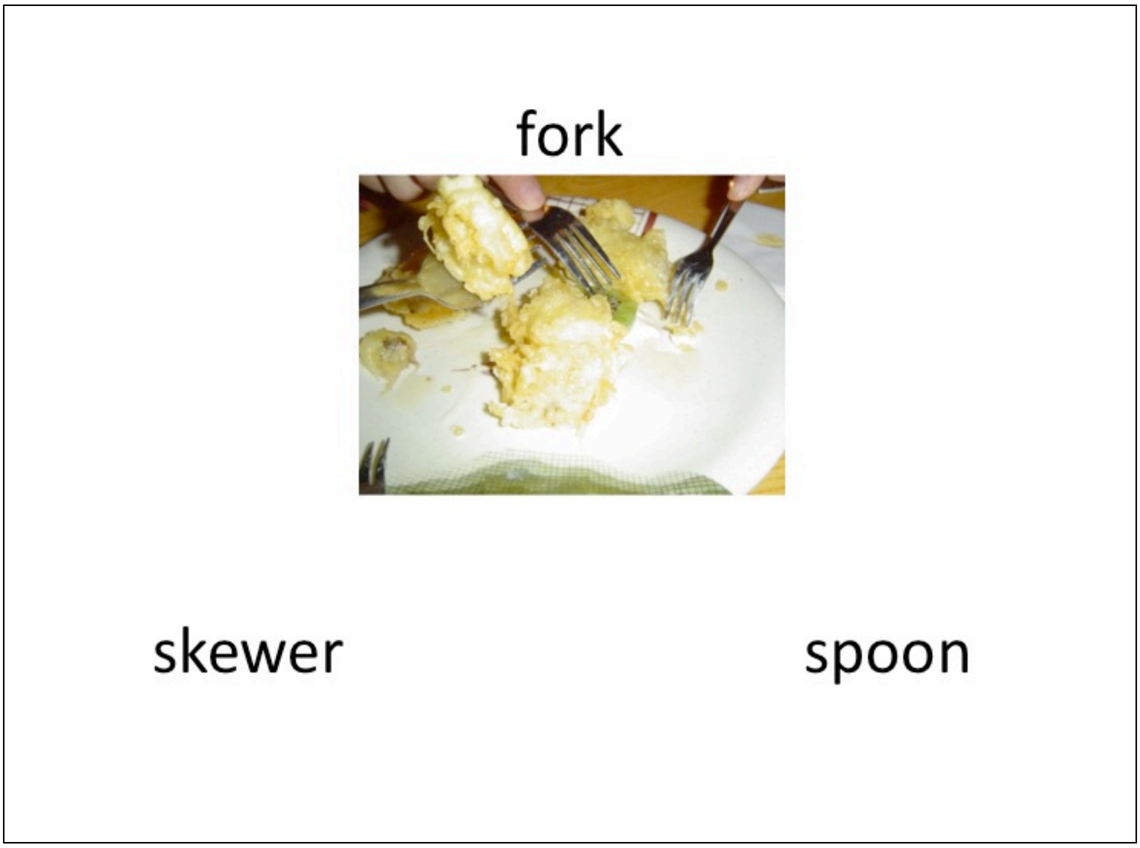


Figure G28. Format of the *fork* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

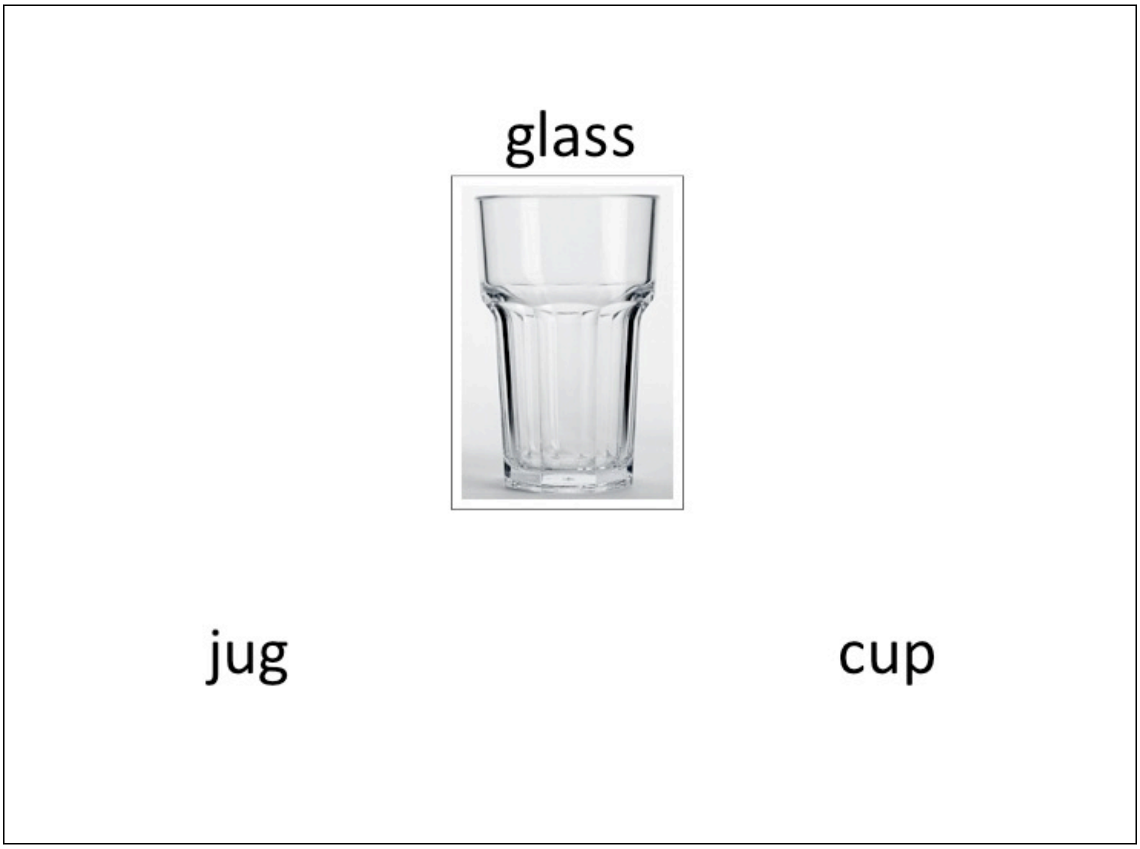


Figure G29. Format of the *glass* triad used in the context-lean condition (Experiment 1).

Figure G30. Format of the *glass* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

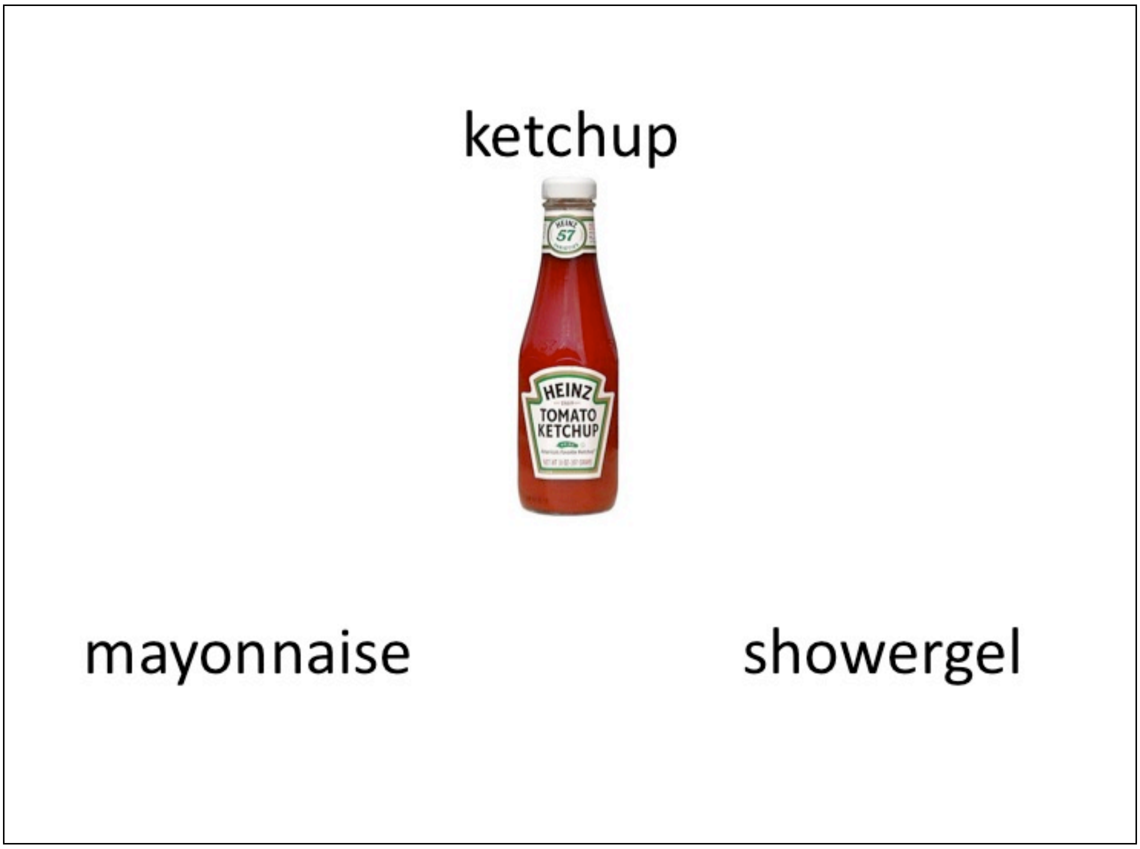


Figure G31. Format of the *ketchup* triad used in the context-lean condition (Experiment 1).

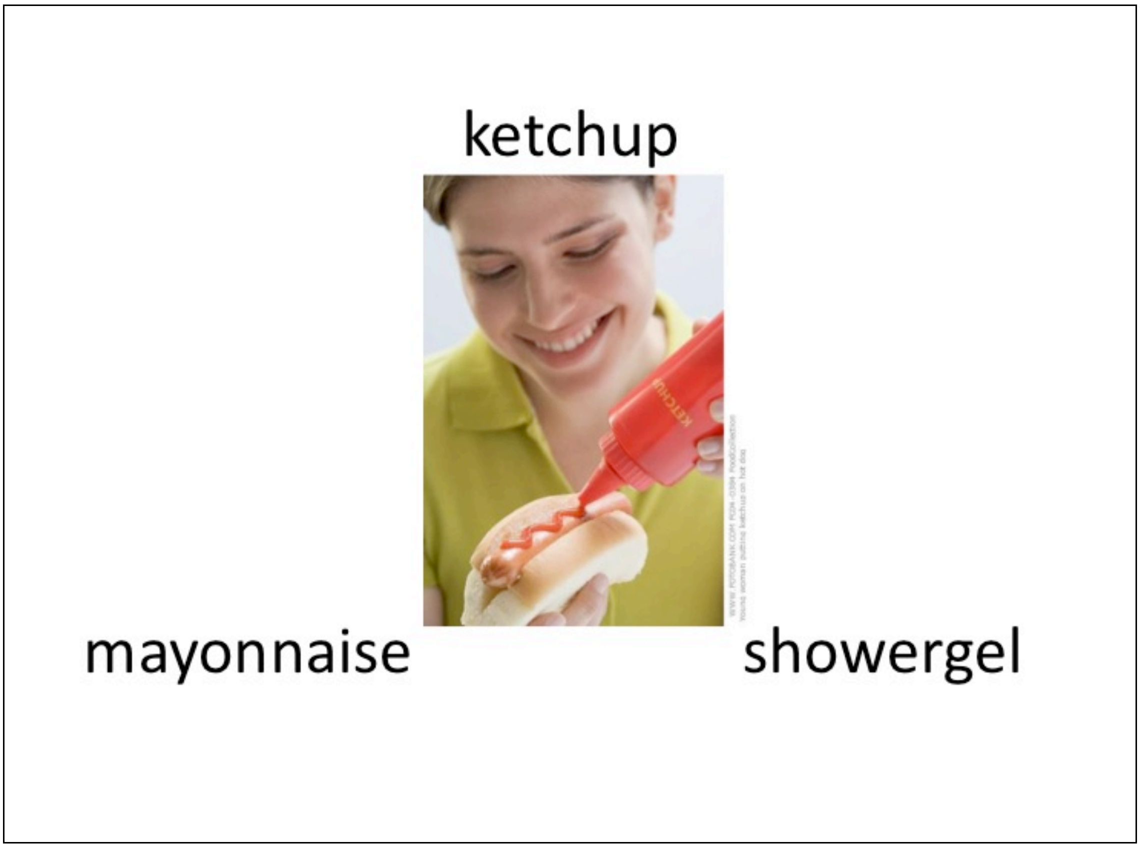


Figure G32. Format of the *ketchup* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

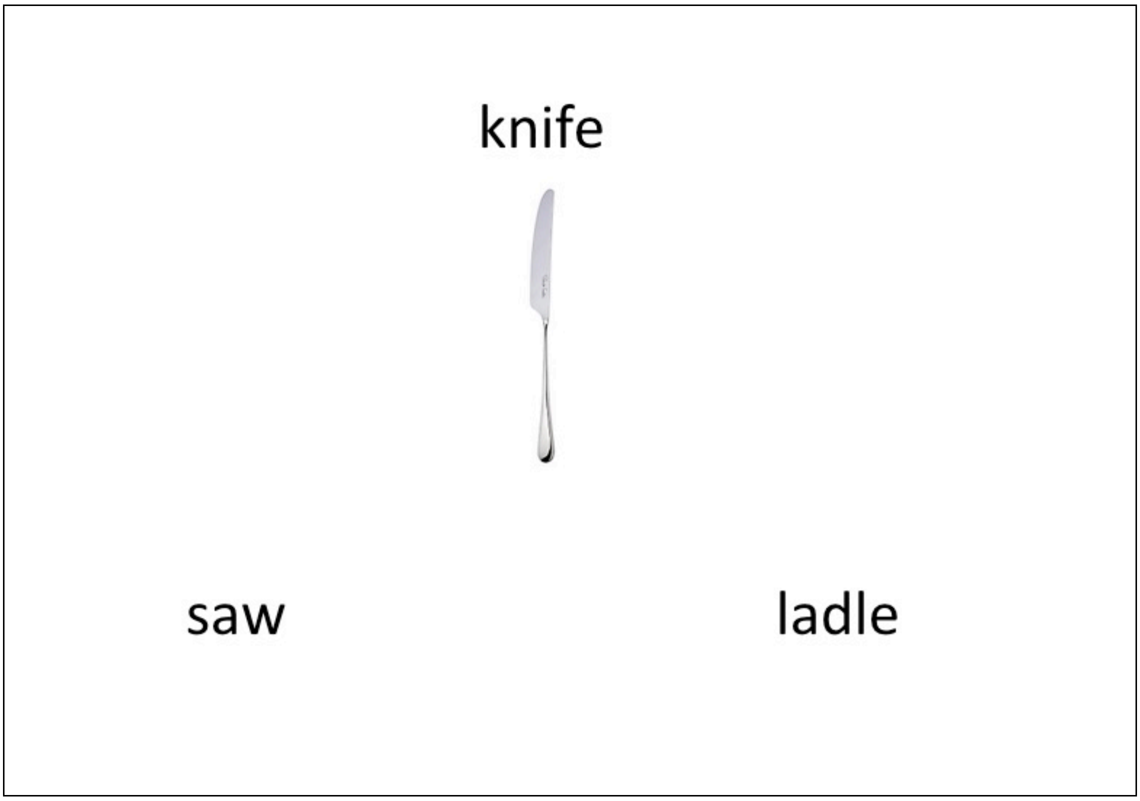


Figure G33. Format of the *knife* triad used in the context-lean condition (Experiment 1).

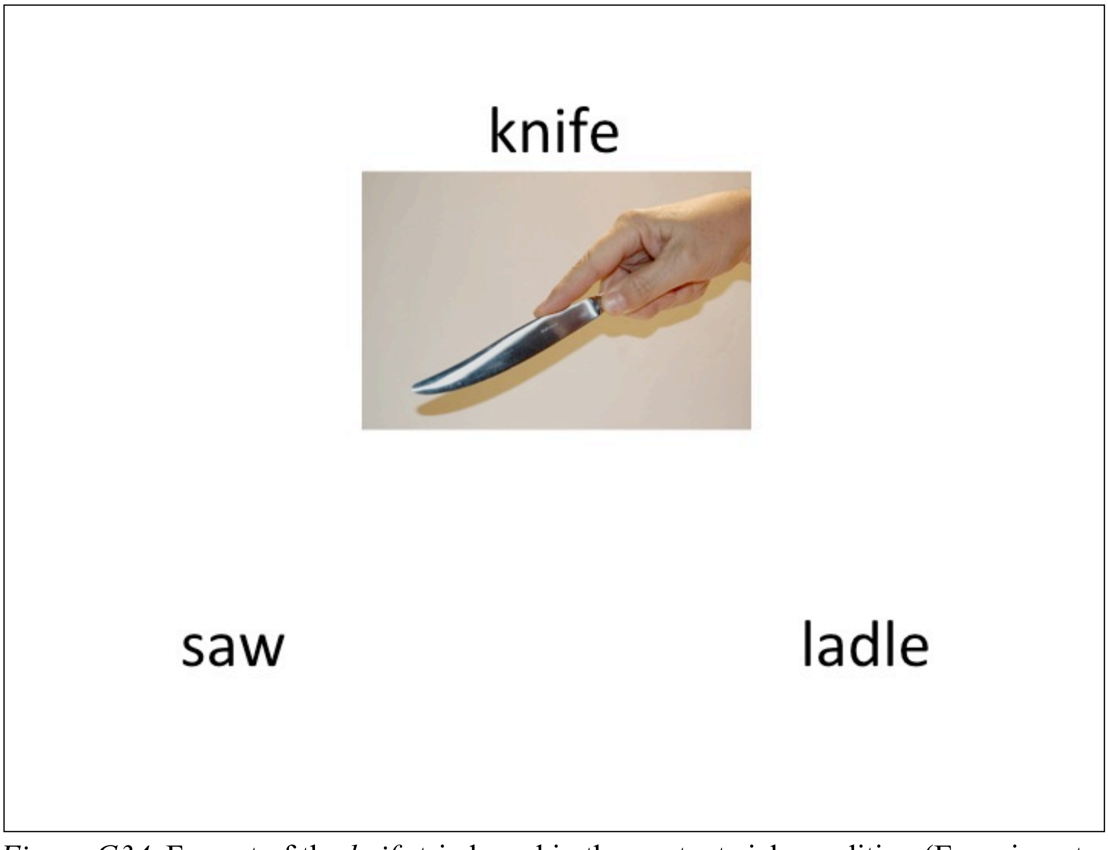


Figure G34. Format of the *knife* triad used in the context-rich condition (Experiment 1).

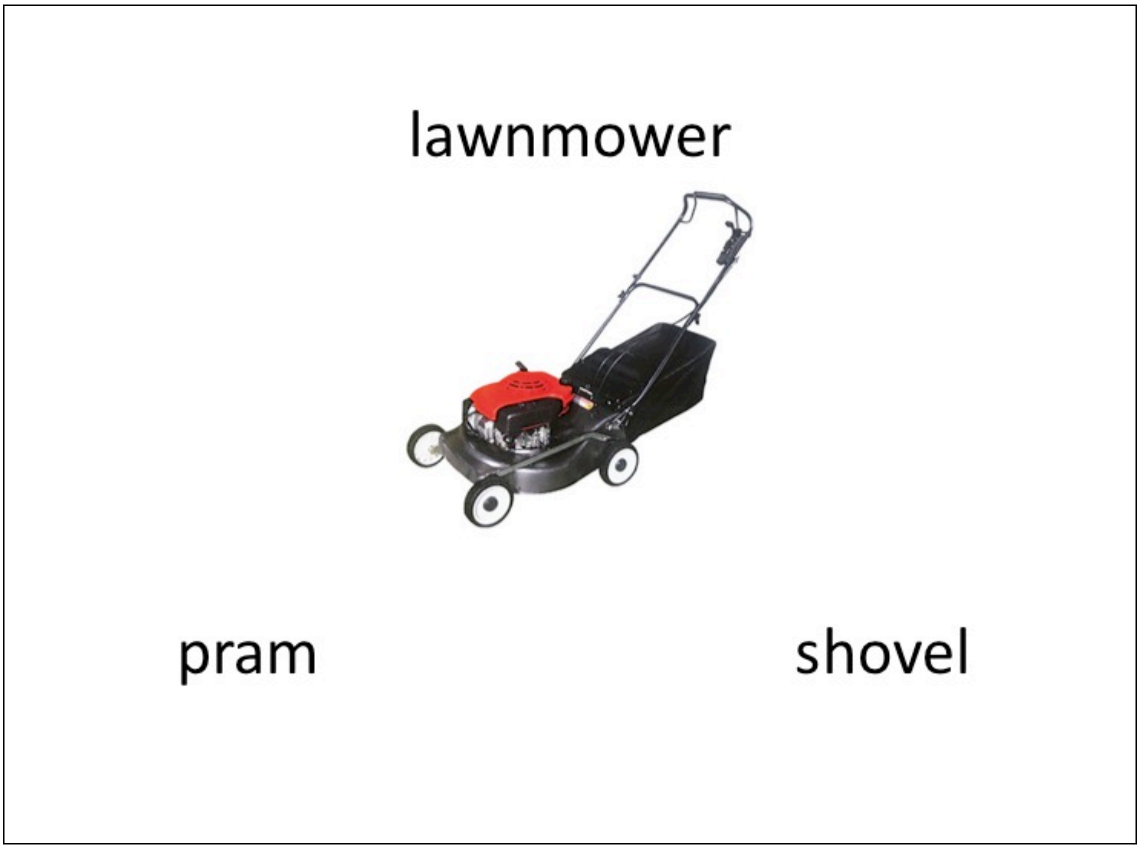


Figure G35. Format of the *lawnmower* triad used in the context-lean condition (Experiment 1).

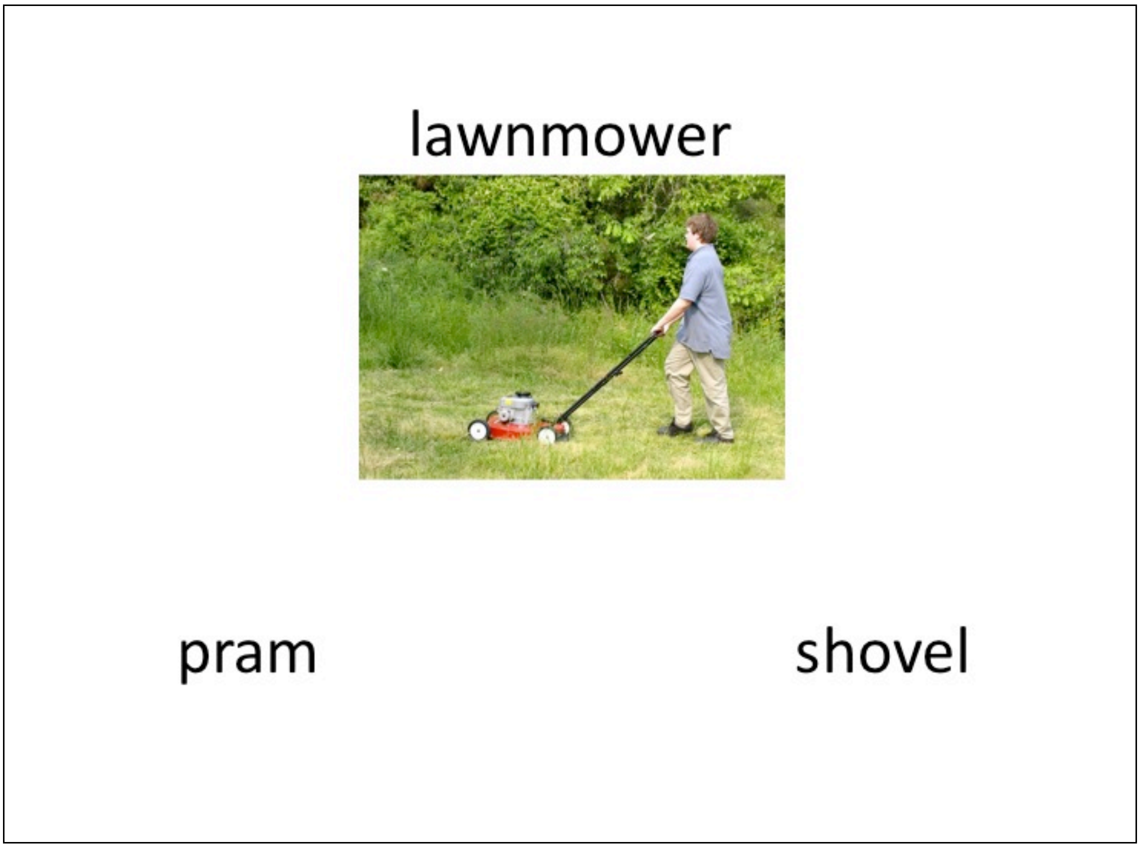


Figure G36. Format of the *lawnmower* triad used in the context-rich condition (Experiment 1).

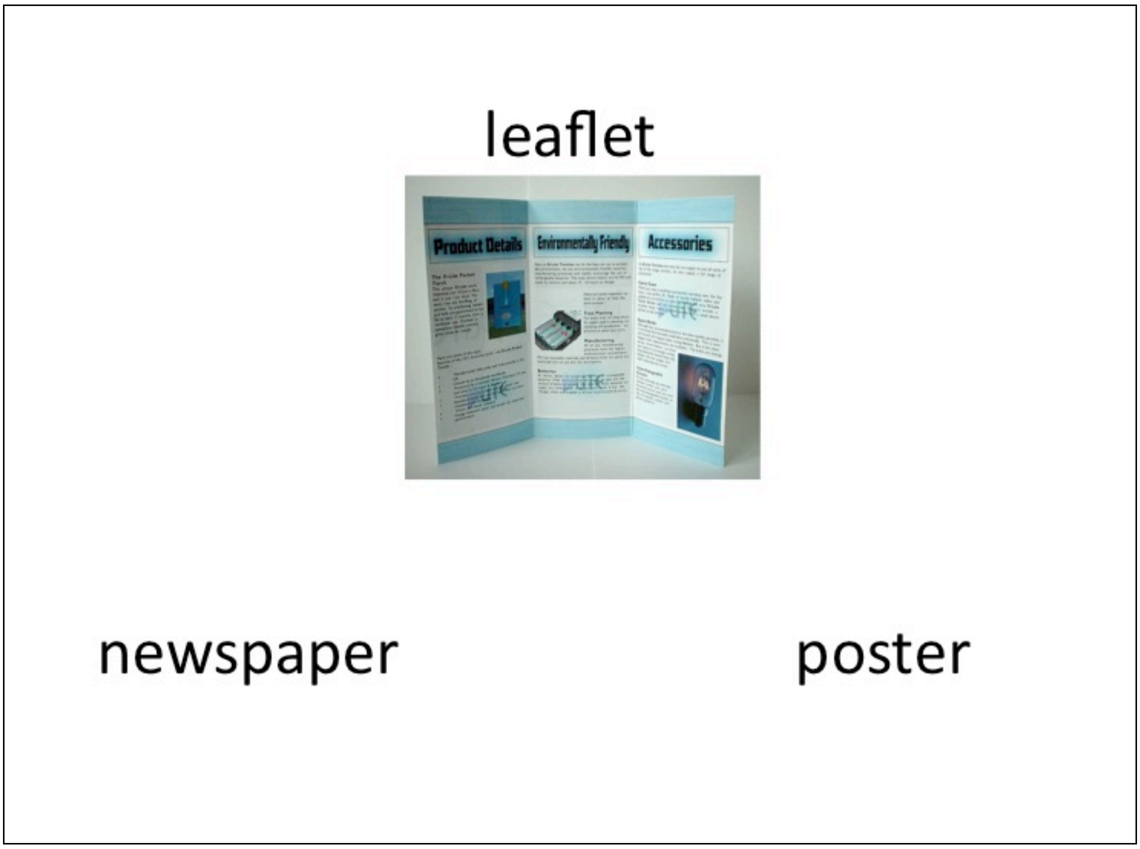


Figure G37. Format of the *leaflet* triad used in the context-lean condition (Experiment 1).

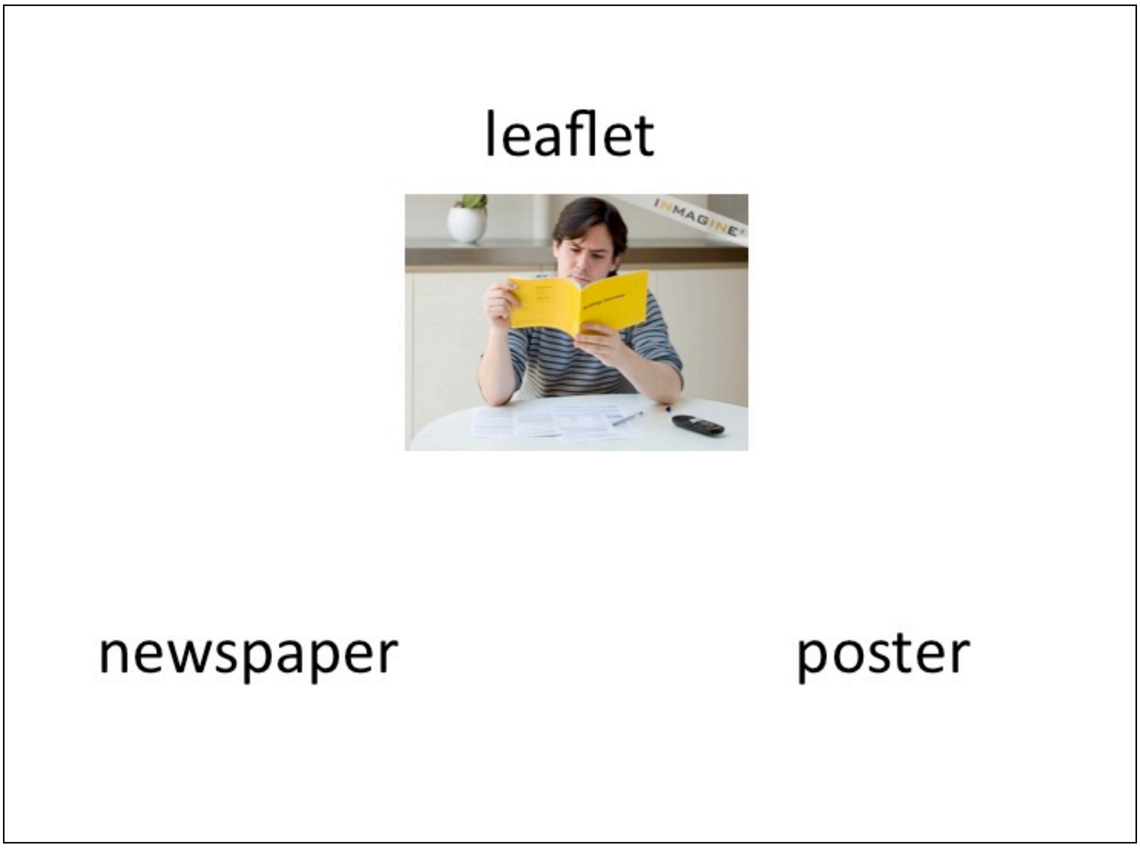


Figure G38. Format of the *leaflet* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

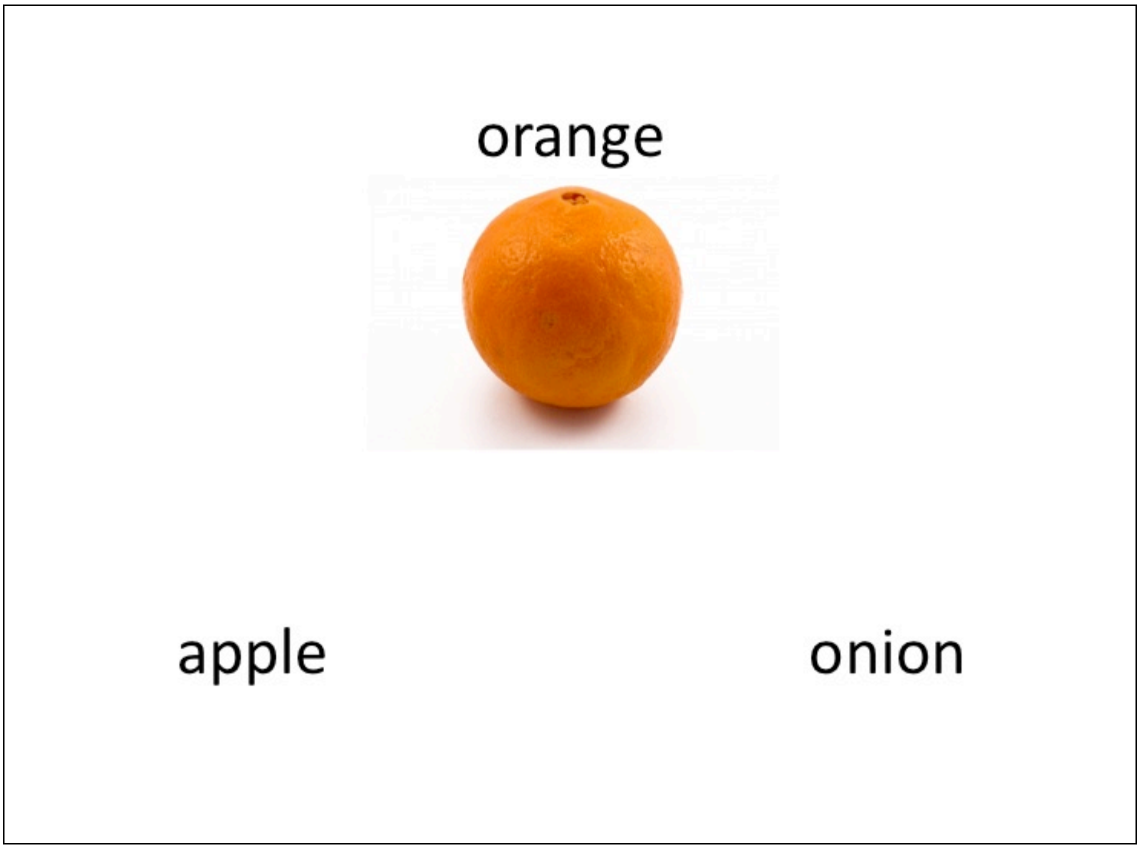


Figure G39. Format of the *orange* triad used in the context-lean condition (Experiment 1).

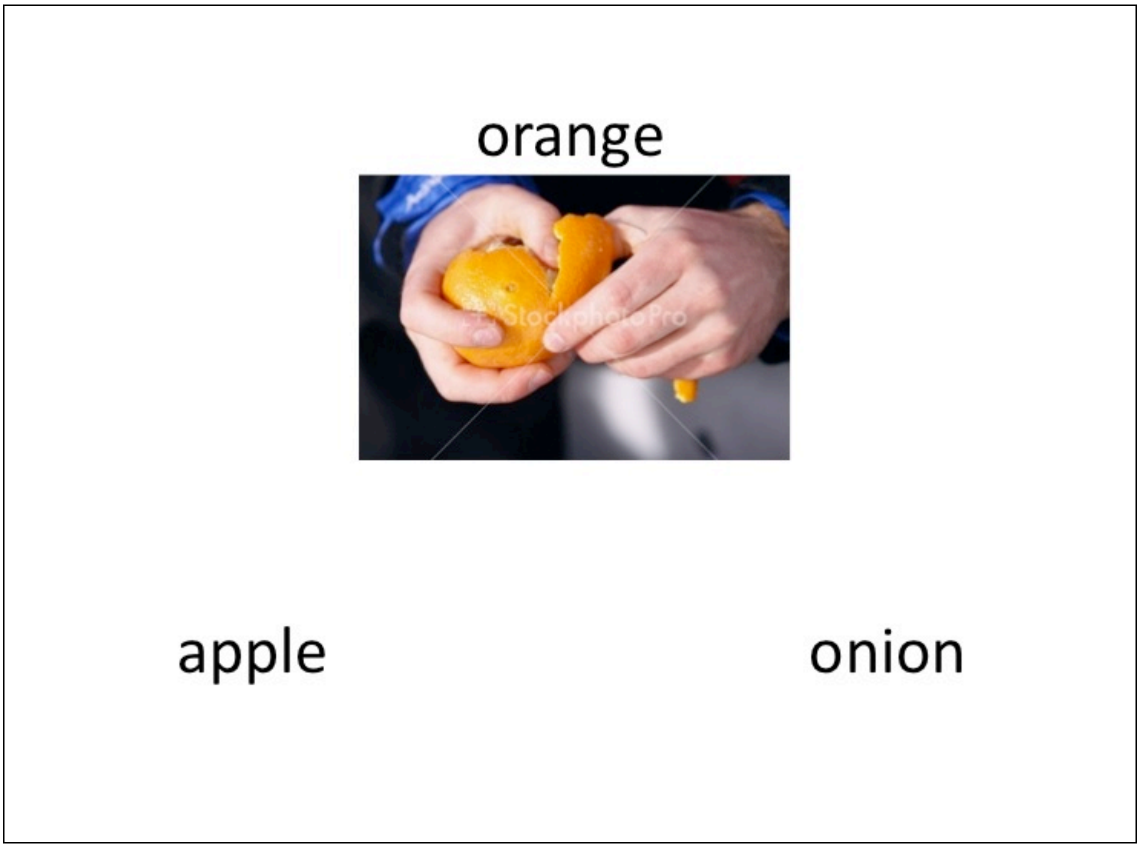


Figure G40. Format of the *orange* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

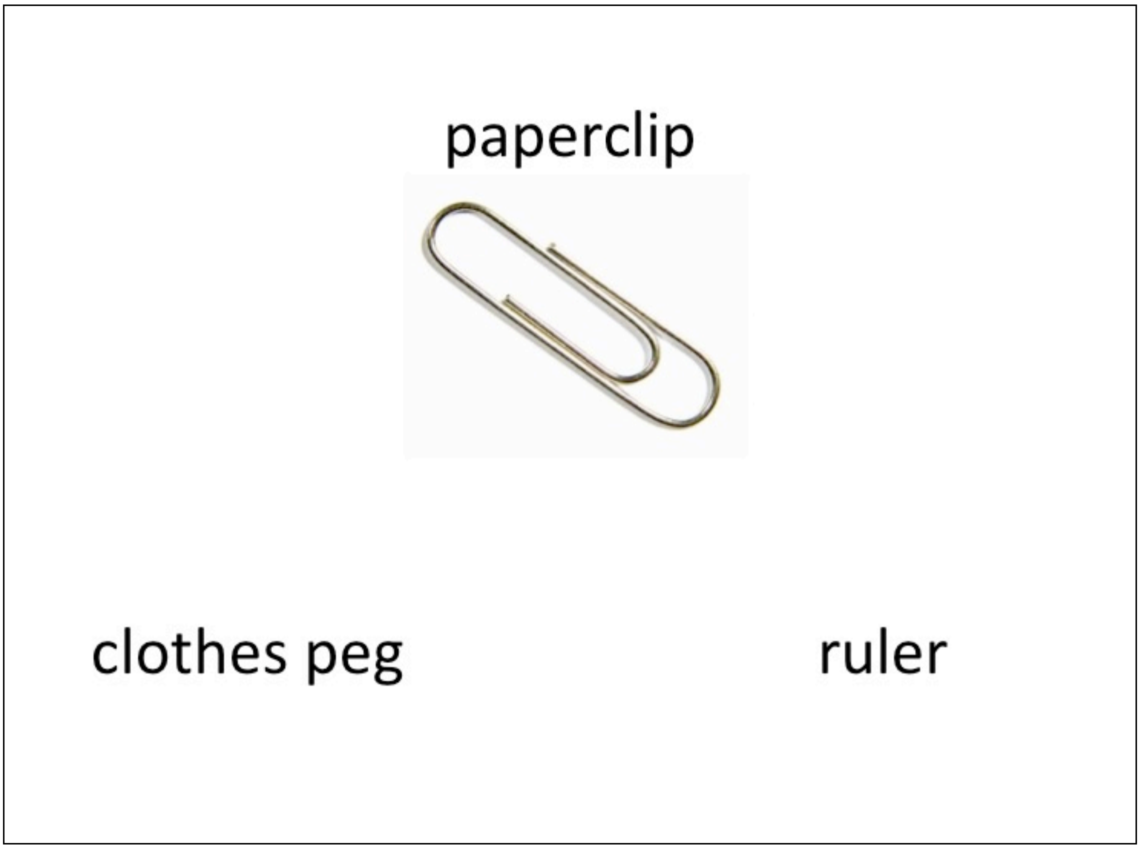


Figure G41. Format of the *paperclip* triad used in the context-lean condition (Experiment 1).

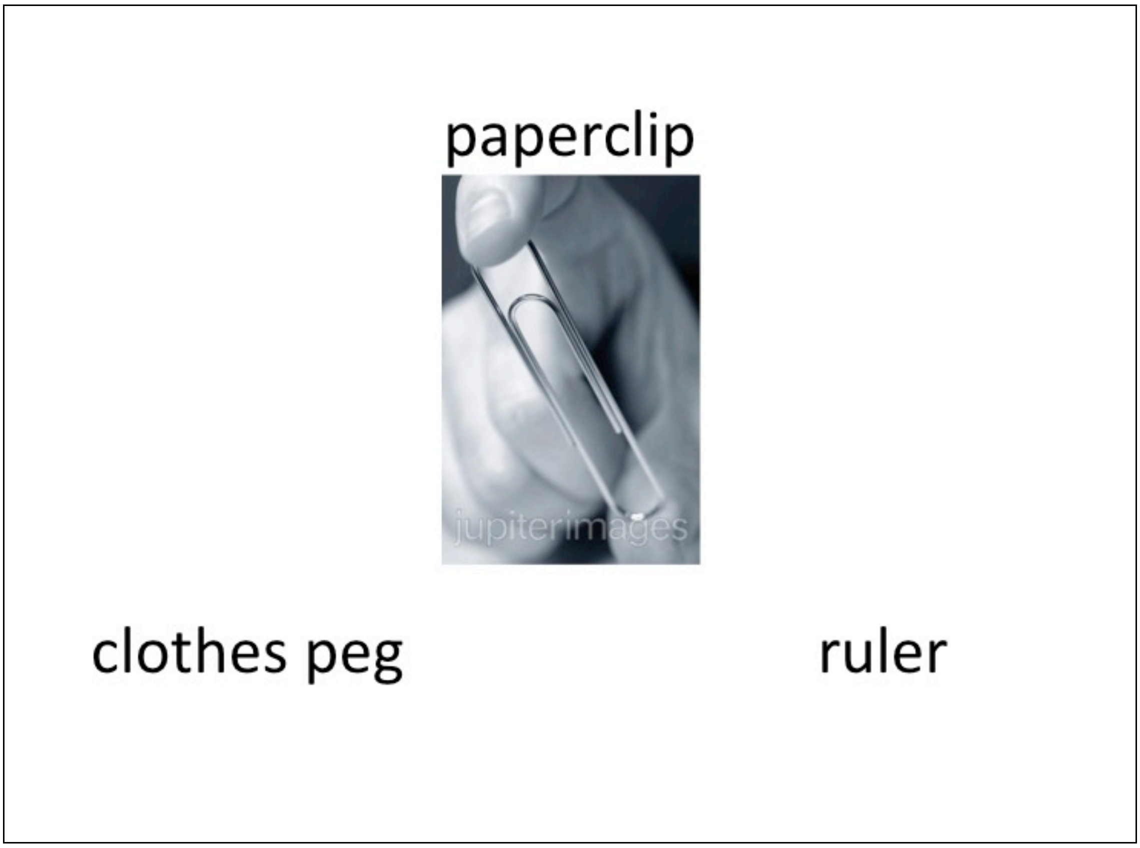


Figure G42. Format of the *paperclip* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

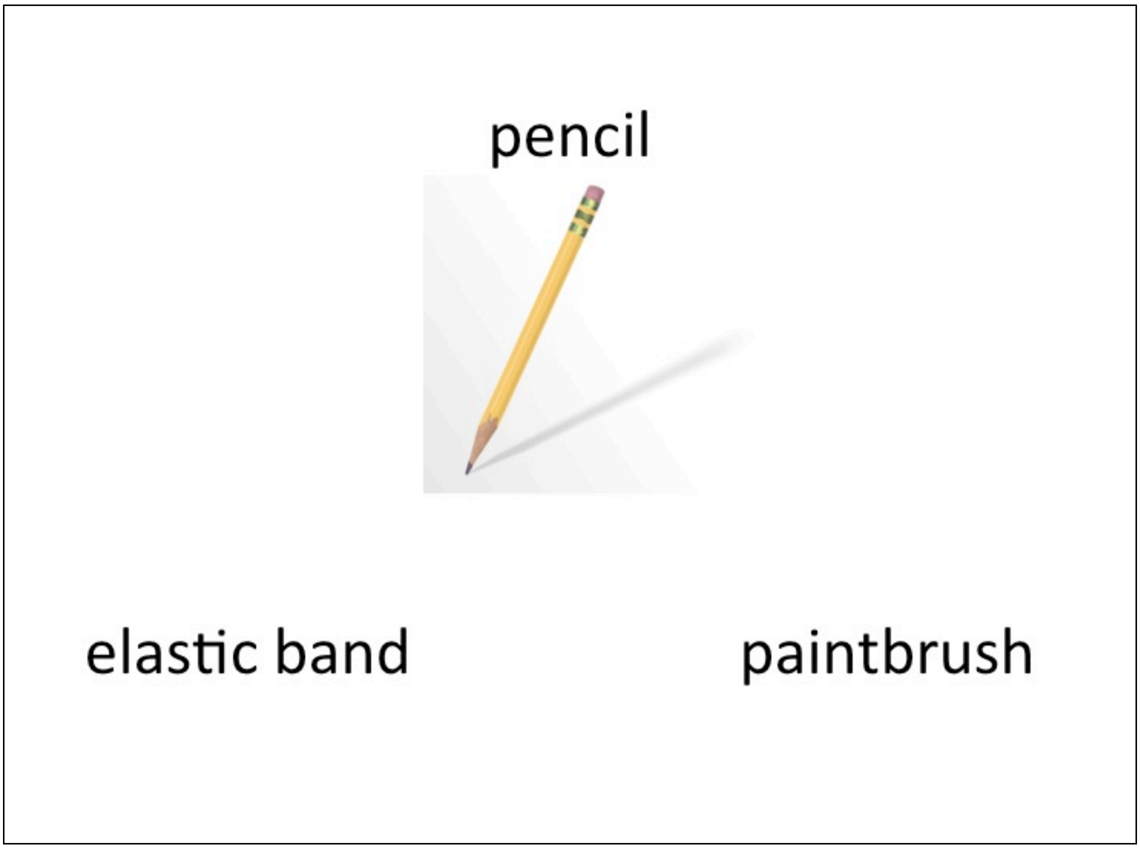


Figure G43. Format of the *pencil* triad used in the context-lean condition (Experiment 1).

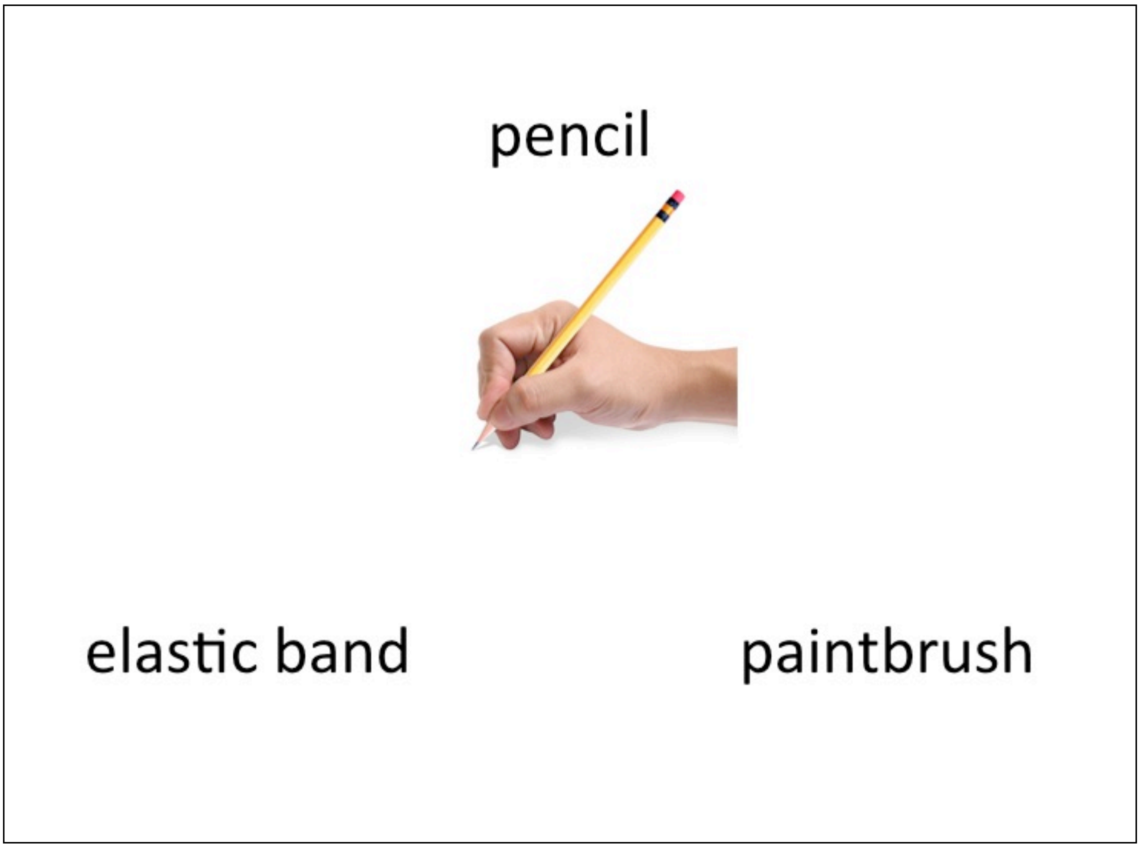


Figure G44. Format of the *pencil* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

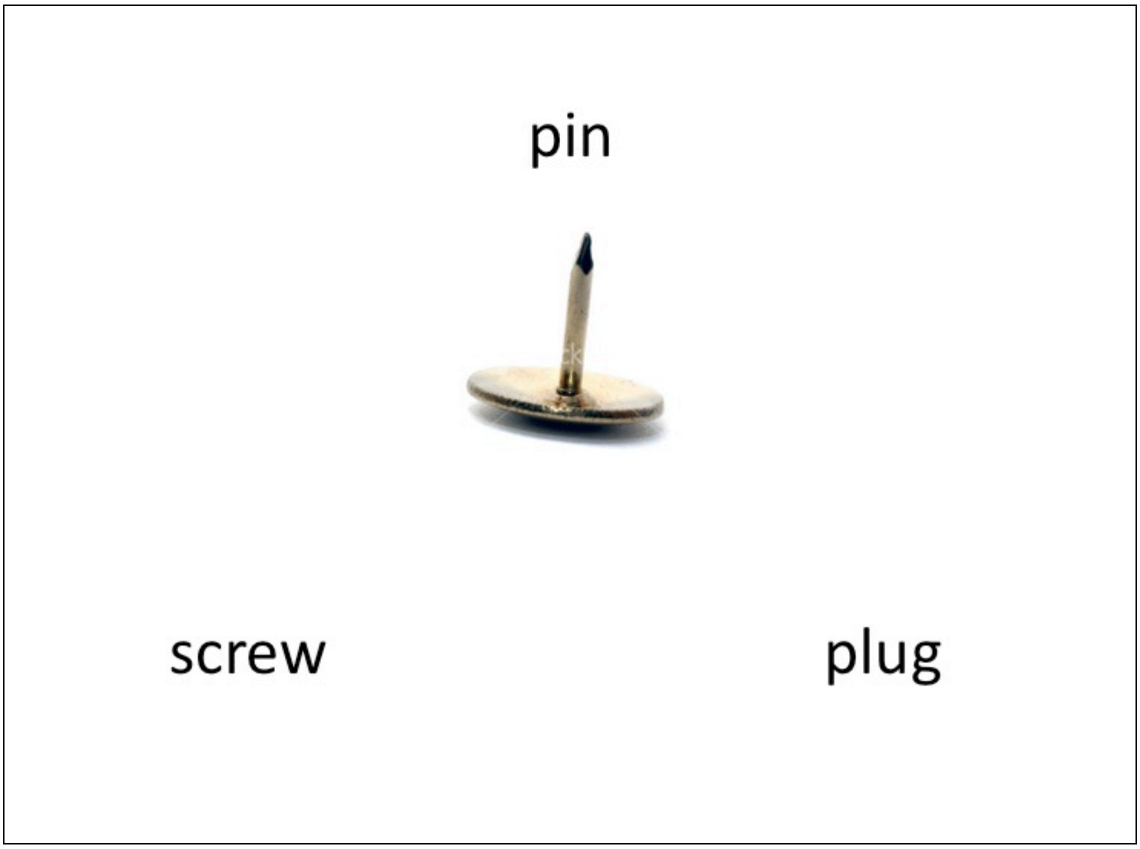


Figure G45. Format of the *pin* triad used in the context-lean condition (Experiment 1).

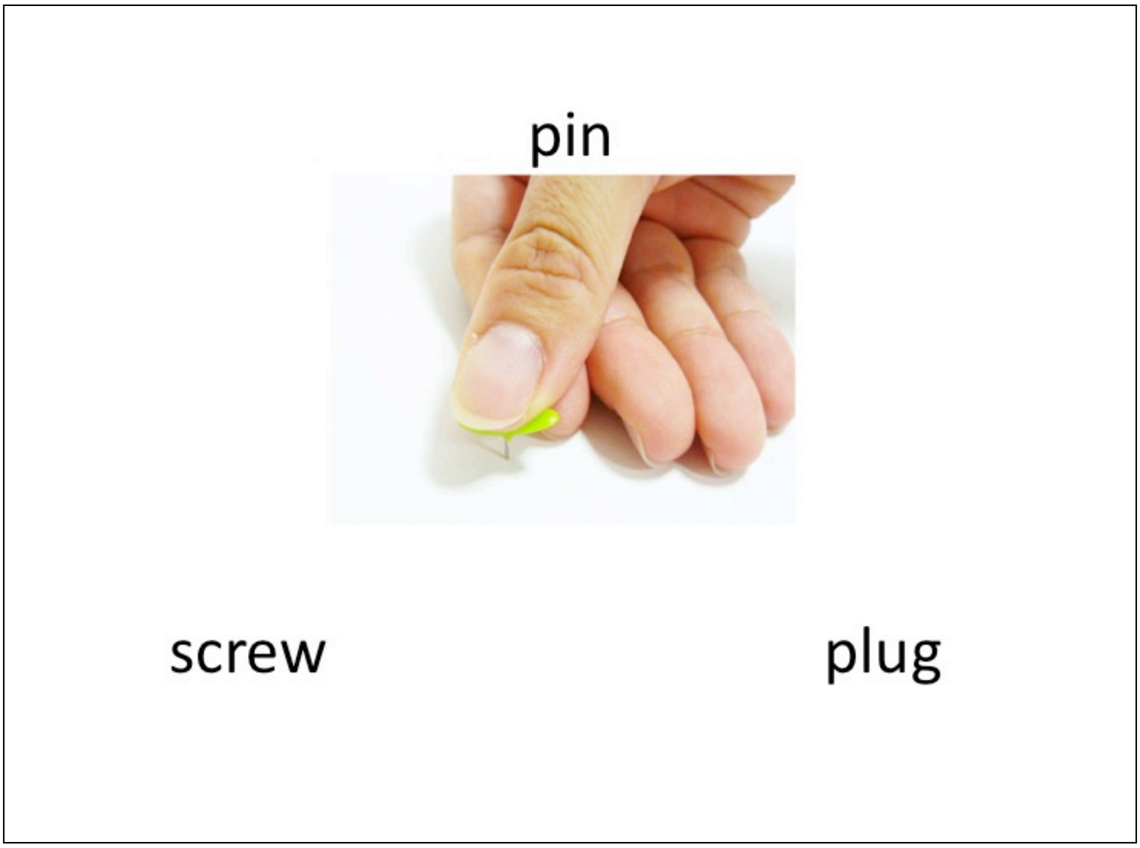


Figure G46. Format of the *pin* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

Figure G47. Format of the *rifle* triad used in the context-lean condition (Experiment 1).

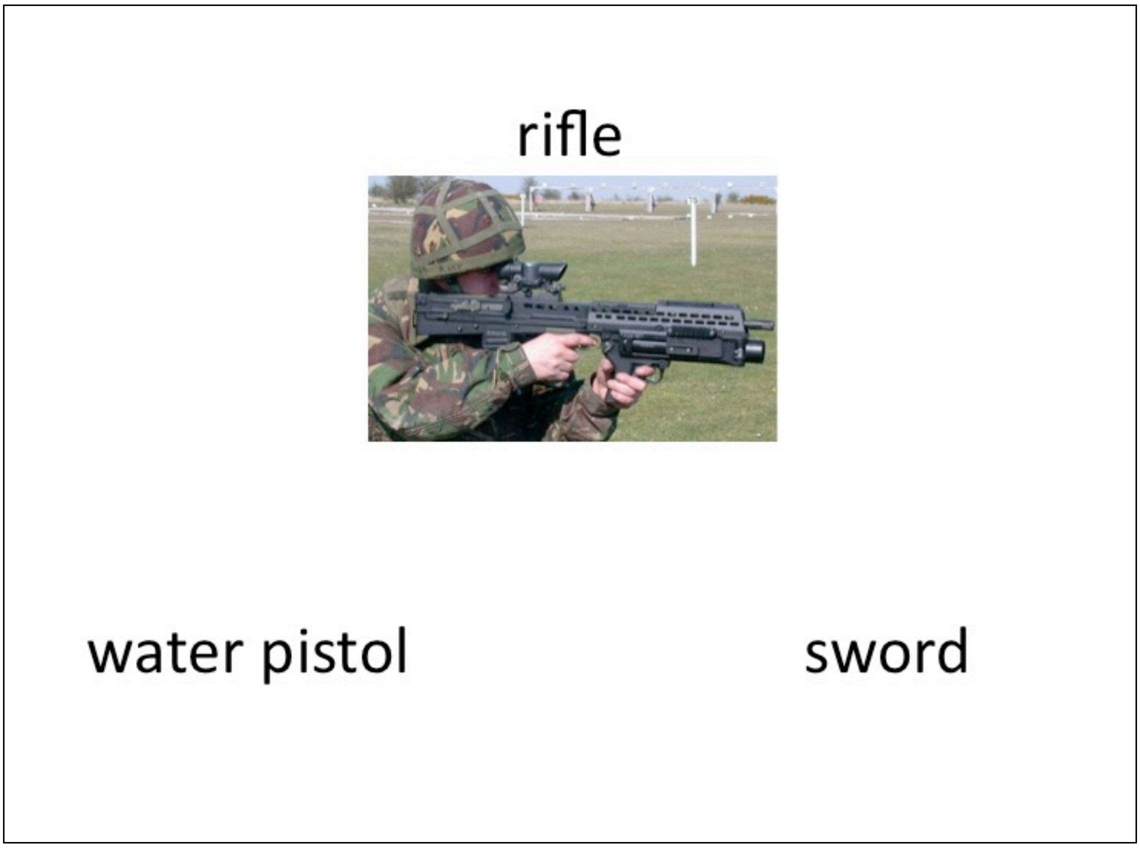


Figure G48. Format of the *rifle* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

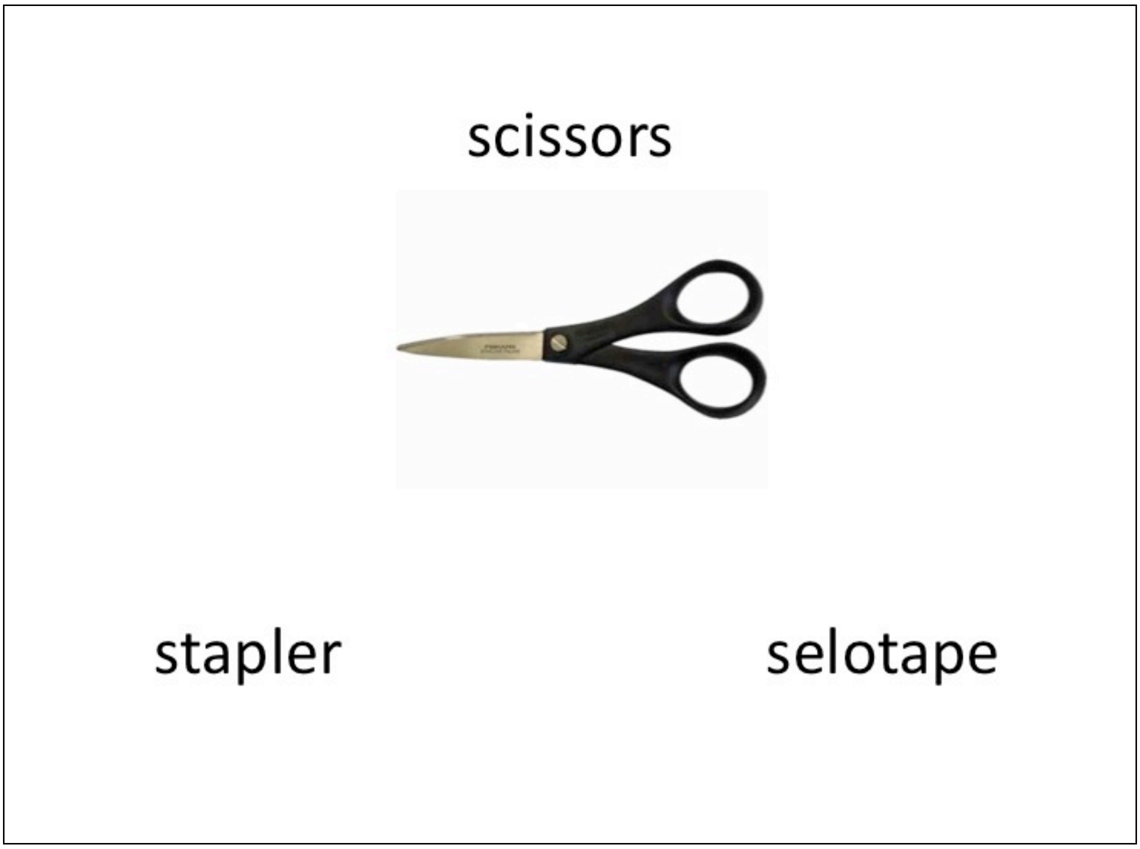


Figure G49. Format of the *scissors* triad used in the context-lean condition (Experiment 1).

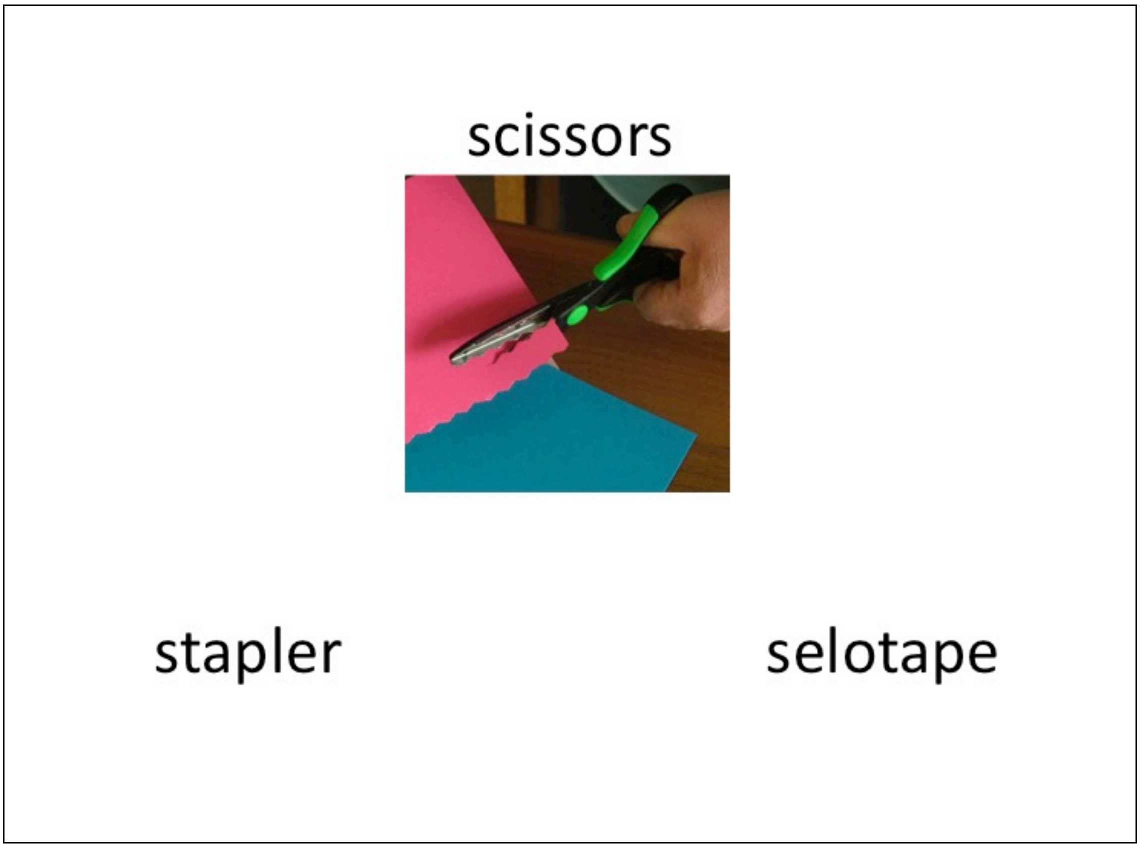


Figure G50. Format of the *scissors* triad used in the context-rich condition (Experiment 1).

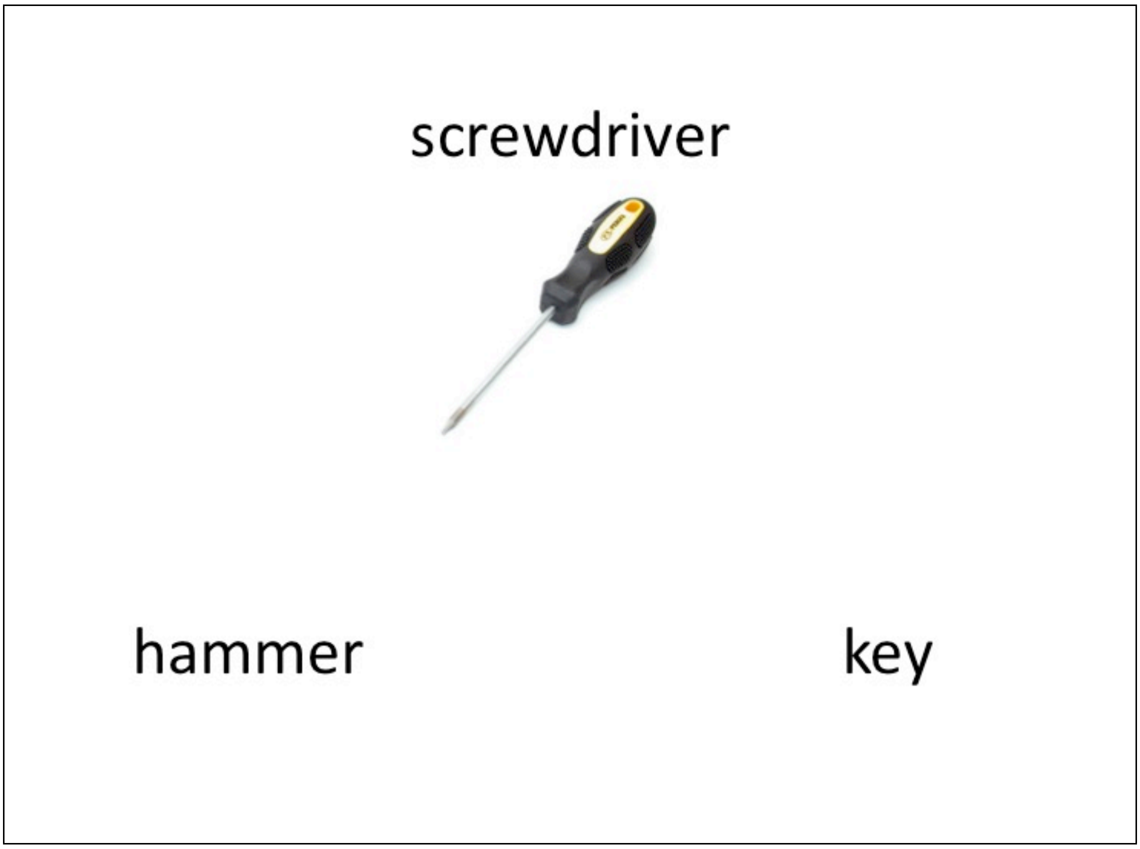


Figure G51. Format of the *screwdriver* triad used in the context-lean condition (Experiment 1).

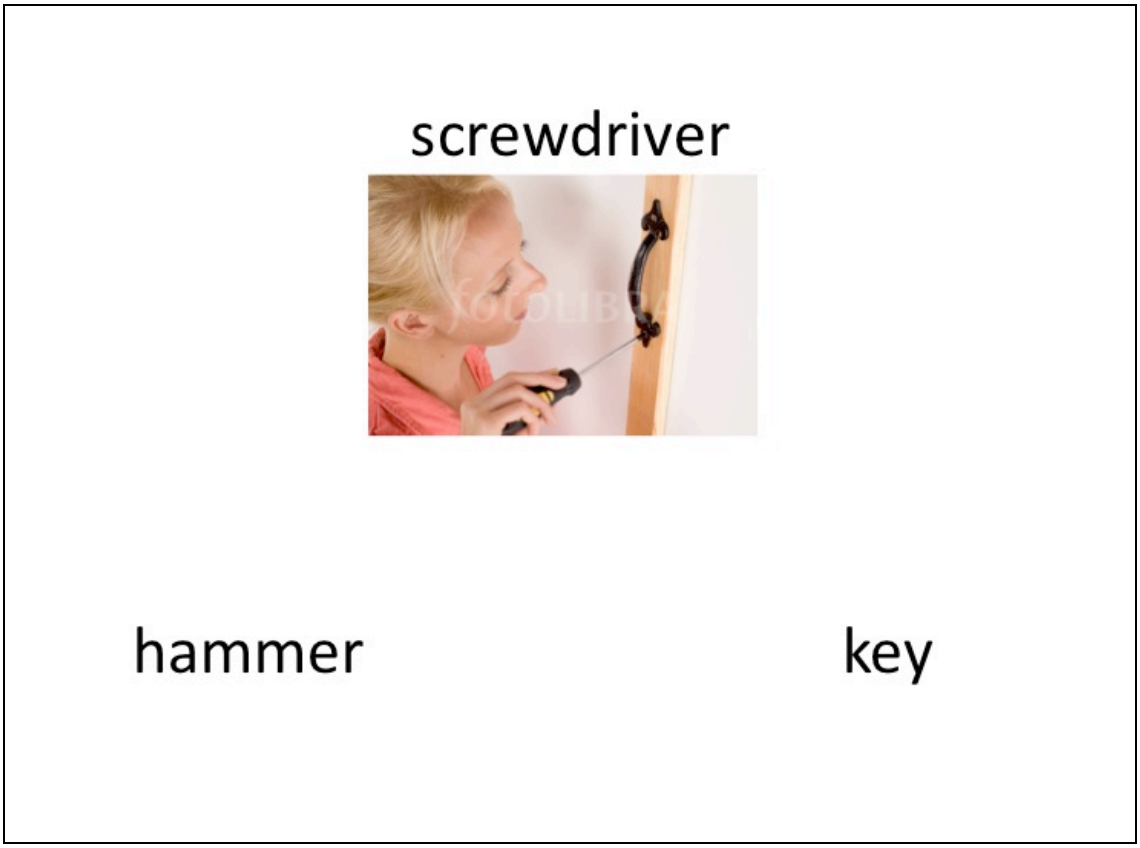


Figure G52. Format of the *screwdriver* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

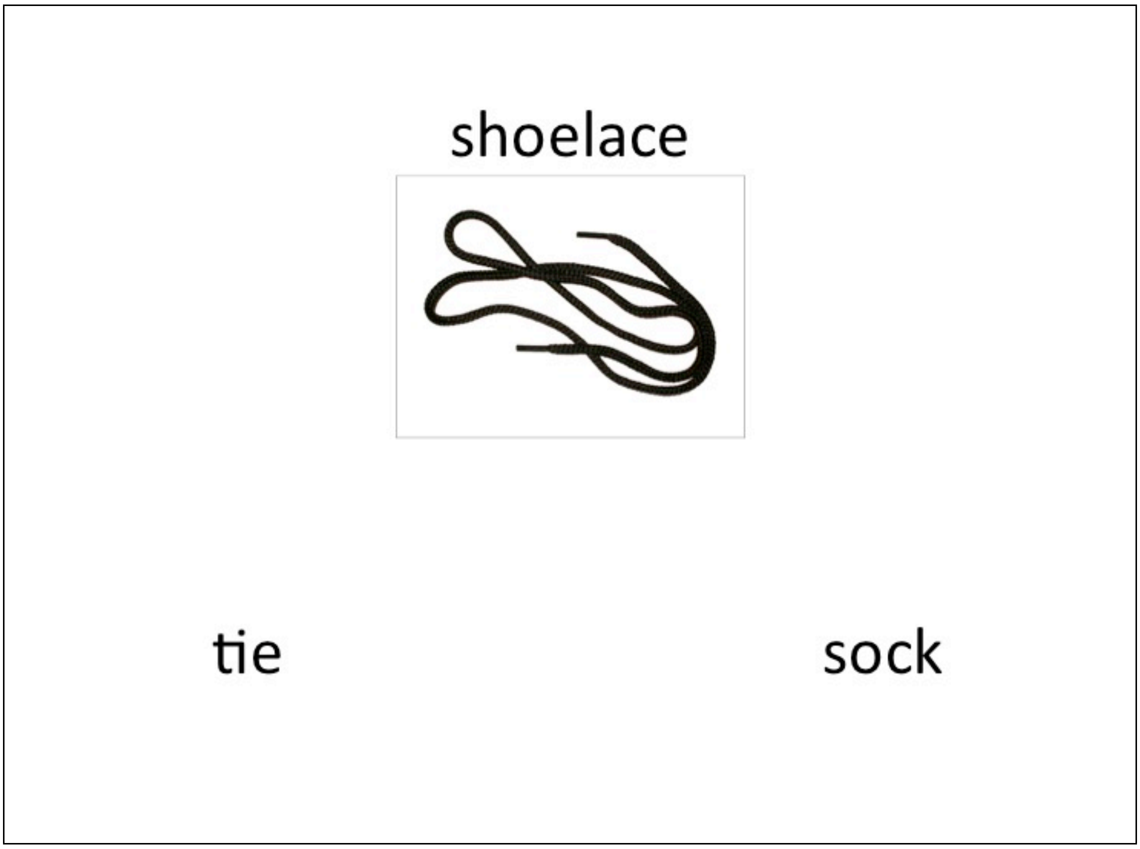


Figure G53. Format of the *shoelace* triad used in the context-lean condition (Experiment 1).

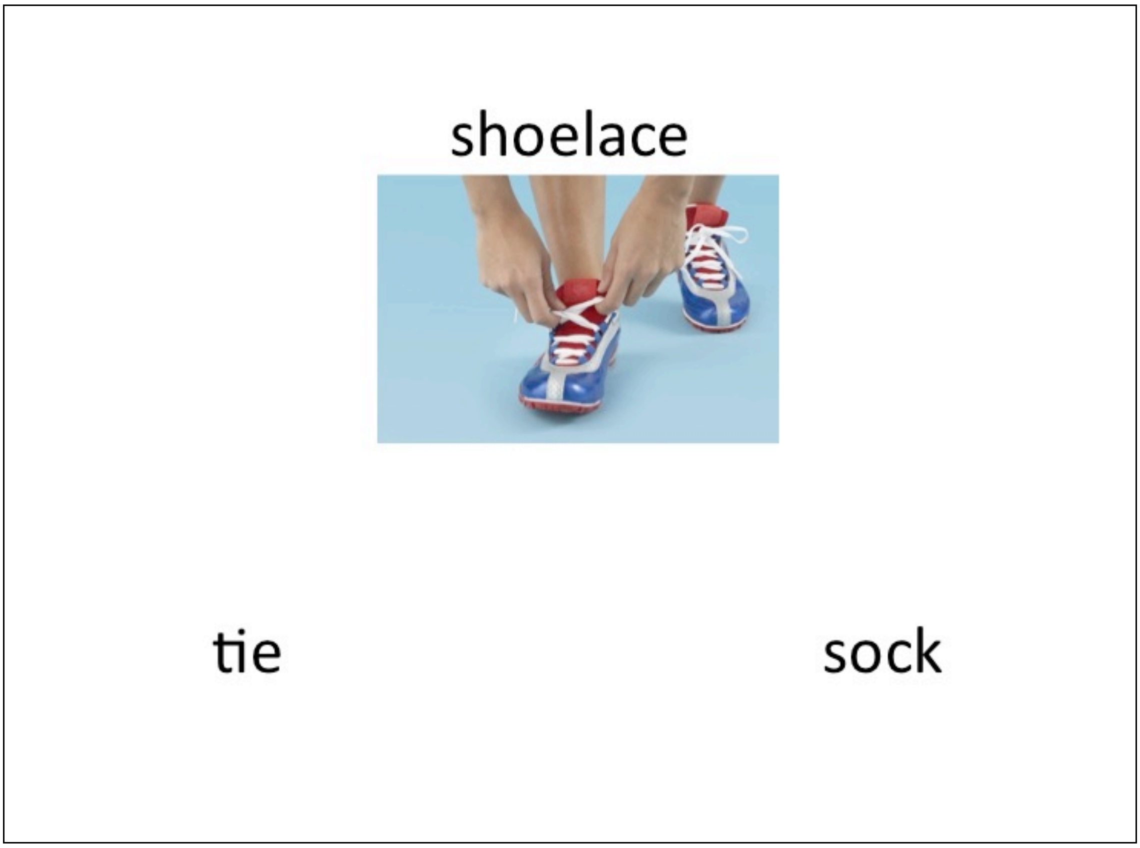


Figure G54. Format of the *shoelace* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

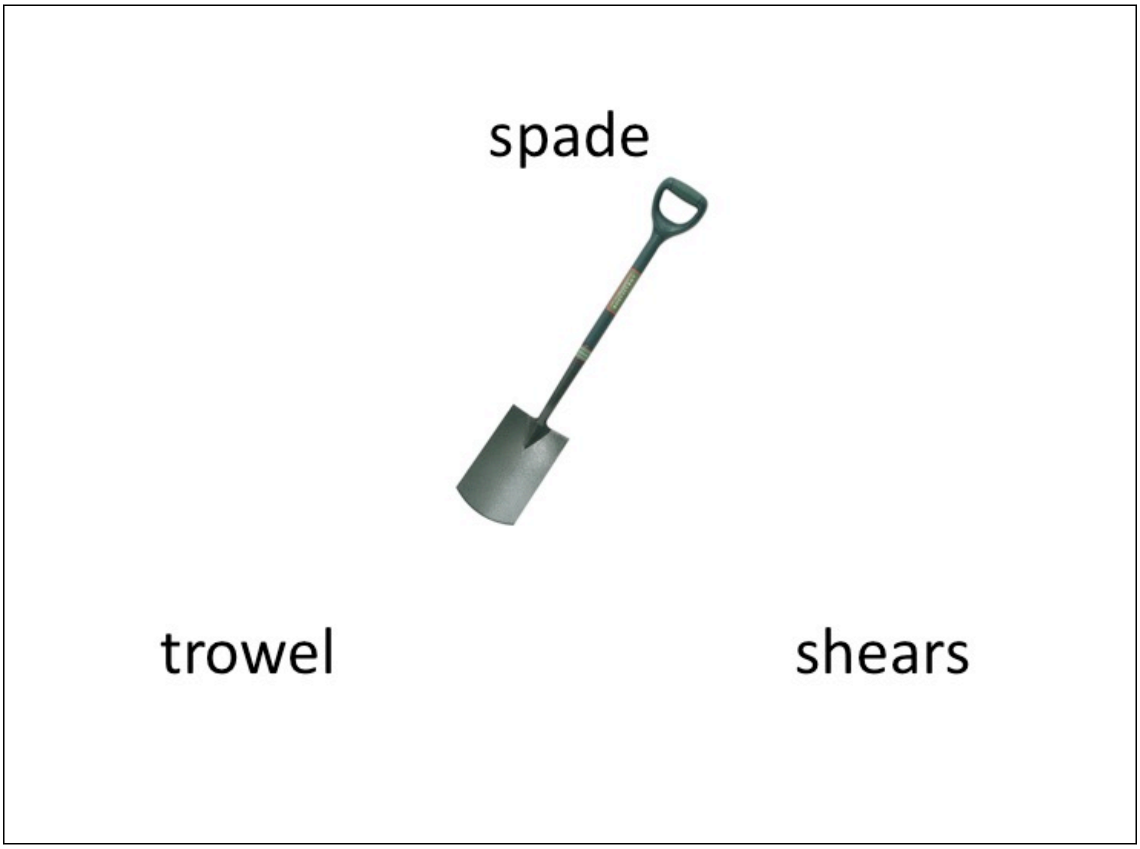


Figure G55. Format of the *spade* triad used in the context-lean condition (Experiment 1).

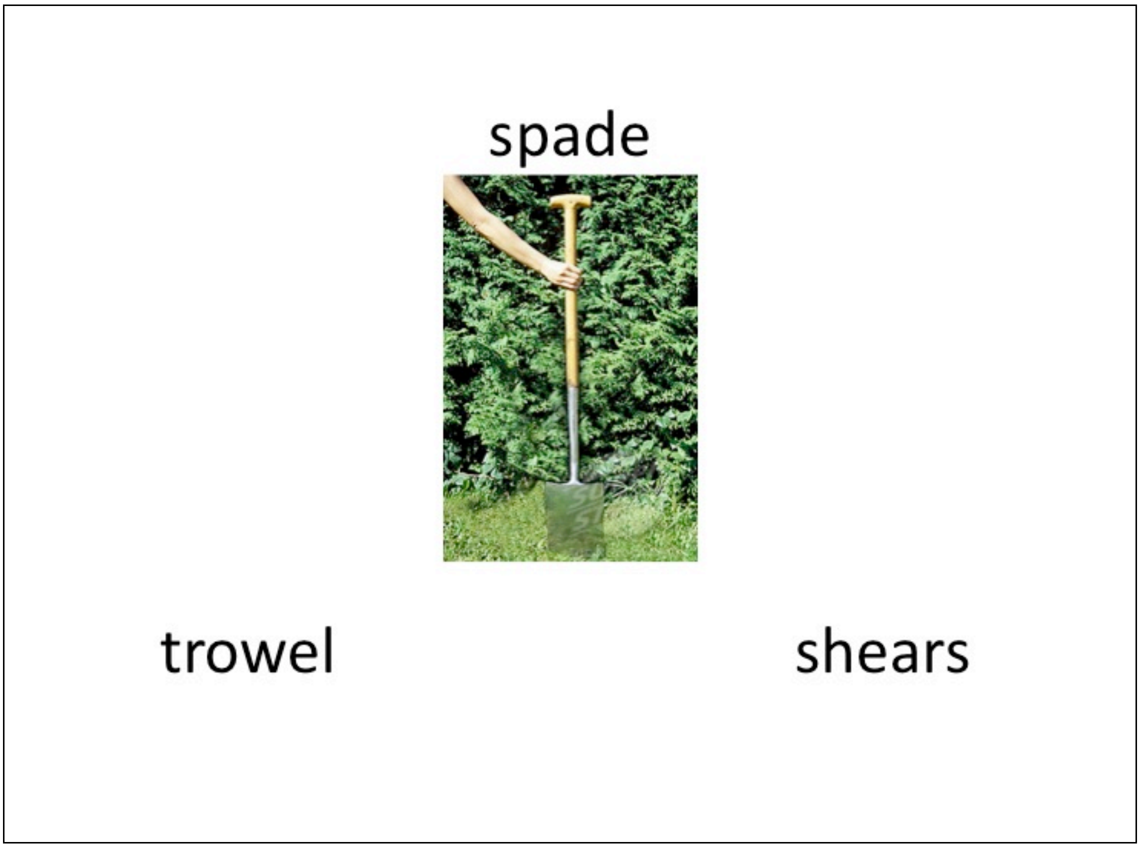


Figure G56. Format of the *spade* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

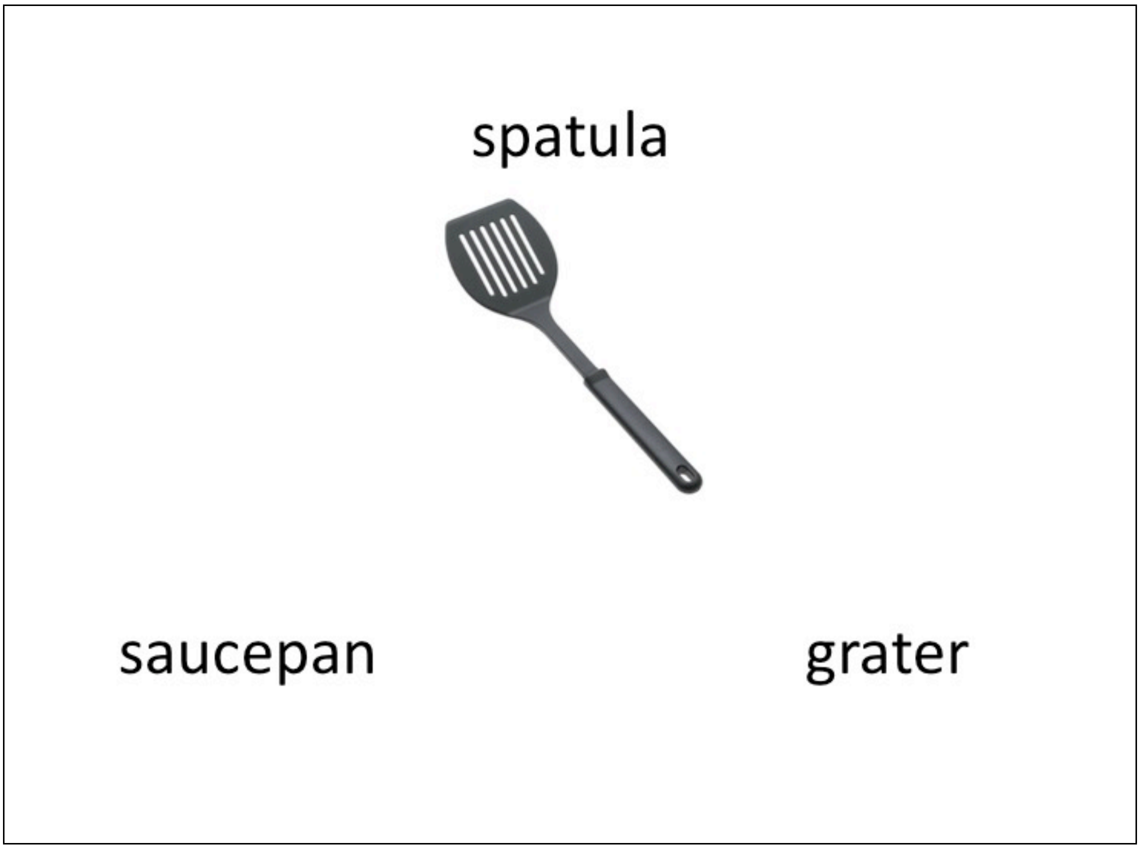


Figure G57. Format of the *spatula* triad used in the context-lean condition (Experiment 1).

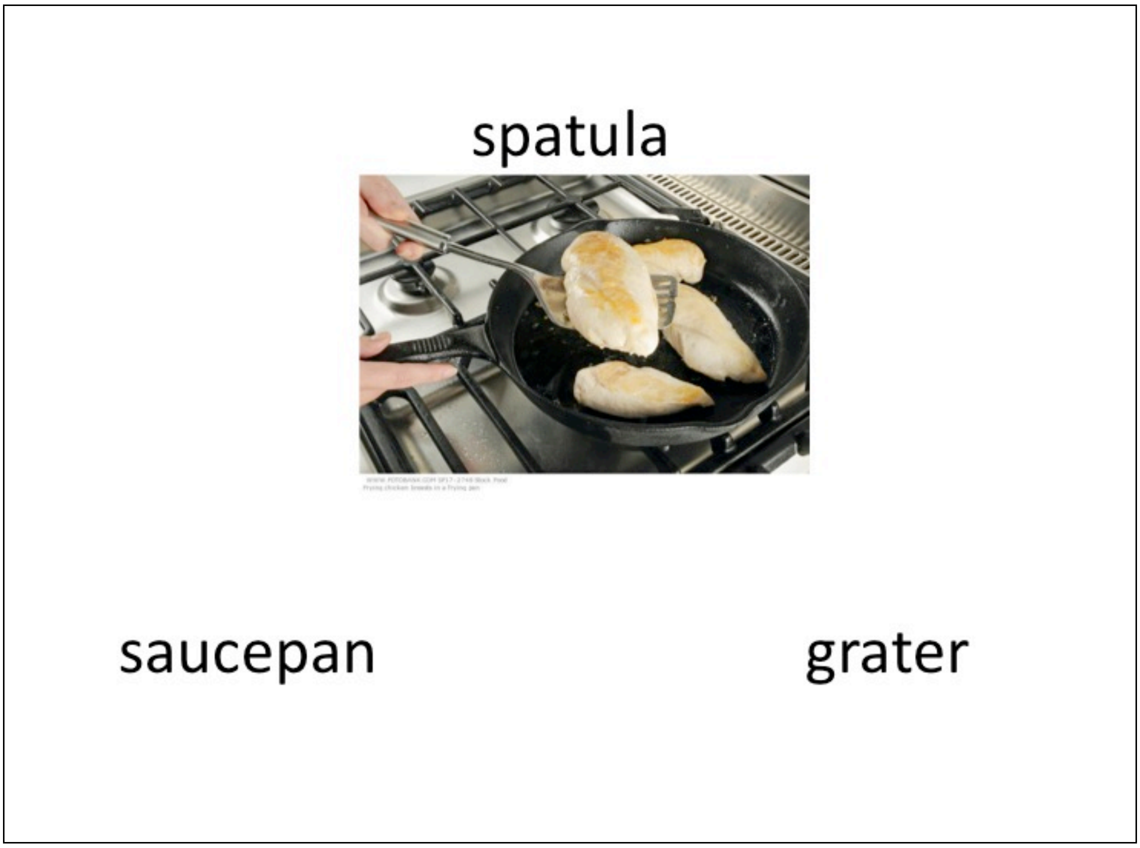


Figure G58. Format of the *spatula* triad used in the context-rich condition (Experiment 1).

Appendix G: Triads used in Experiment 1 (context-lean and the context-rich conditions).

Figure G59. Format of the *teapot* triad used in the context-lean condition (Experiment 1).

Figure G60. Format of the *teapot* triad used in the context-rich condition (Experiment 1).

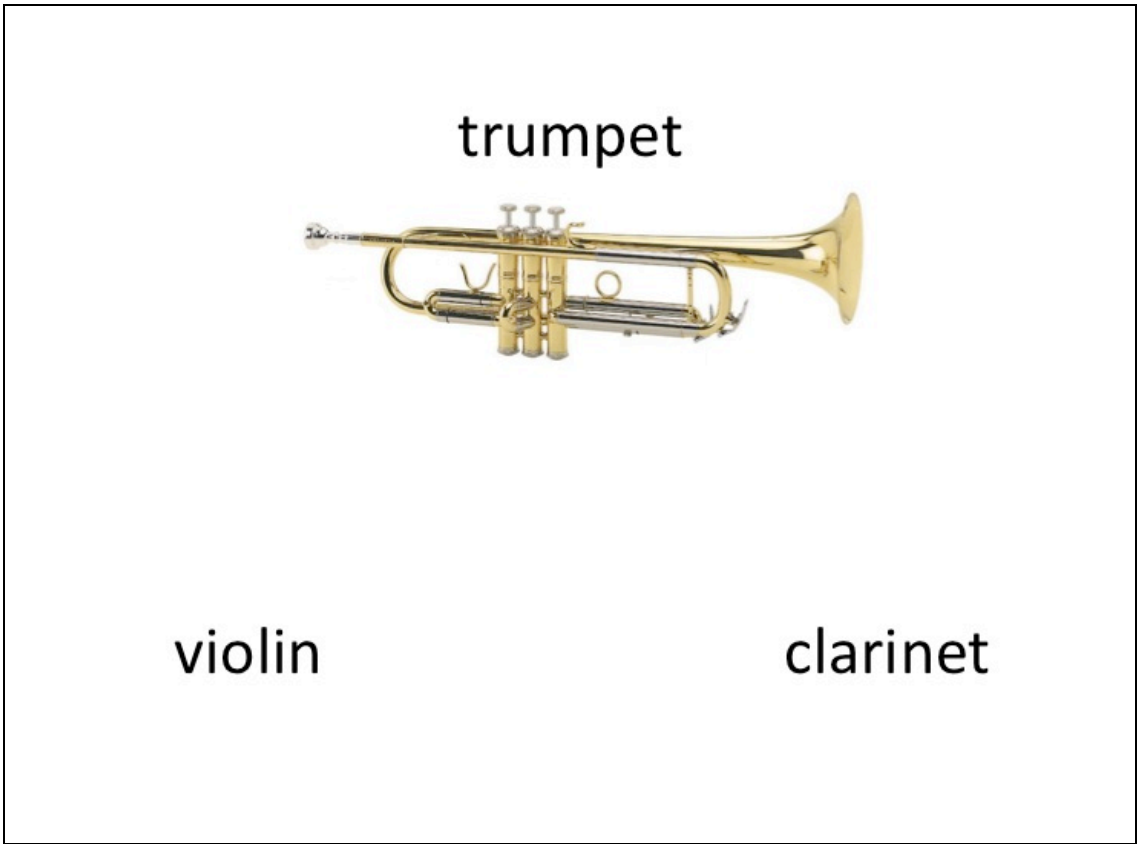


Figure G61. Format of the *trumpet* triad used in the context-lean condition (Experiment 1).

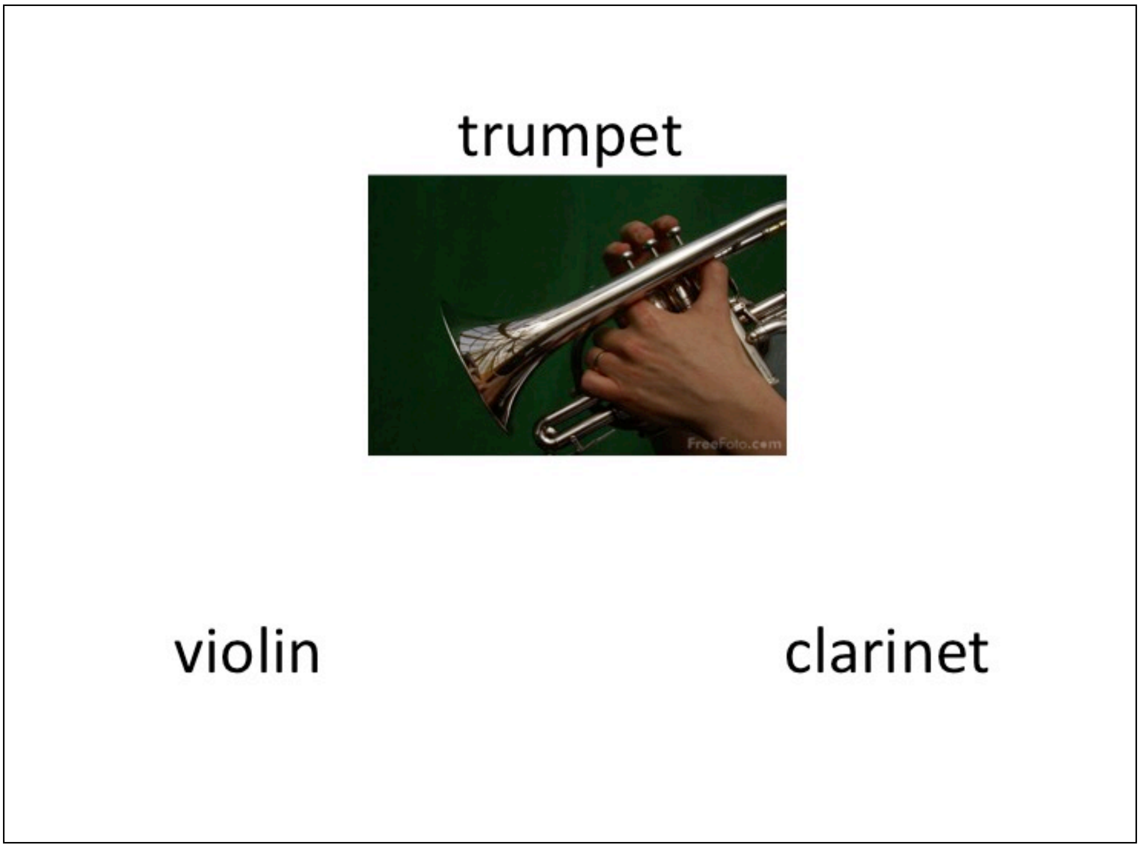


Figure G62. Format of the *trumpet* triad used in the context-rich condition (Experiment 1).

Appendix H: Animal foils used in Experiment 1.

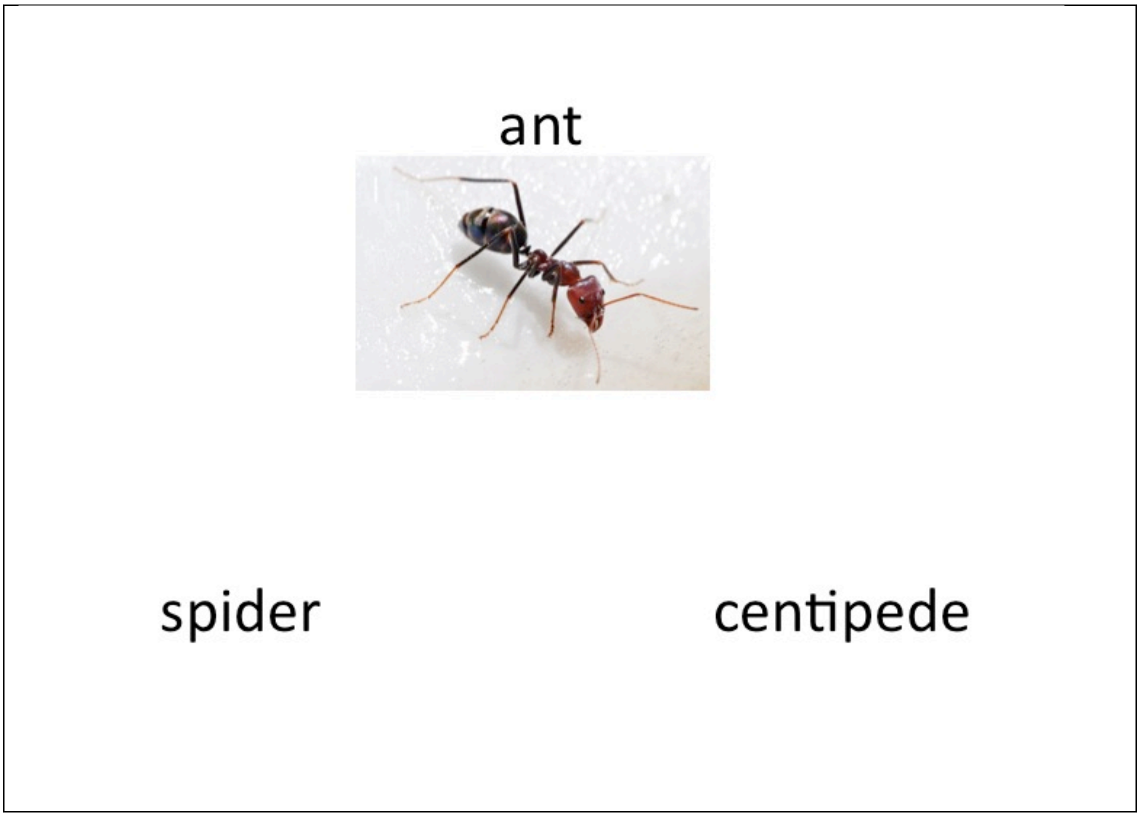


Figure H1. Format of the *ant* triad (Experiment 1).

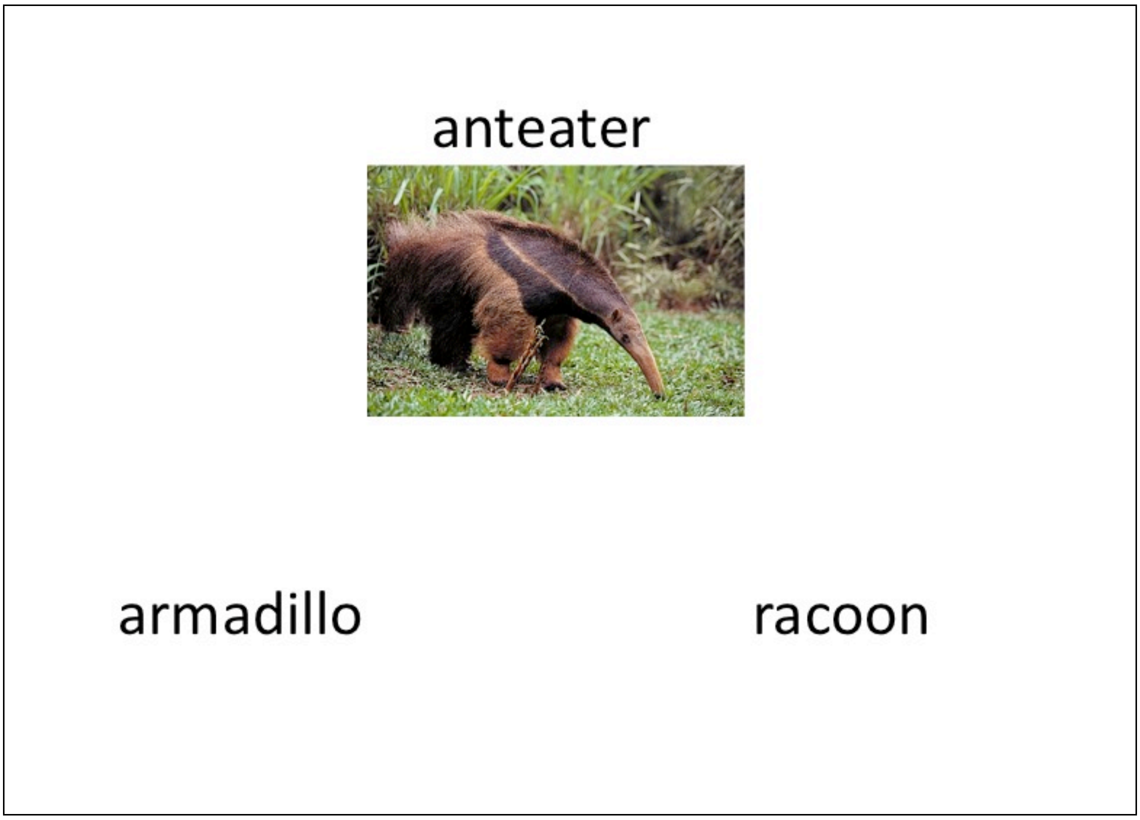


Figure H2. Format of the *anteater* triad (Experiment 1).

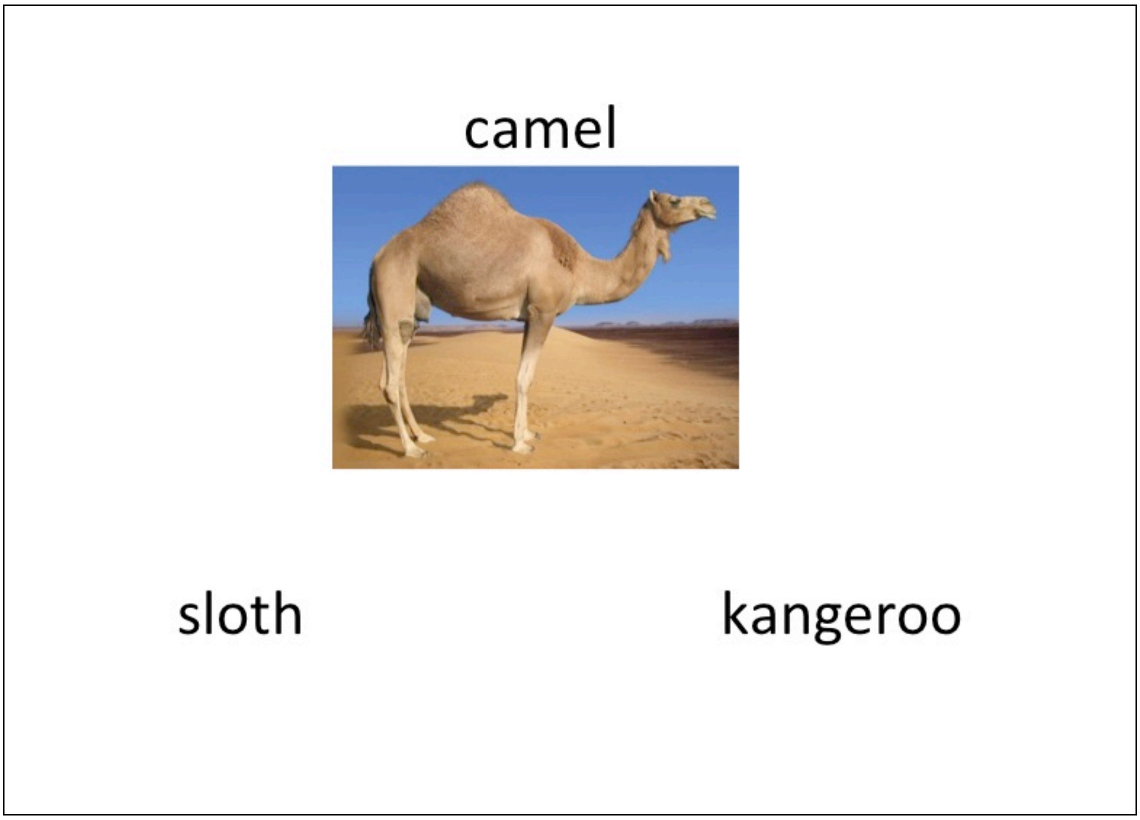


Figure H3. Format of the *camel* triad (Experiment 1).

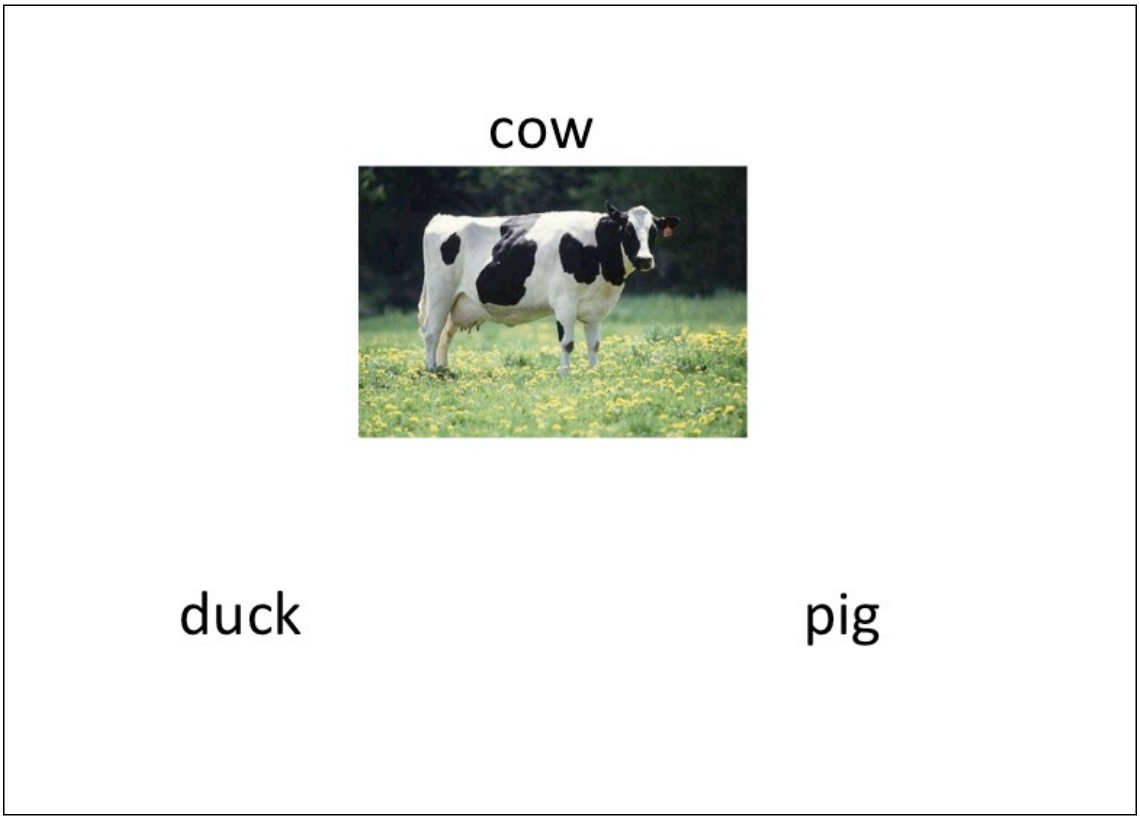


Figure H4. Format of the *cow* triad (Experiment 1).

Appendix H: Animal foils used in Experiment 1.

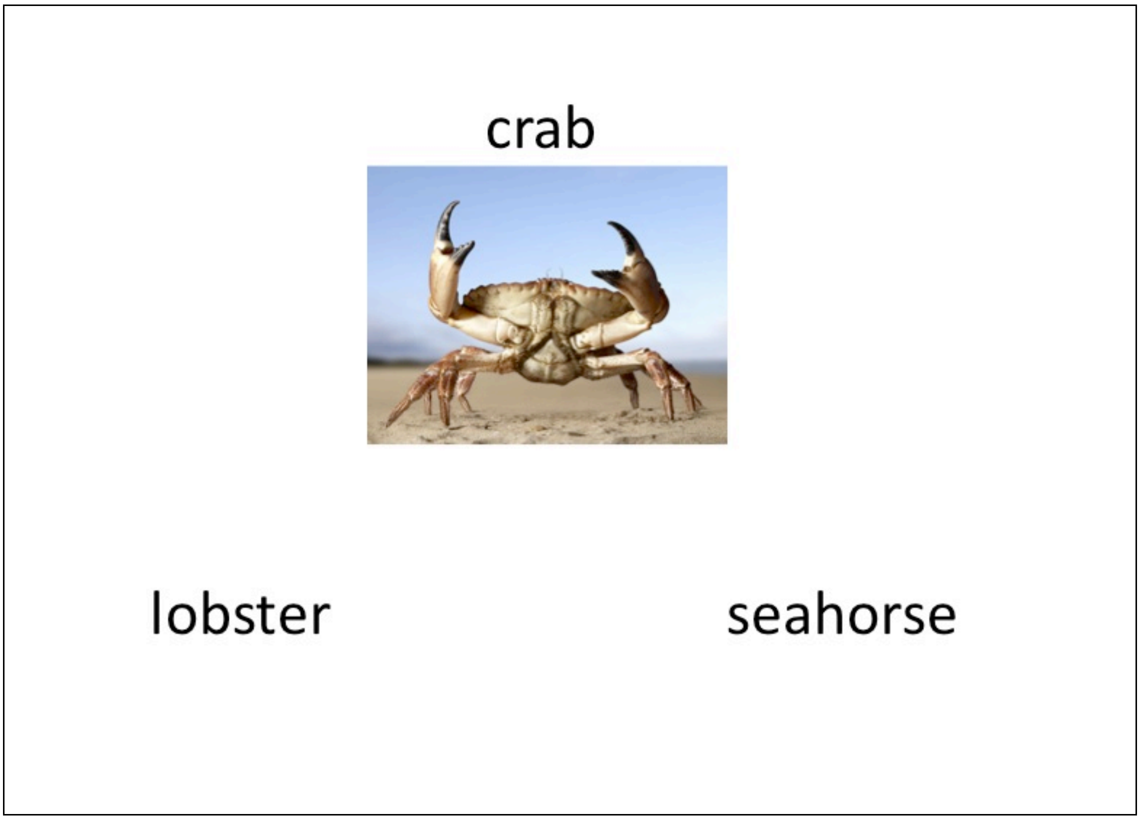


Figure H5. Format of the *crab* triad (Experiment 1).

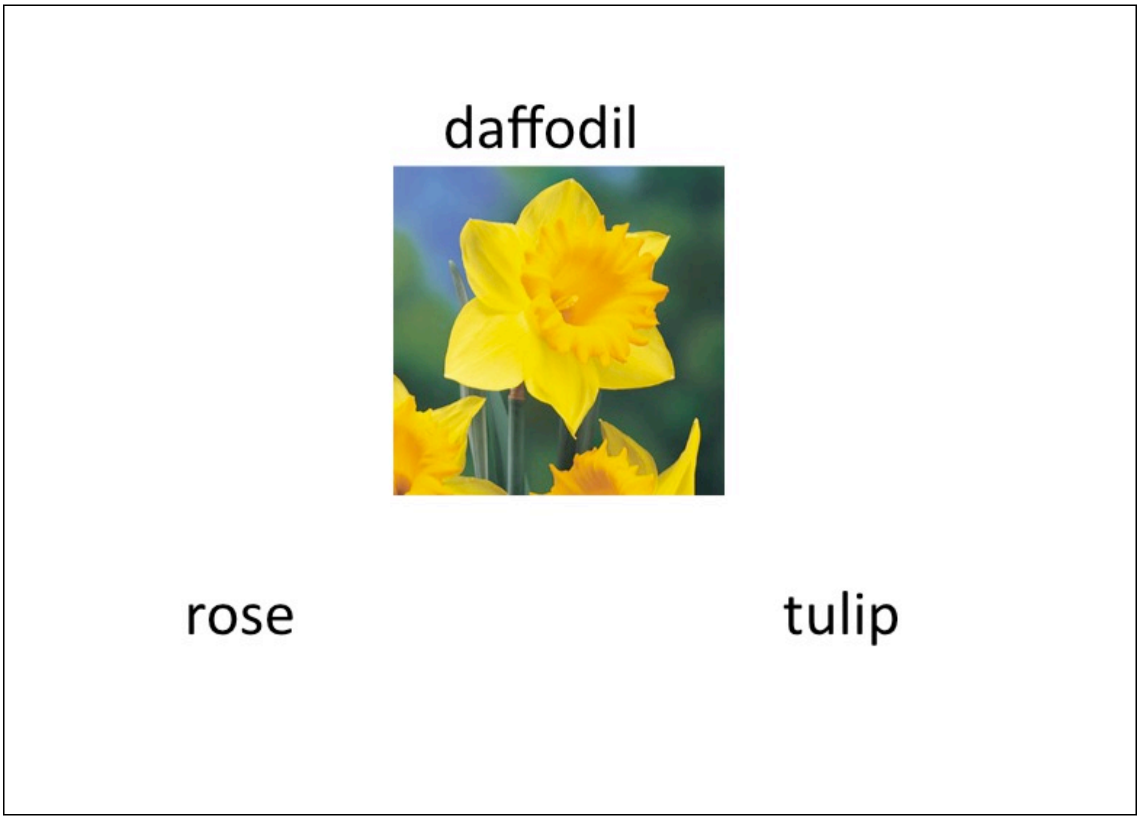


Figure H6. Format of the *daffodil* triad (Experiment 1).

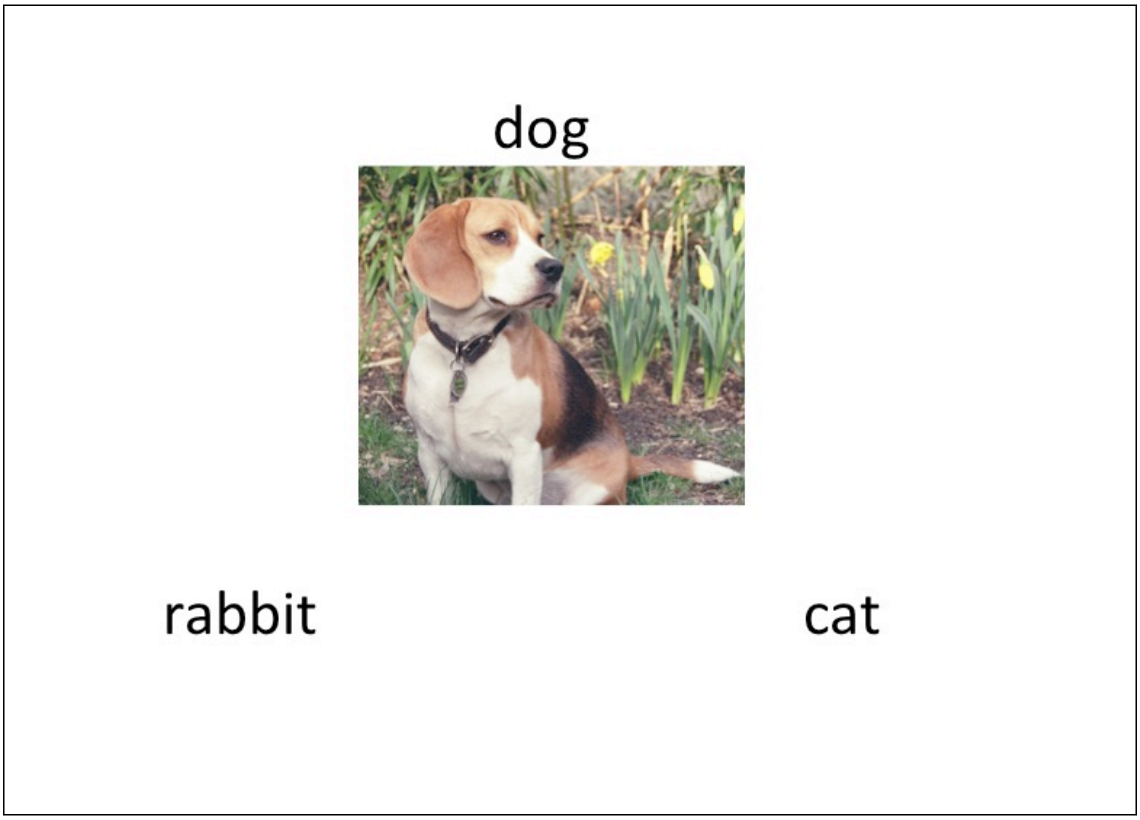


Figure H7. Format of the *dog* triad (Experiment 1).

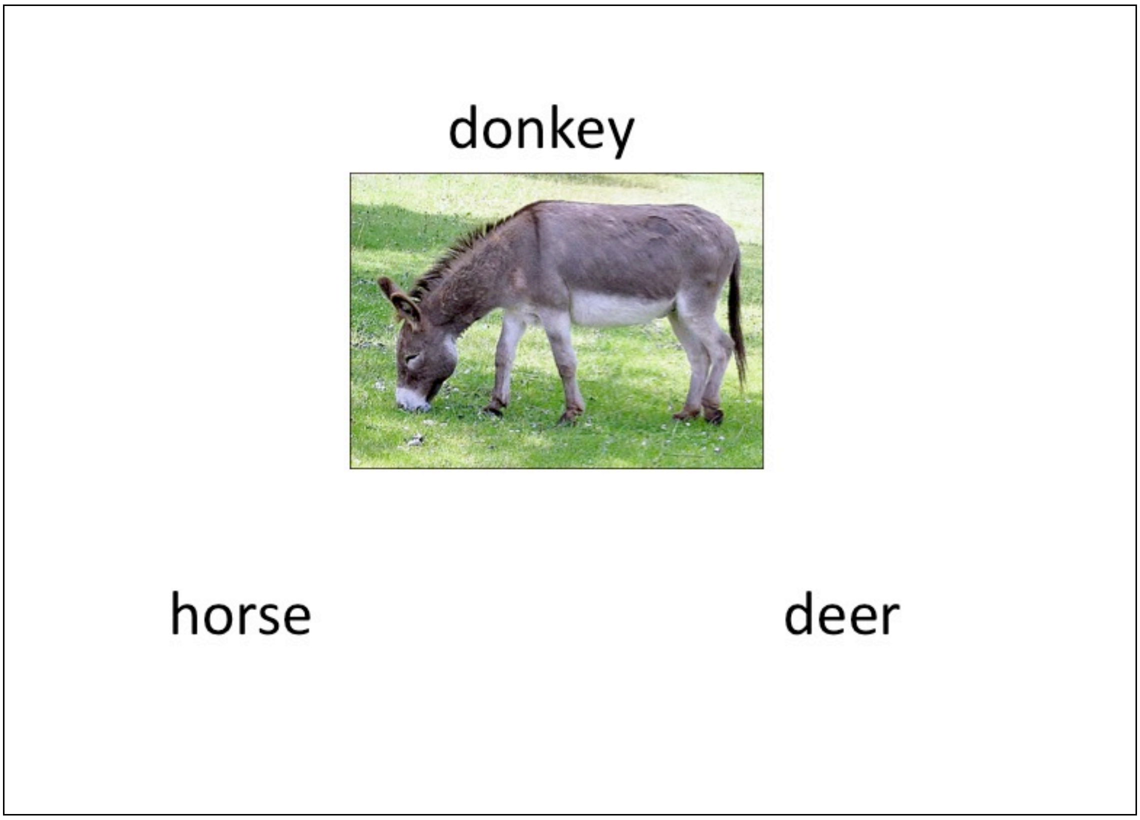


Figure H8. Format of the *donkey* triad (Experiment 1).

Appendix H: Animal foils used in Experiment 1.

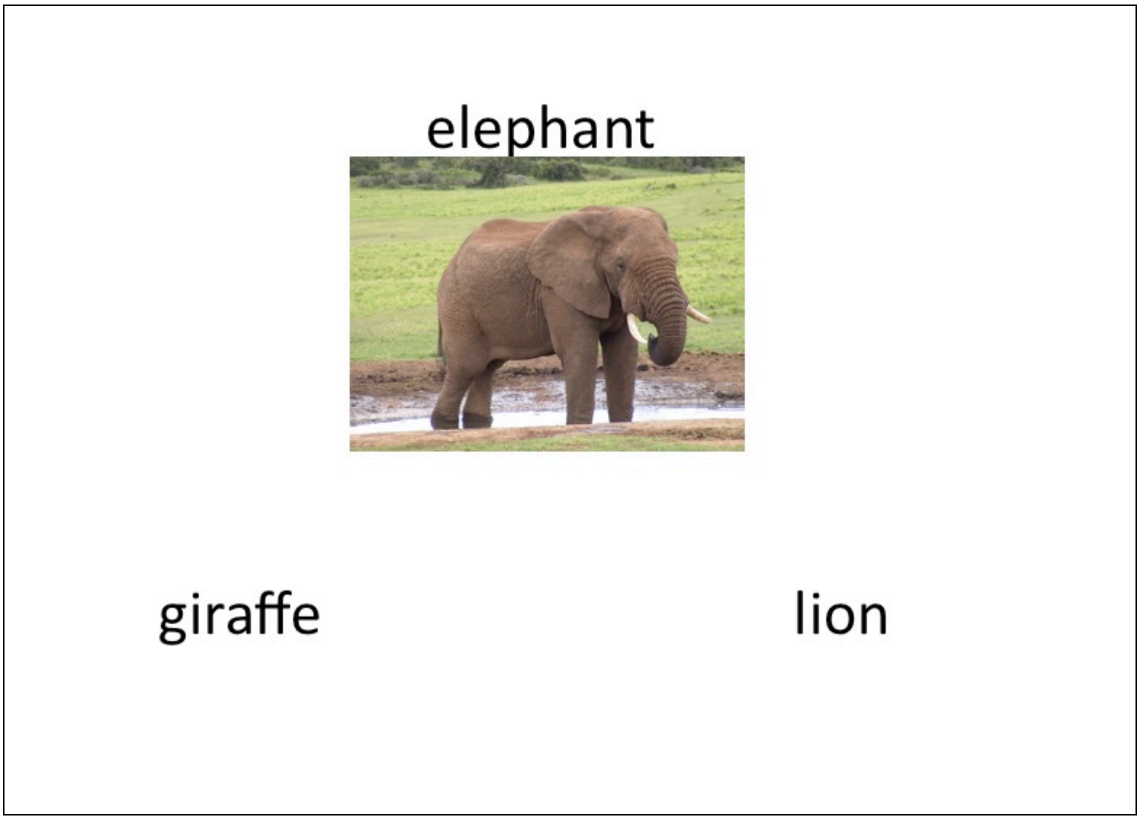


Figure H9. Format of the *elephant* triad (Experiment 1).

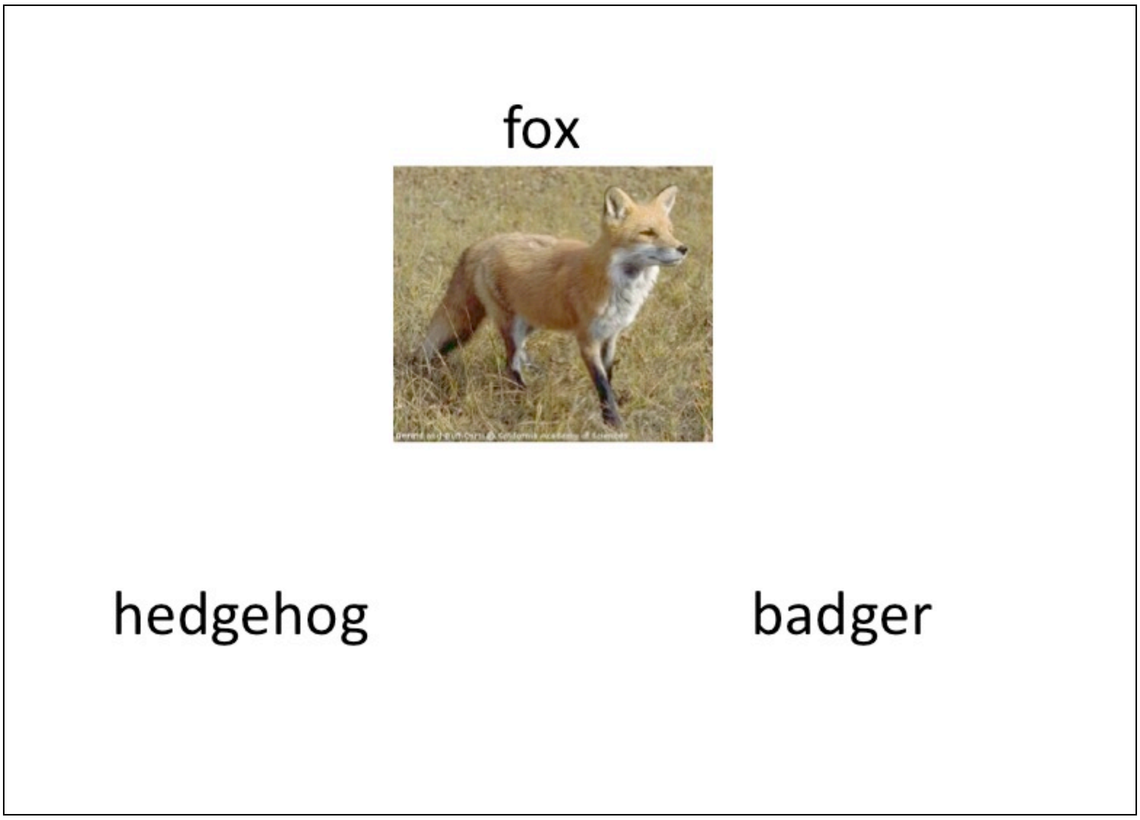


Figure H10. Format of the *fox* triad (Experiment 1).

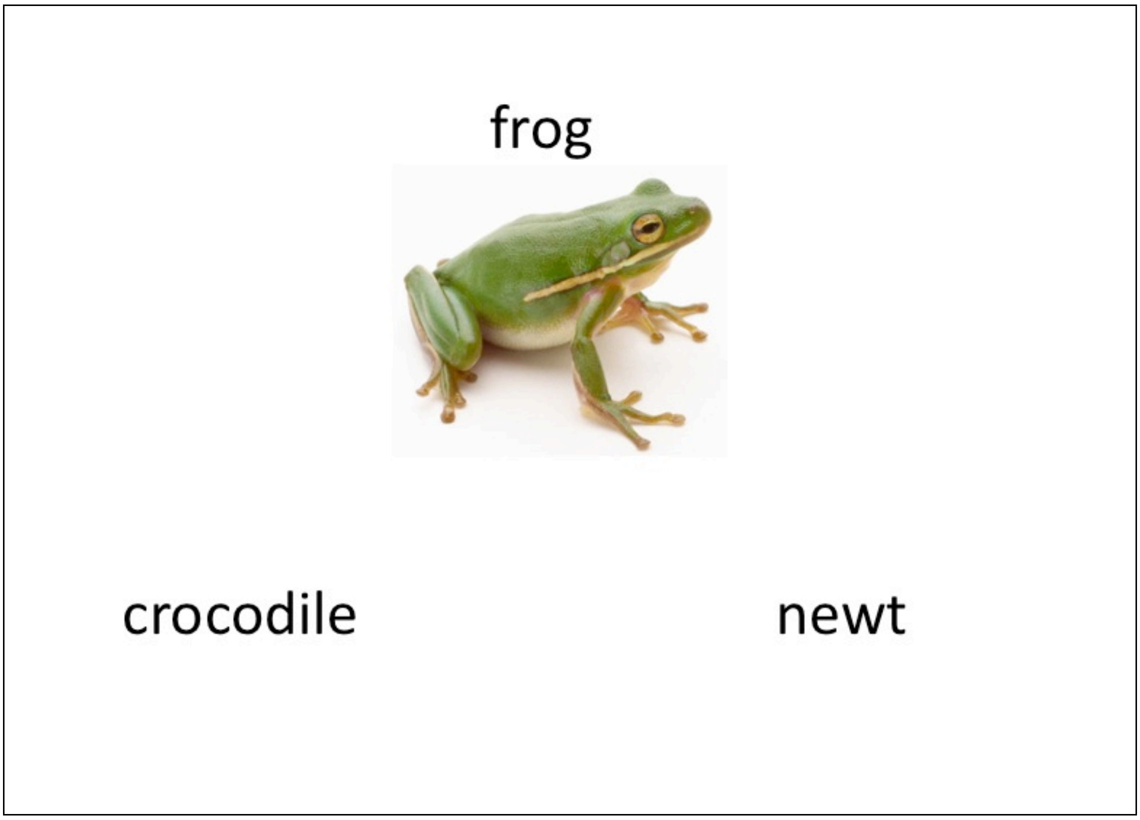


Figure H11. Format of the *frog* triad (Experiment 1).

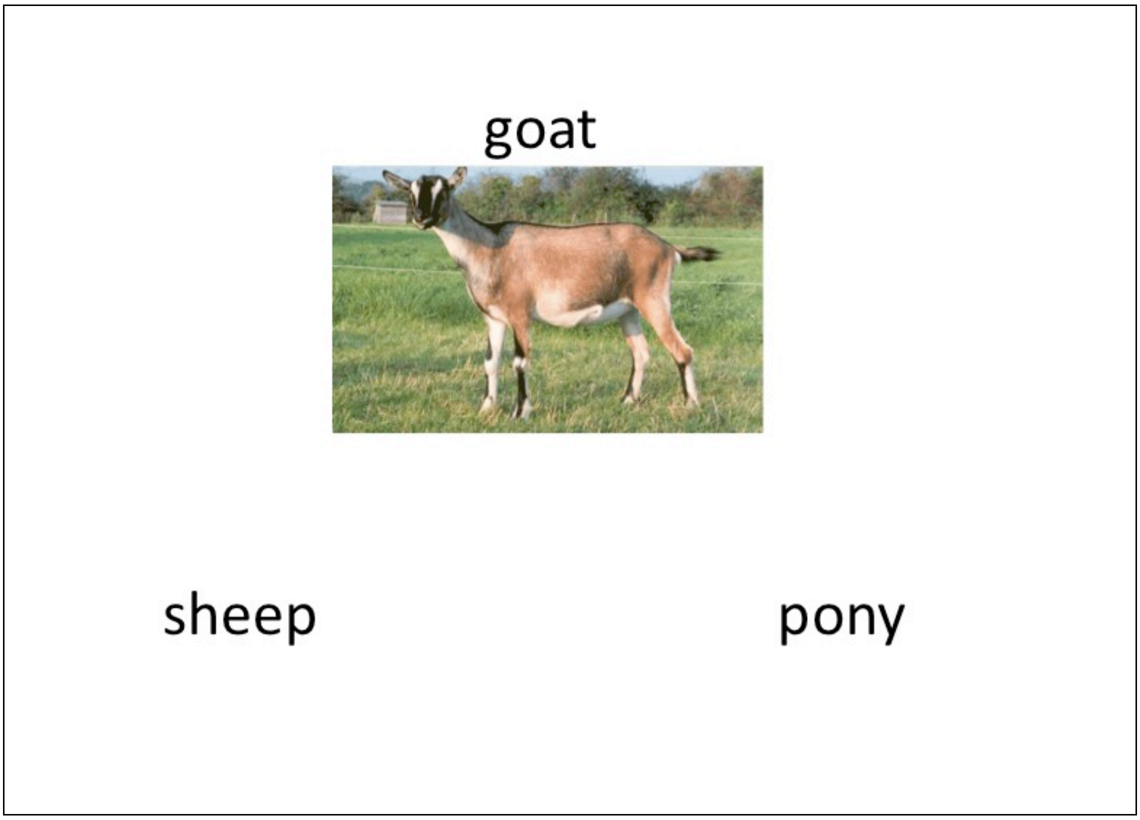


Figure H12. Format of the *goat* triad (Experiment 1).

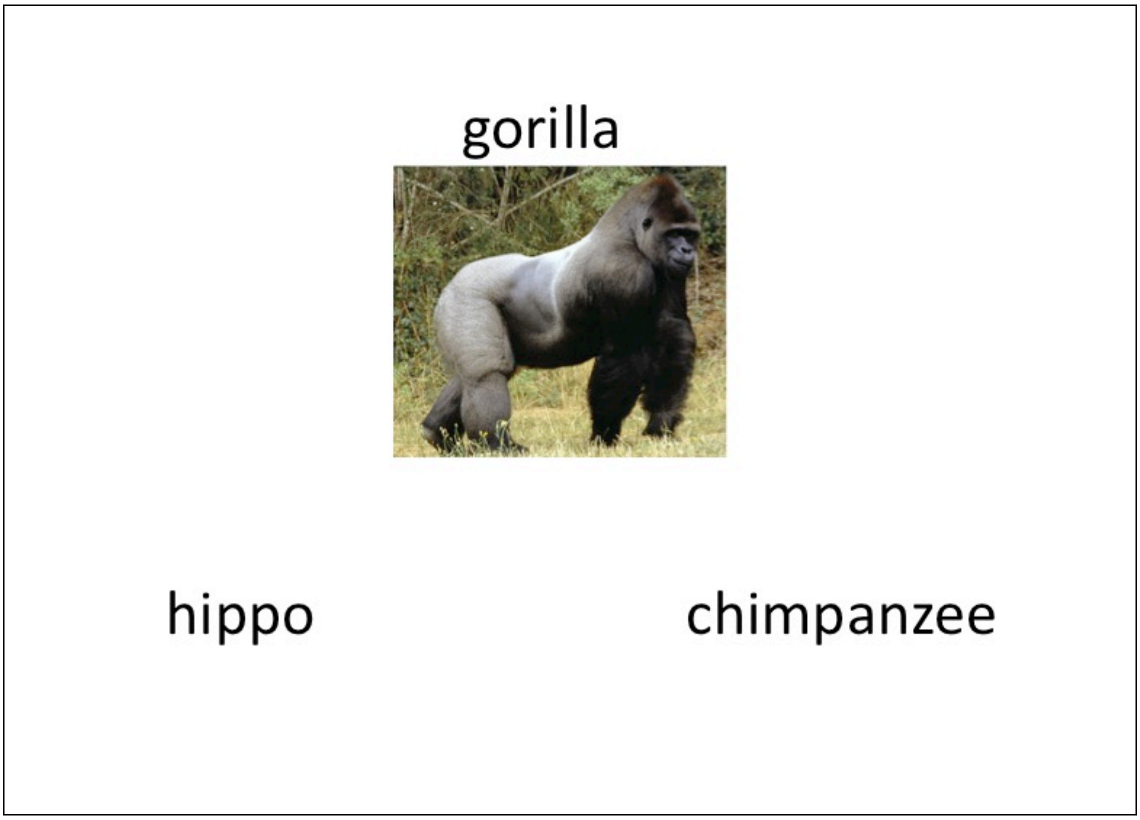


Figure H13. Format of the *gorilla* triad (Experiment 1)

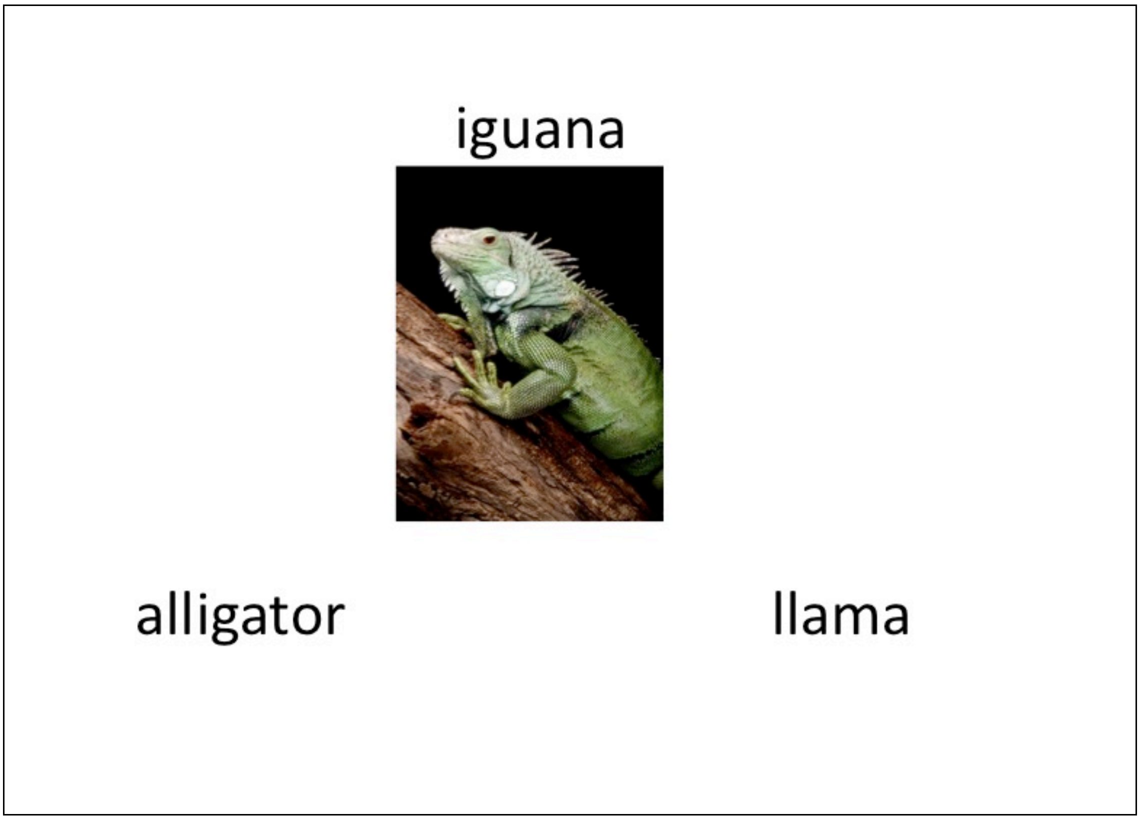


Figure H14. Format of the *iguana* triad (Experiment 1).

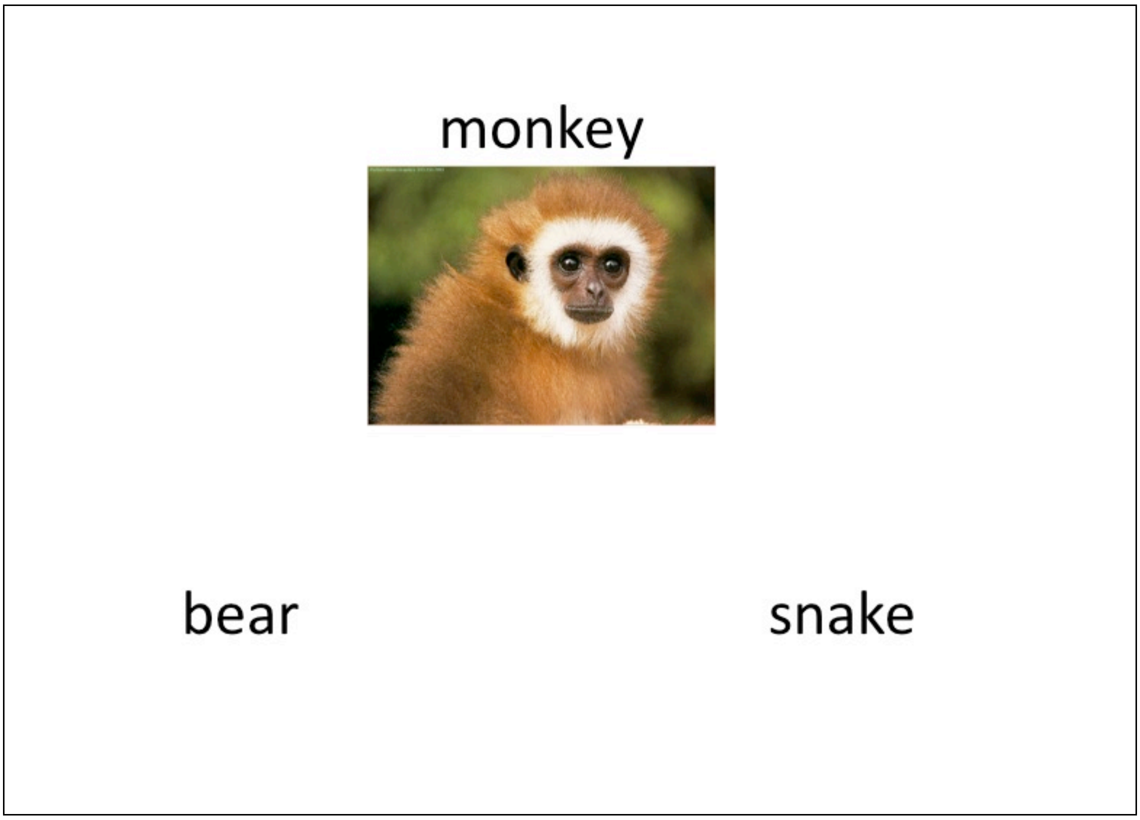


Figure H15. Format of the *monkey* triad (Experiment 1).

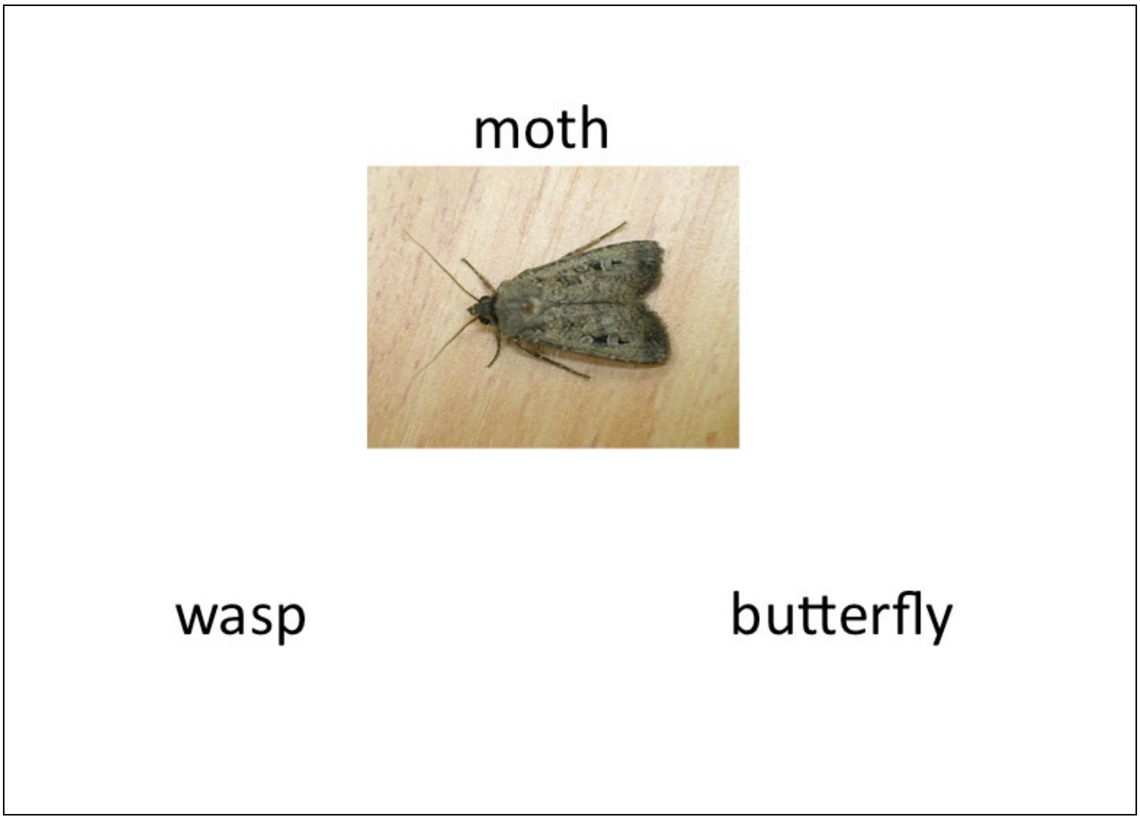


Figure H16. Format of the *moth* triad (Experiment 1).

Appendix H: Animal foils used in Experiment 1.

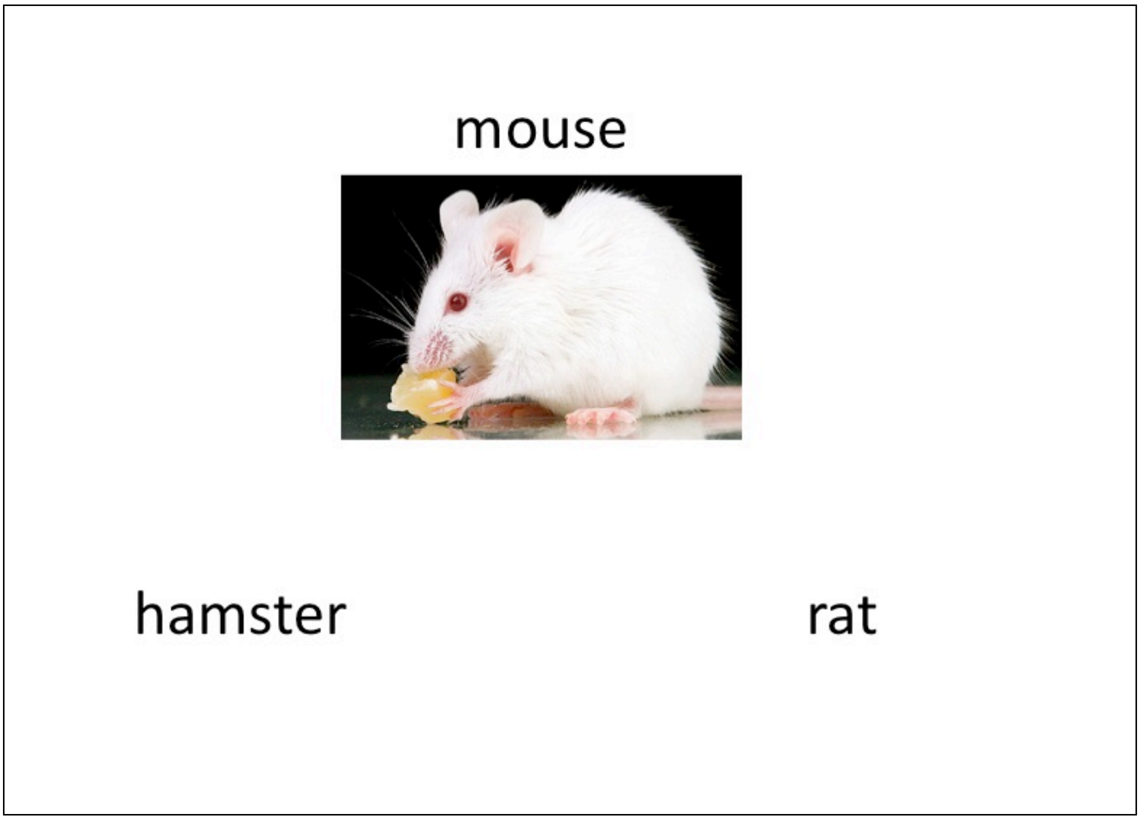


Figure H17. Format of the *mouse* triad (Experiment 1).

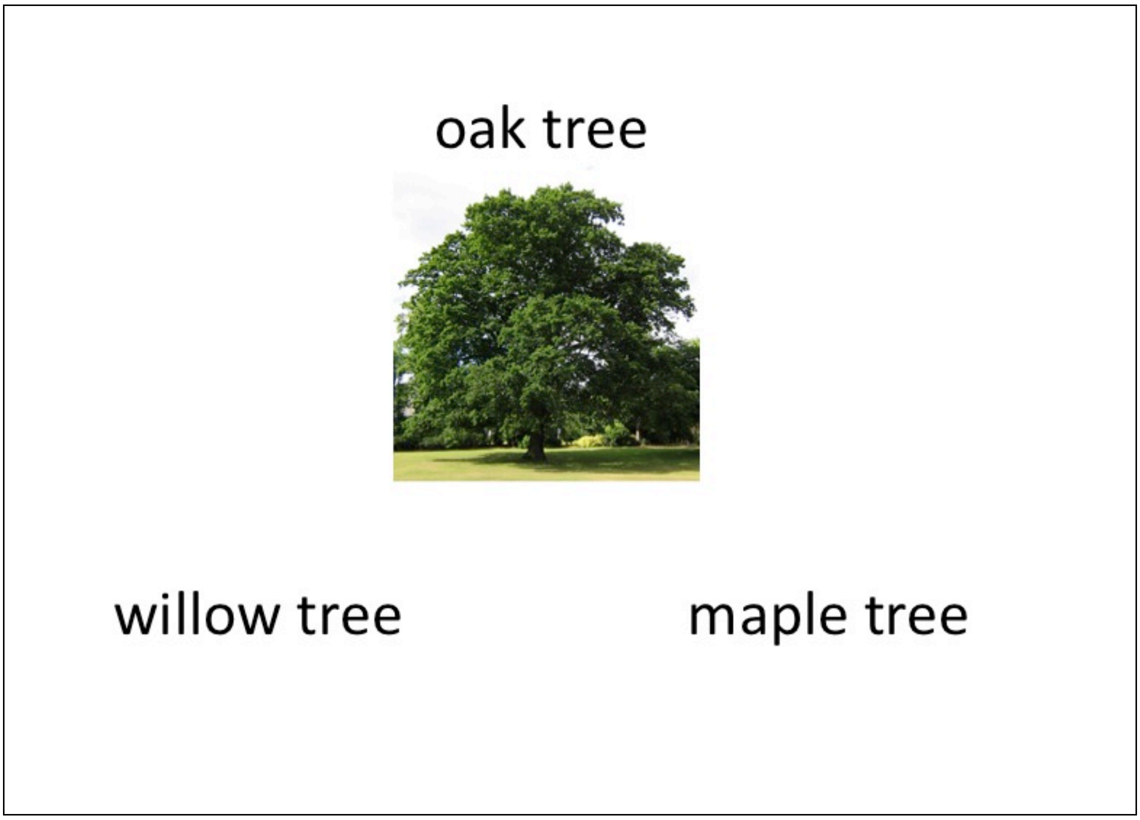


Figure H18. Format of the *oak tree* triad (Experiment 1).

Figure H19. Format of the *owl* triad (Experiment 1).

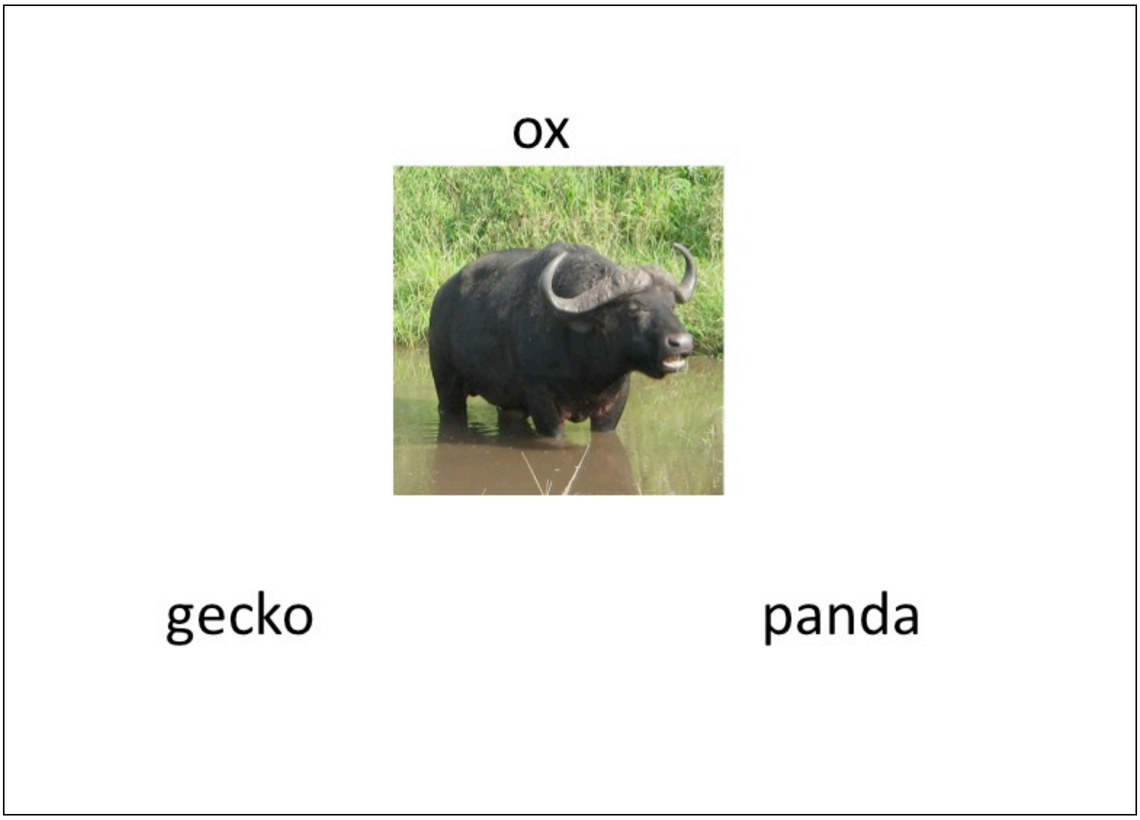


Figure H20. Format of the *ox* triad (Experiment 1).

Appendix H: Animal foils used in Experiment 1.

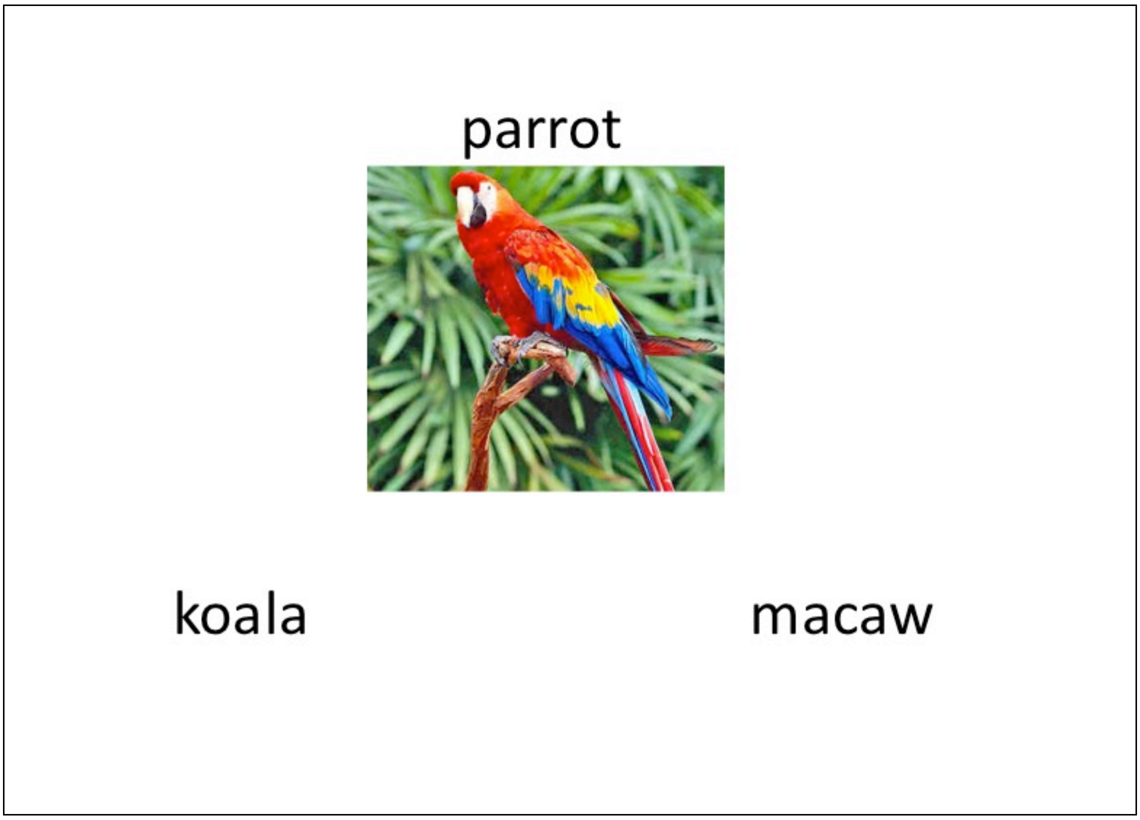


Figure H21. Format of the *parrot* triad (Experiment 1).

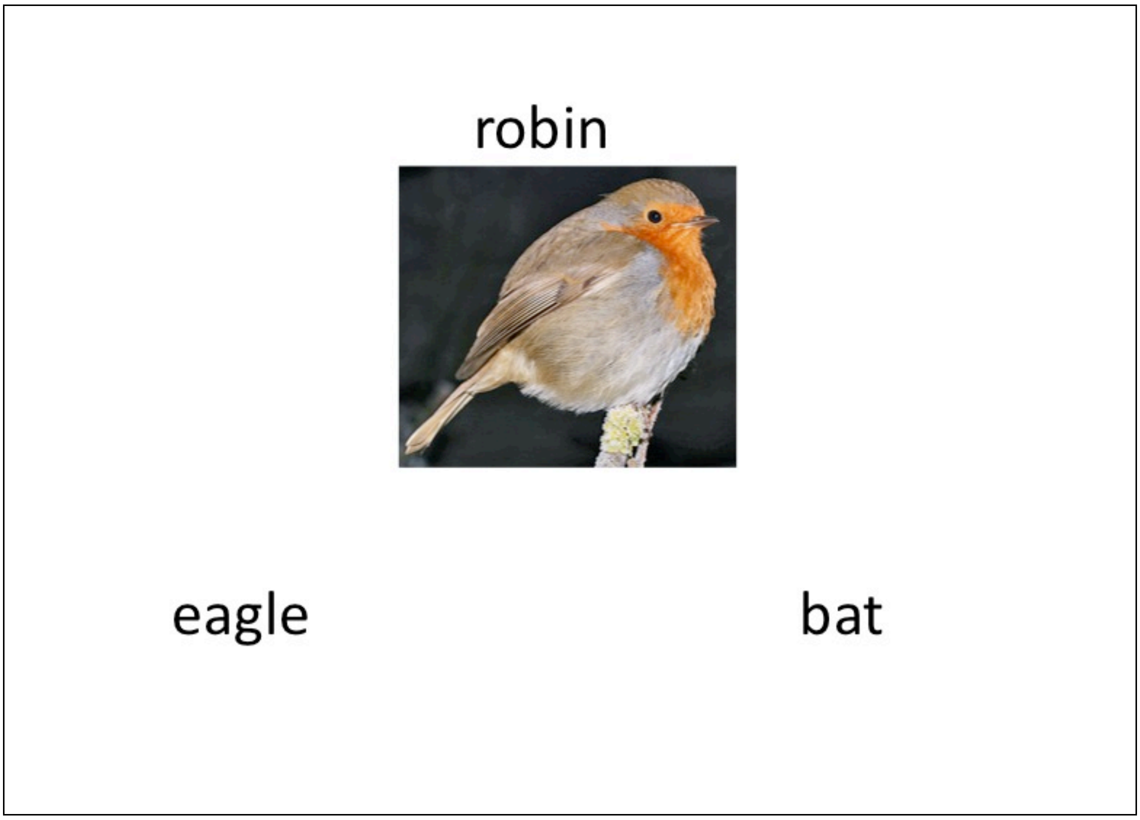


Figure H22. Format of the *robin* triad (Experiment 1).

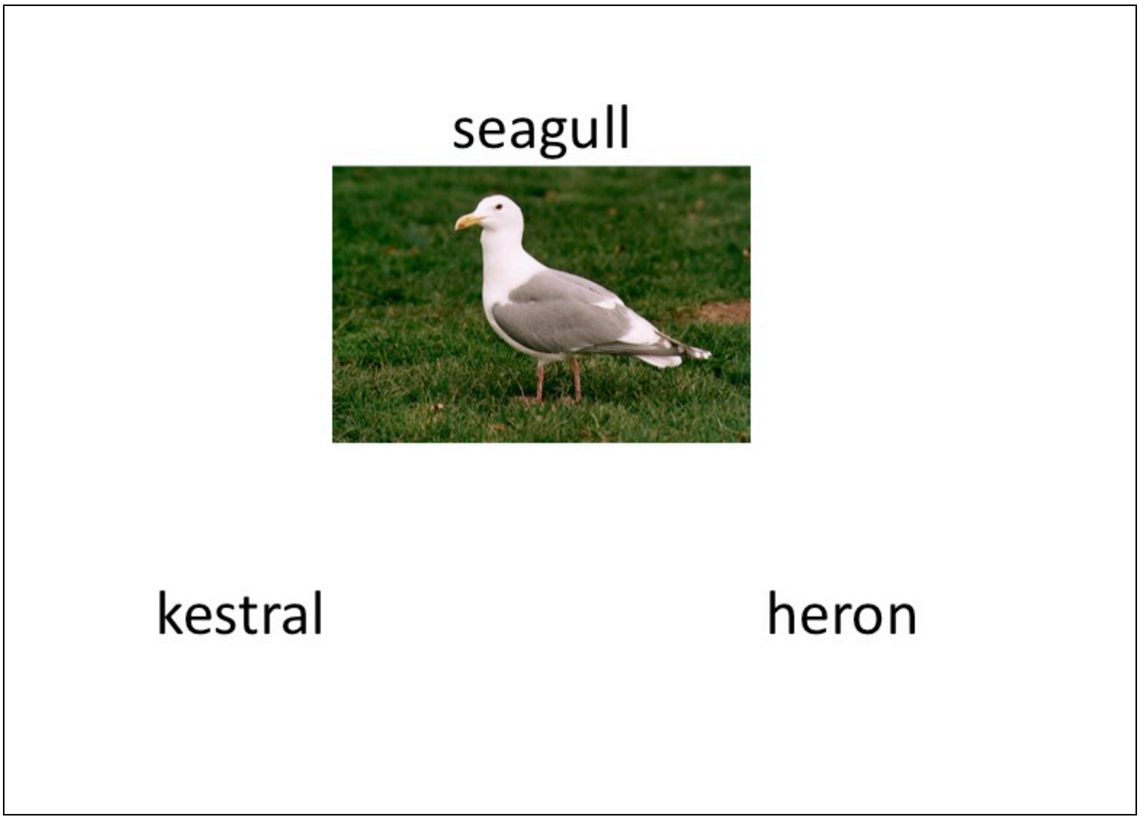


Figure H23. Format of the *seagull* triad (Experiment 1).

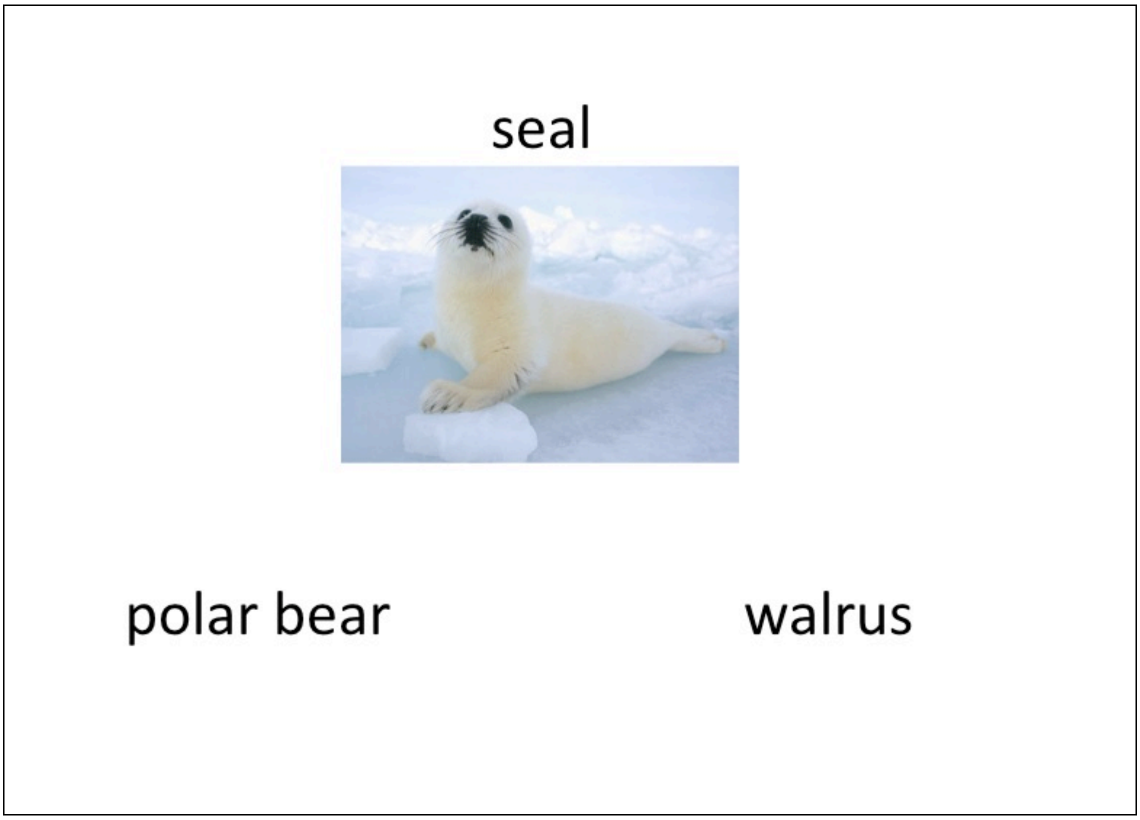


Figure H24. Format of the *seal* triad (Experiment 1).

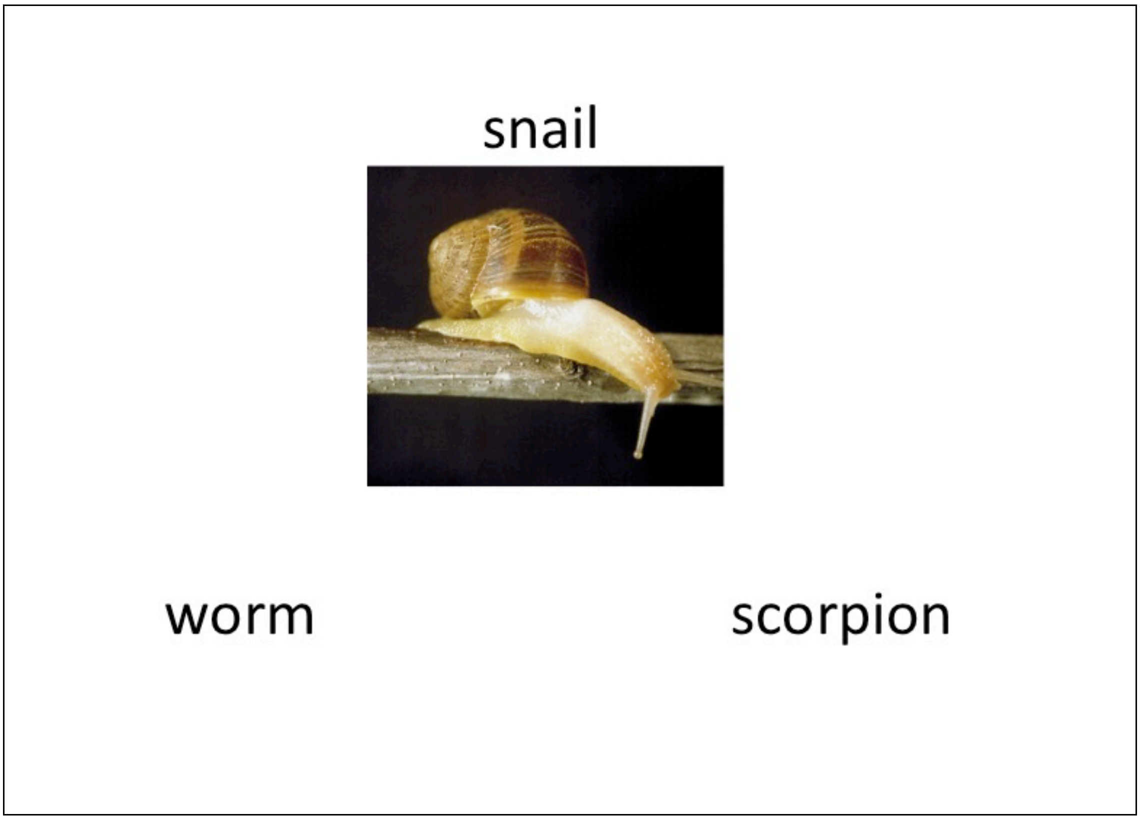


Figure H25. Format of the *snail* triad (Experiment 1).

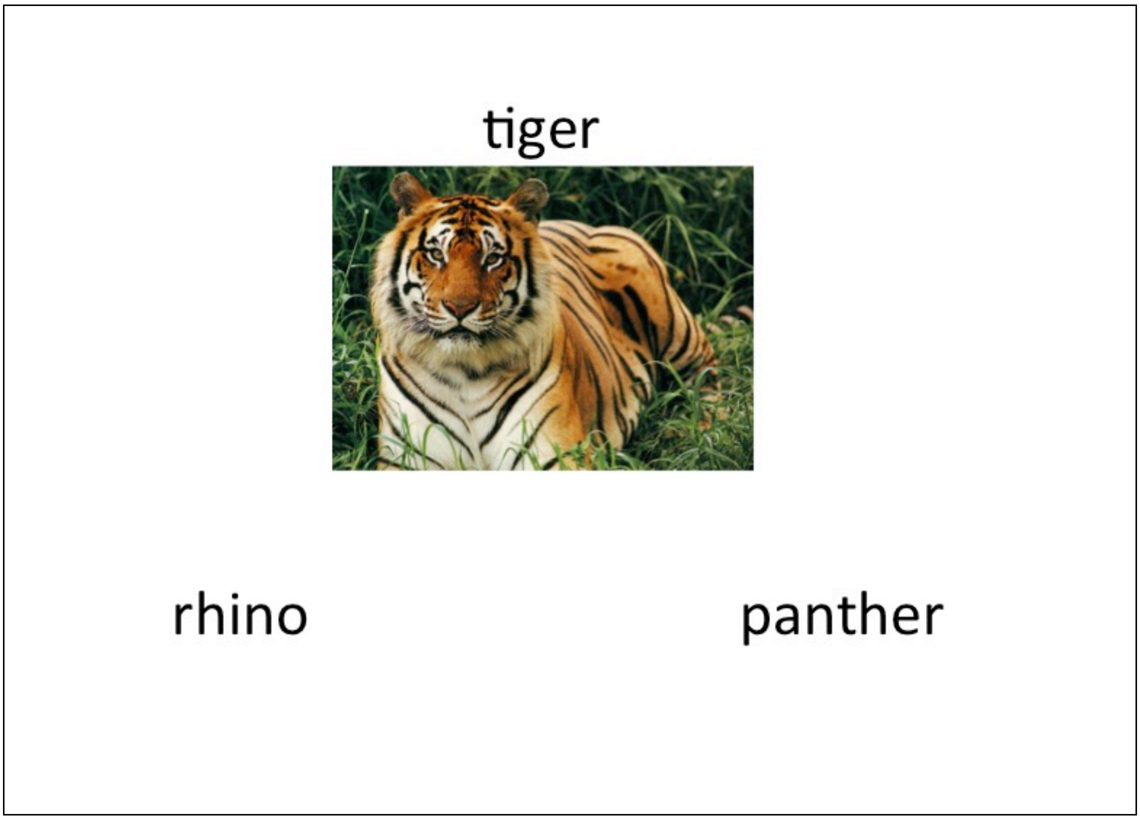


Figure H26. Format of the *tiger* triad (Experiment 1).

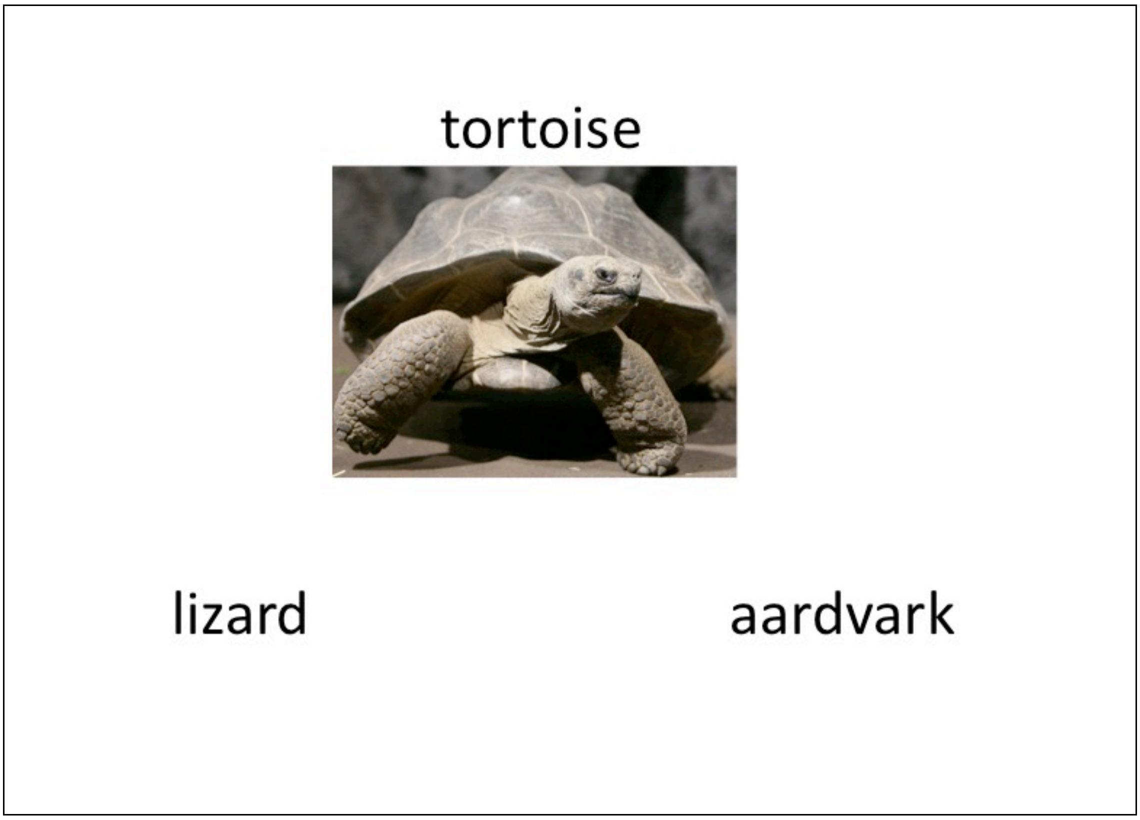


Figure H27. Format of the *tortoise* triad (Experiment 1).

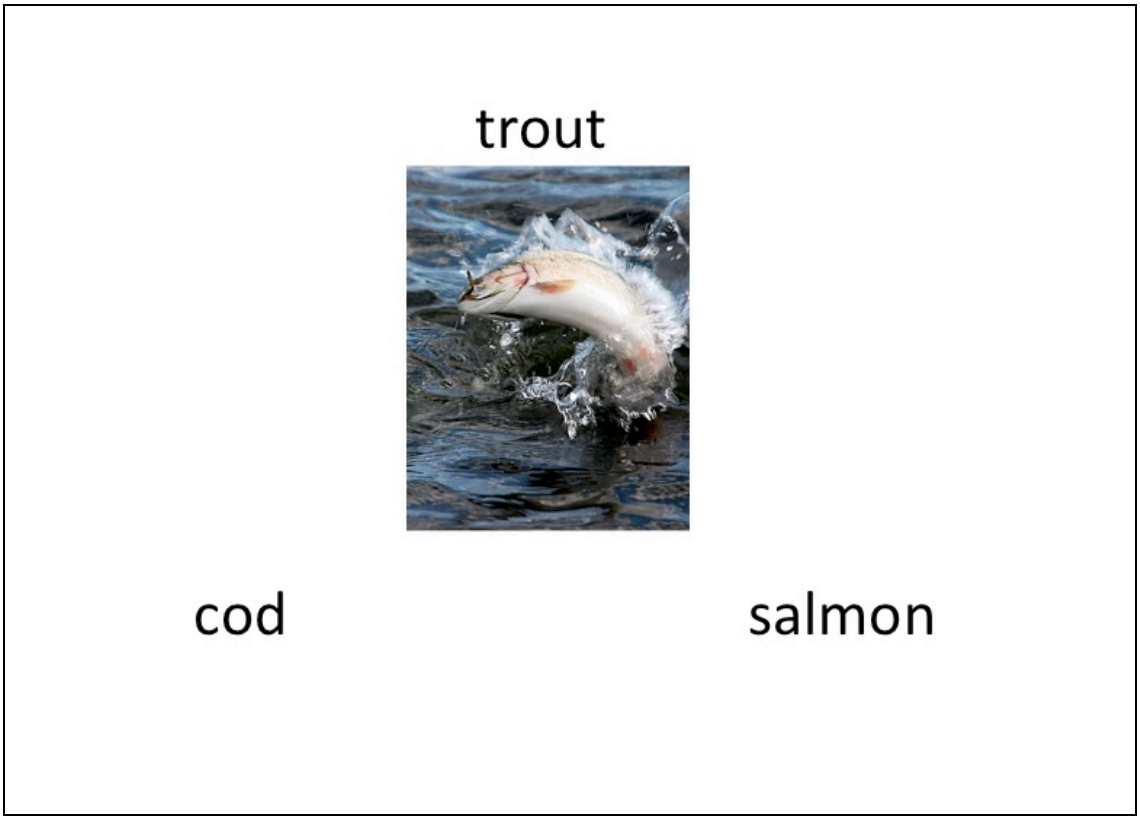


Figure H28. Format of the *trout* triad (Experiment 1).

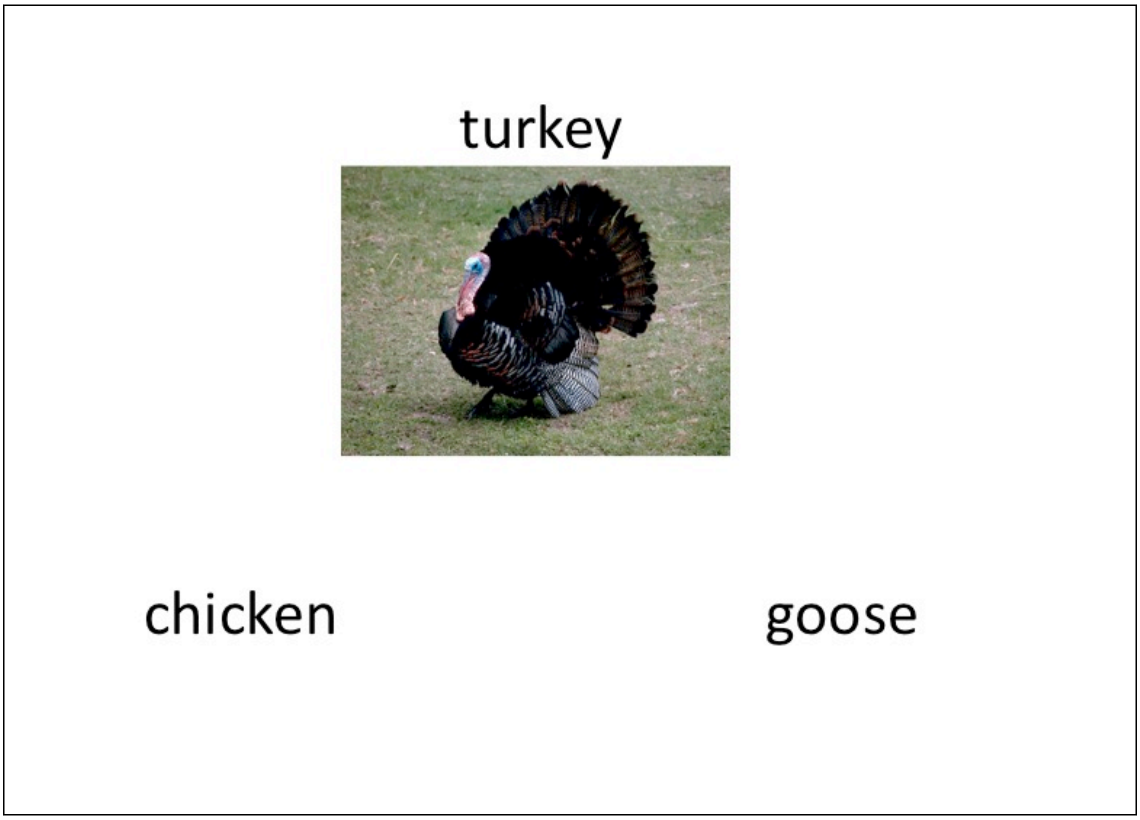


Figure H29. Format of the *turkey* triad (Experiment 1).

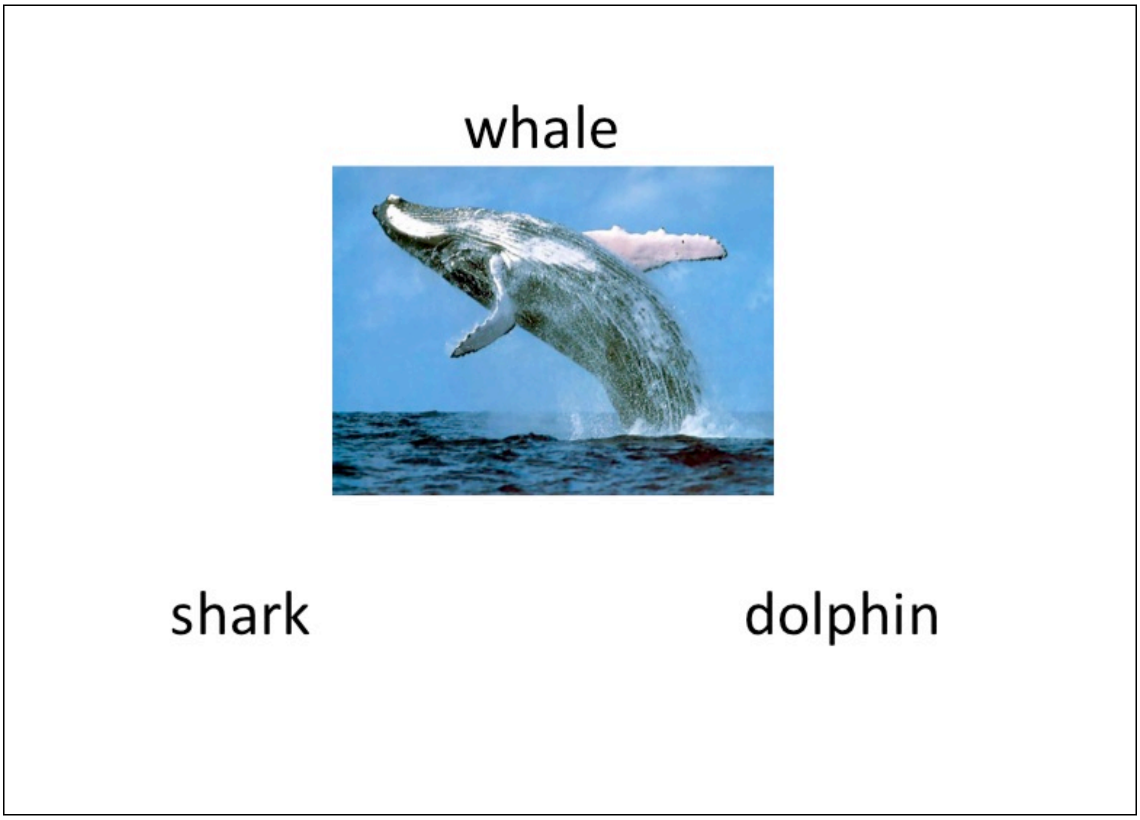


Figure H30. Format of the *whale* triad (Experiment 1).

Appendix I: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

Information Sheet

I am a PhD student from the University of Hertfordshire undertaking a study into semantic knowledge.

If you agree to take part, you will be asked to complete a short questionnaire which should take no longer than 10 minutes.

As a participant you will be asked not to discuss the study with others until the study is completed in February 2012.

You will have an opportunity to ask questions now and at the end of the experiment.

Please note that any information you may supply today will only be used for the purposes outlined here. You may withdraw your assistance from this study at any time.

You may use the contact email address below, should any queries or concerns arise in the future.

Thank you for your participation.

Name of researcher: Nicholas Shipp

Email address: n.j.shipp@herts.ac.uk

Ethics protocol number: PSY/04/11/NS

Consent Form

I ____ (please type name) give my full consent to take part in the following research investigation with the full understanding that I may withdraw at any time without giving any reason.

If I withdraw from the study, the data that I have submitted will also be withdrawn at my request. I have received an information sheet explaining what the experiment entails and what will be expected from me.

I understand that the information that I will submit will be confidential and completely anonymous and used only for this study. I have read and understand the above information.

I agree/do not agree to participate in the study.

Signed:

Date:

Appendix I: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

Action Questionnaire

On the next page you are about to see a list of 15 triads. Please circle which two of the three objects share the same action I terms of how we operate them. If you feel that all three items share the same action then please circle all three. Look at the example below;

computer printer piano



If you think that computer and printer share the operated in the same way then circle them two. If you feel that computer and piano are operated in the same way circle those two. Circle all three if you feel they are all operated in the same way.

If you feel that none of them share an action then do not circle any.

Turn the page to start when you are ready.

Thank you.

Appendix I: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

1. axe

cane

tennis racket

2. wrapping paper

mace

baseball bat

3. speakers

hairspray

wine bottle

4. usb pen

chewing gum

phone charger

5. joystick | suitcase | handbrake



6. balloon | clarinet | wooden spoon



7. nut | money | car key

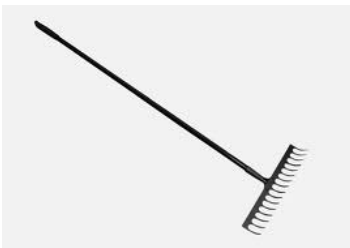

8. storage box | shoe | present



9. telephone | thermos | plant pot

10. gun | hairdryer | cleaning spray

11. rake | staple remover | hairclip



12. hairwax | peppermill | spraypaint

Appendix I: Pilot questionnaire on shared actions (including information sheet, consent form and debrief sheet).

13. facewipes

jewellery box

sandwich packet

14. cheese grater

cookie jar

handbag

15. maracas

cocktail shaker

vase.

Debriefing

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to see how you grouped the items together for use in a later experiment.

If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

Appendix J: Pilot questionnaire on perceptual properties (only page 1 included because the questionnaire was exactly the same as that in Appendix J with the exception of the instructions).

<u>Visual Questionnaire</u>

On the next page you are about to see a list of 15 triads. Please circle which two of the three objects share visual properties, i.e. they look similar to each other. If you feel that all three items look similar to each other then please circle all three. Look at the example below;

computer printer piano

If you think that computer and printer look similar then circle them two. If you feel that computer and piano look similar circle those two. Circle all three if you feel they are all look the same.

If you feel that none of them share visual properties then do not circle any.

Turn the page to start when you are ready.

Thank you.

INFORMATION SHEET

I am a PhD student from the University of Hertfordshire undertaking a study into semantic knowledge. Semantic knowledge is one form of long term memory which stores information regarding the world around us and objects which exist in that world.

If you agree to take part, you will be asked to complete a triad choice task. The whole task should take no longer than 15 minutes.

As a participant you will be asked not to discuss the study with others until the study is completed in March 2012.

You will have an opportunity to ask questions now and at the end of the experiment.

Please note that any information you may supply today will only be used for the purposes outlined here. You may withdraw your assistance from this study at any time.

You may use the contact email address below, should any queries or concerns arise in the future.

Thank you for your participation.

Name of researcher: Nicholas Shipp

Email address: n.j.shipp@herts.ac.uk

Ethics protocol number: PSY/04/11/NS

DEBRIEFING

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate whether our semantic memory contains information related to actions associated with everyday objects. It further aimed to see whether people would select an item that shared the same action over its categorical function.

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

List of Triads Used (Experiments 2-8)

Table M1

List of the Same Category Object (SCO) Triads used in Experiments 2-8.

Target Item	Choice Items	
	Taxonomic Choice	Taxonomic and Action Choice
Pencil	Elastic band	Paintbrush
Glass	Jug	Cup
Spatula	Grater	Saucepan
Pin	Screw	Plug
Orange	Banana	Strawberry
DVD player	Television	CD player
Bed	Wardrobe	Sofa
Leaflet	Poster	Newspaper
Spade	Shears	Trowel
Ketchup	Vinegar	Salt

Table M2

List of the Different Category Object (DCO) Triads used in Experiments 2-8.

Target Item	Choice Items	
	Taxonomic Choice	Action Choice
Fax machine	Telephone	Photocopier
Screwdriver	Hammer	Key
Drink bottle	Mug	Jam jar
Rifle	Sword	Water pistol
Computer	Printer	Piano
Calculator	Set square	Mobile phone
Book	Ipod	Wallet
Paperclip	Ruler	Clothes peg
Deodorant	Hair gel	Insect repellent
Knife	Ladle	Saw

Table M3

List of the Perceptual Category Object (PCO) Triads used in Experiment 2-8.

Target Item	Choice Items	
	Perceptual Choice	Action Choice
Axe	Cane	Tennis racket
Baseball bat	Wrapping paper	Mace
USB pen	Chewing gum	Phone charger
Clarinet	Wooden spoon	Balloon
Nut	Money	Car key
Present	Storage box	Shoe
Cocktail shaker	Vase	Maracas
Gun	Hairdryer	Cleaning spray
Peppermill	Spray paint	Hairwax
Handbag	Cheese grater	Cookie jar

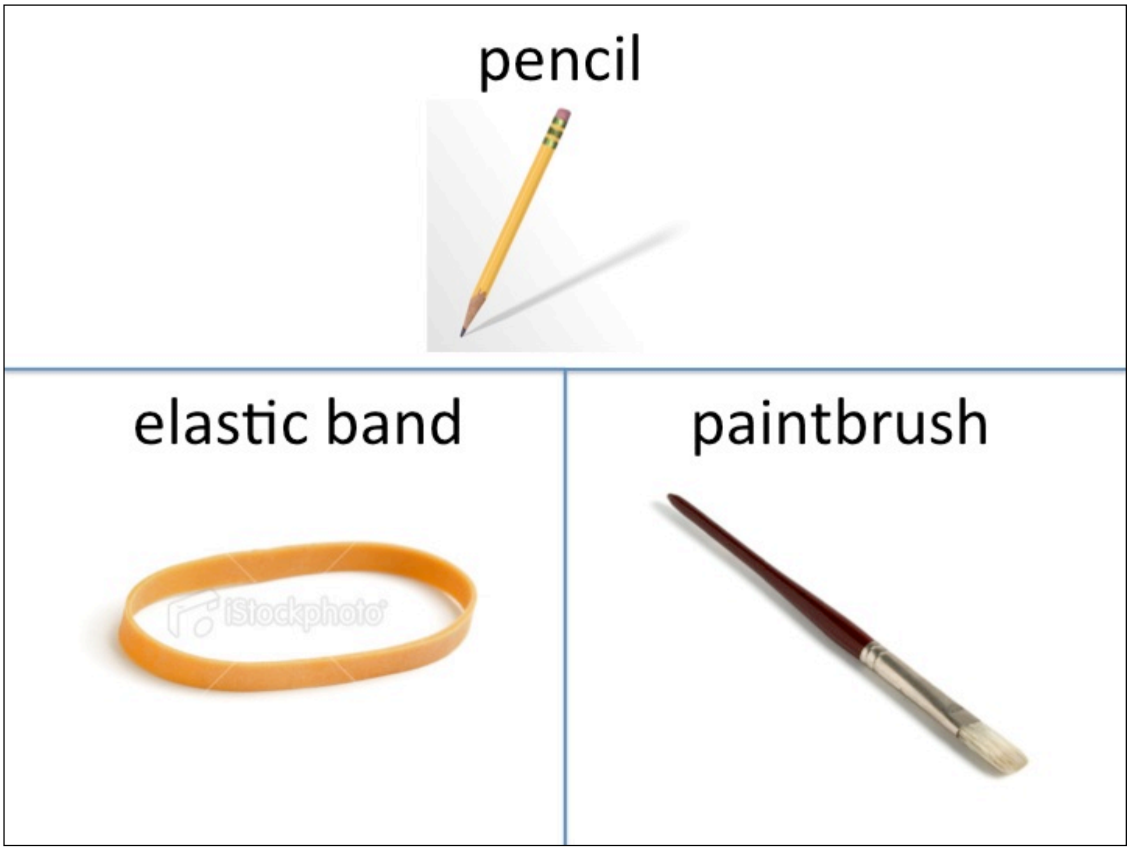


Figure N1. Format of the *pencil* triad used in the context-lean condition (Experiments 2-8).

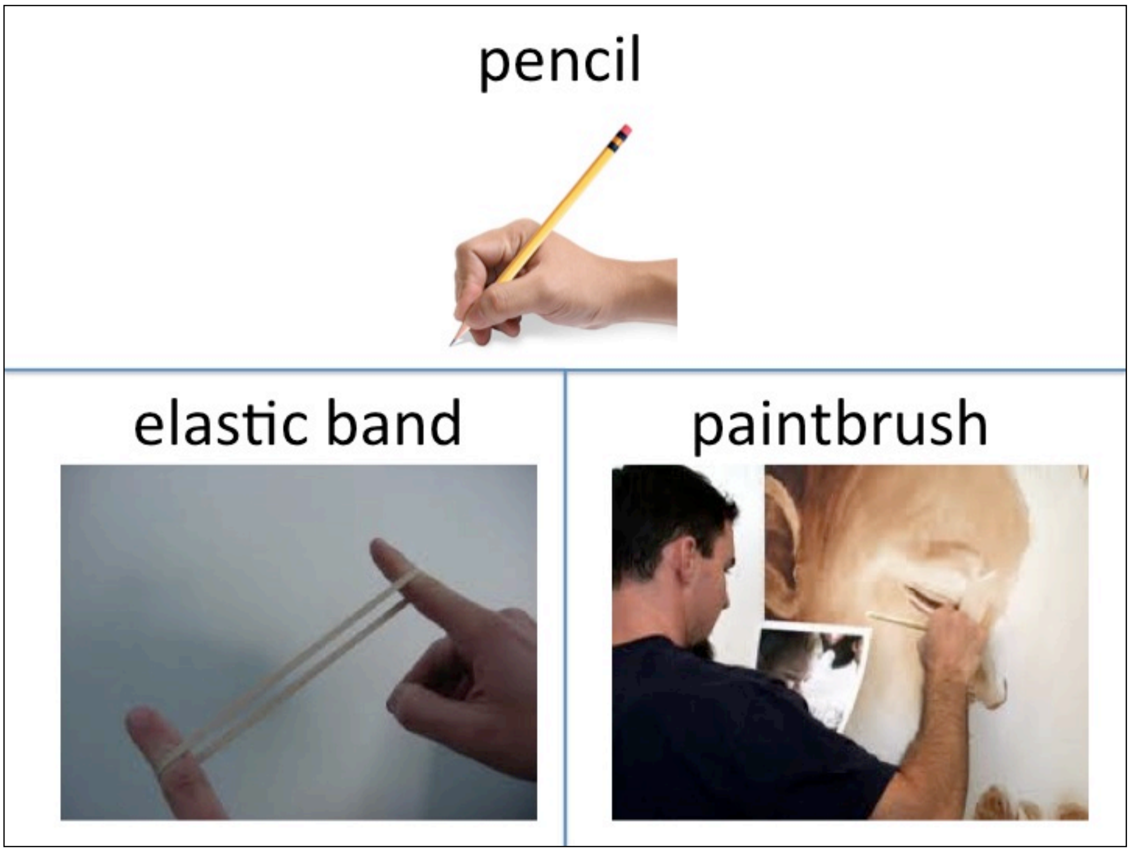


Figure N2. Format of the *pencil* triad used in the context-rich condition (Experiments 2-8).

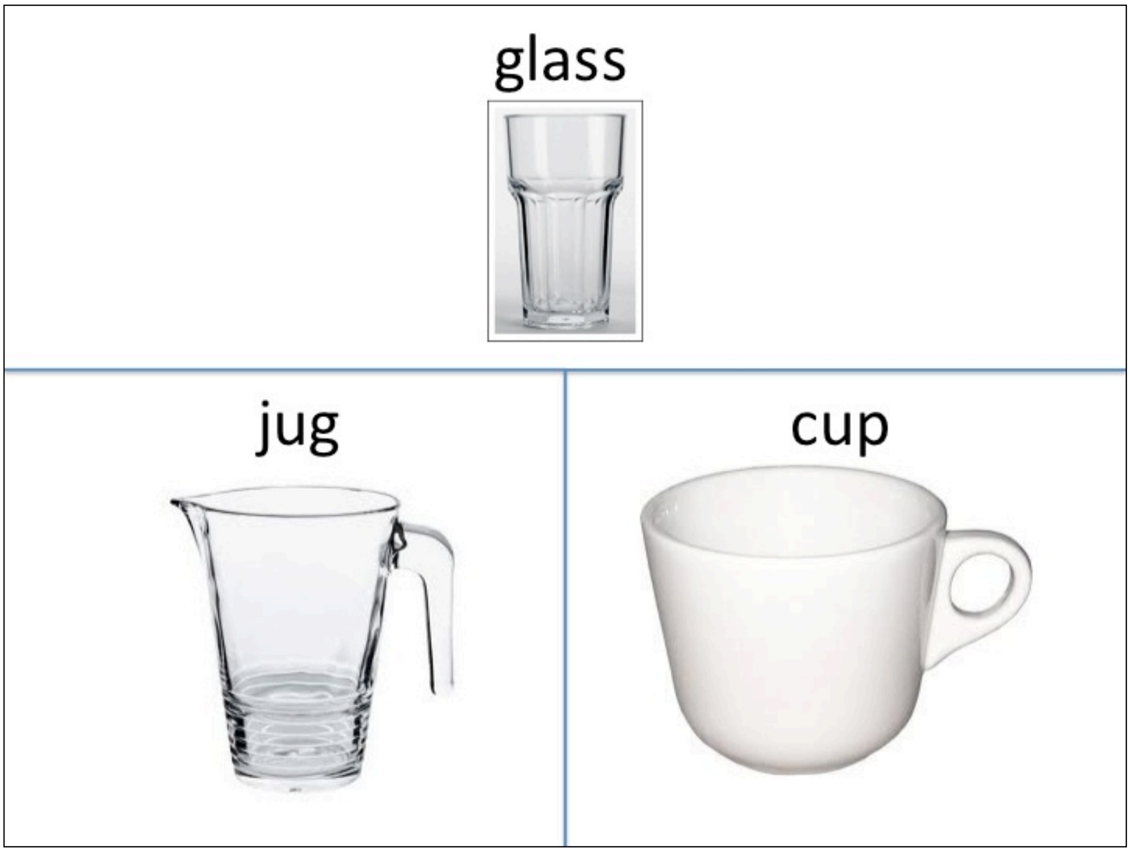


Figure N3. Format of the *glass* triad used in the context-lean condition (Experiments 2-8).

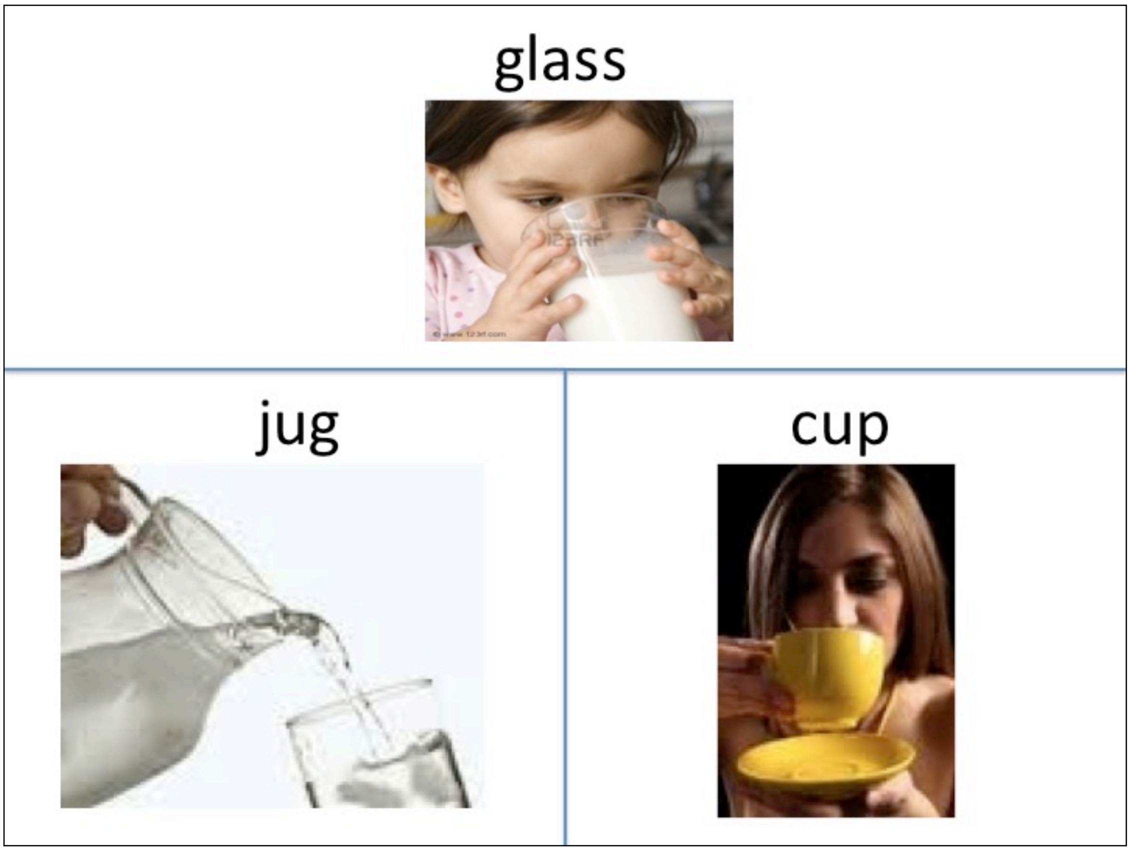


Figure N4. Format of the *glass* triad used in the context-rich condition (Experiments 2-8).

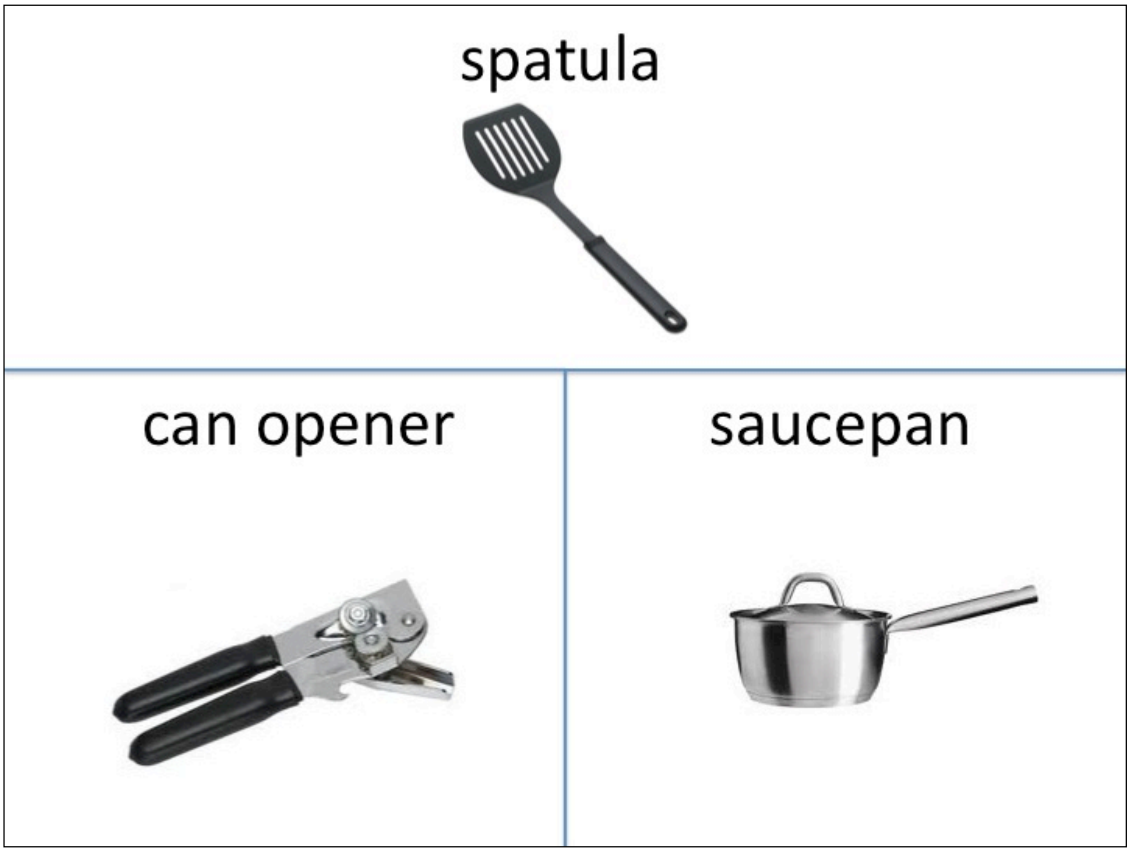


Figure N5. Format of the *spatula* triad used in the context-lean condition (Experiments 2-8).

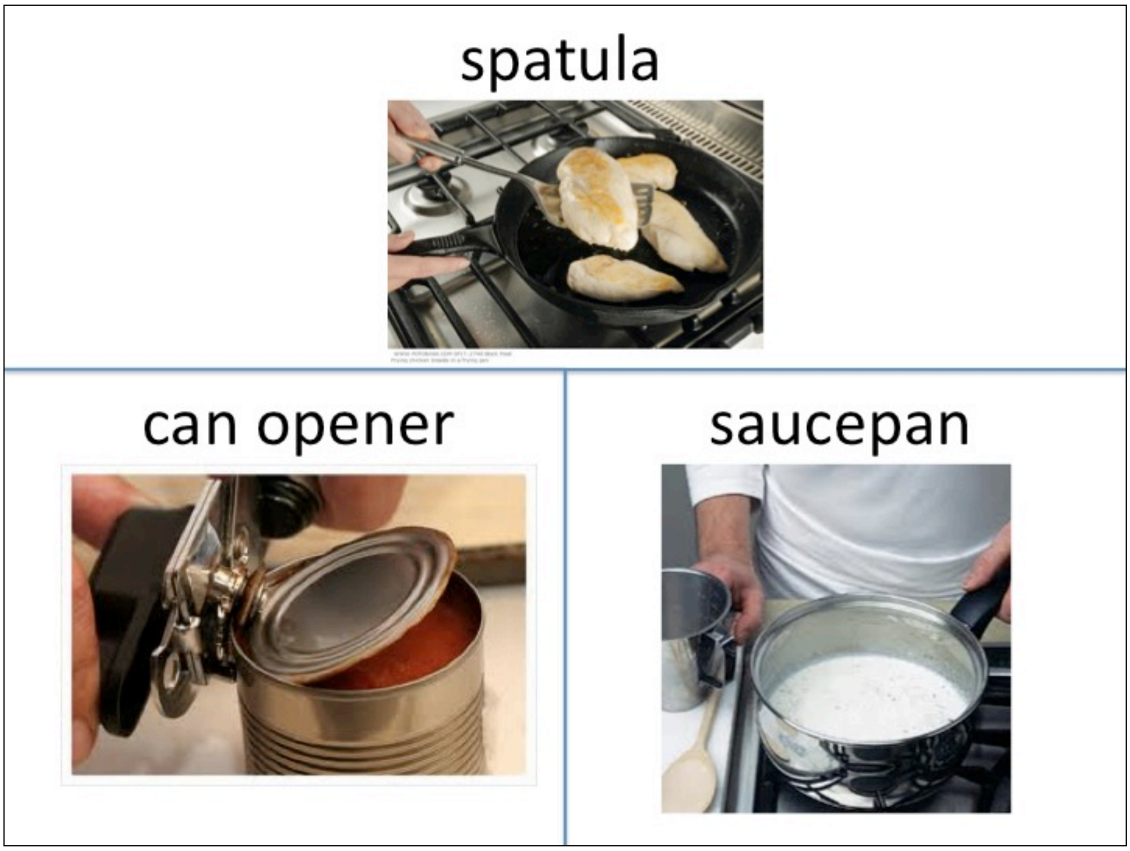


Figure N6. Format of the *spatula* triad used in the context-rich condition (Experiments 2-8).

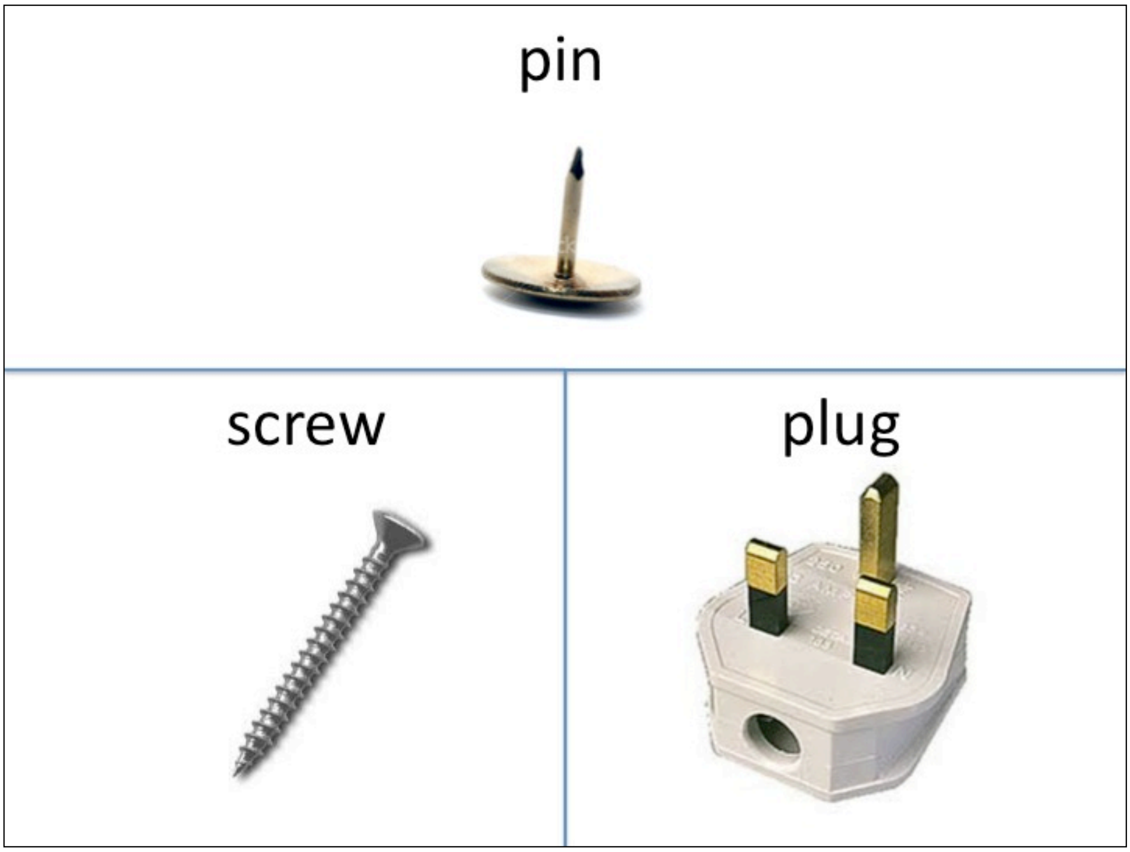


Figure N7. Format of the *pin* triad used in the context-lean condition (Experiments 2-8).

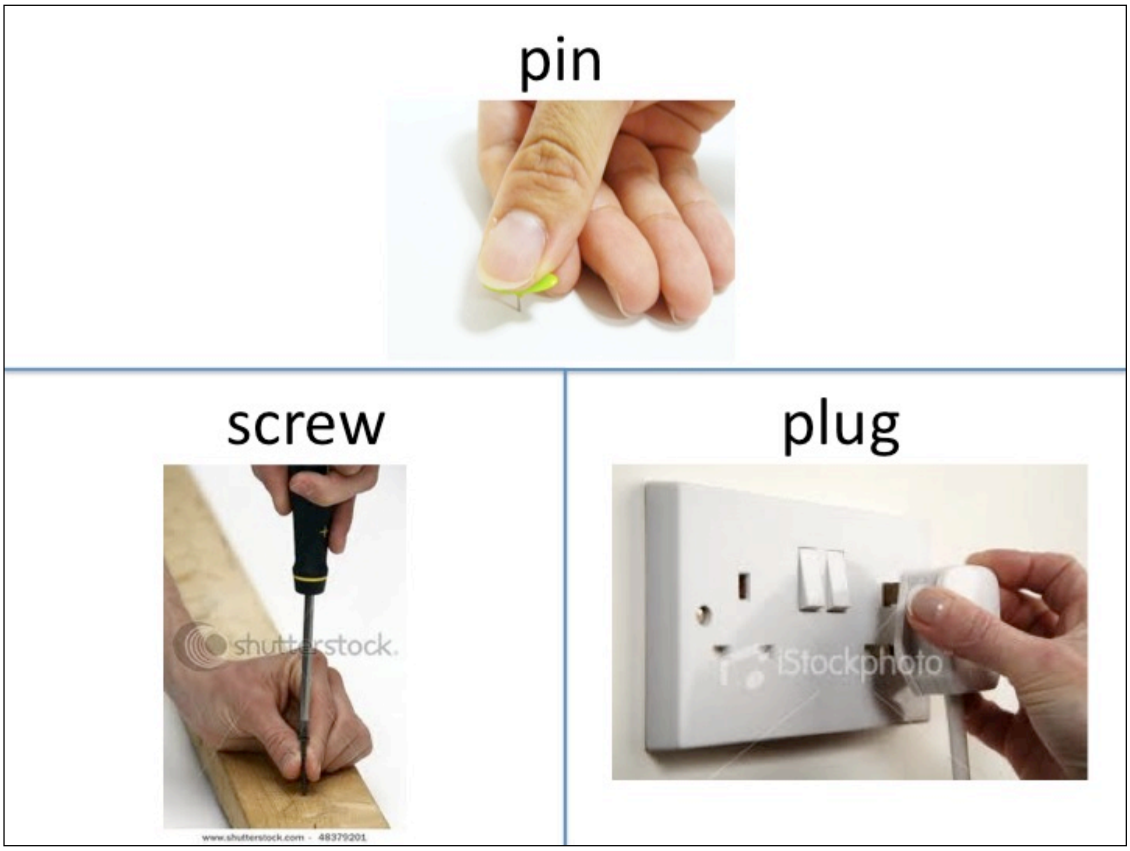


Figure N8. Format of the *pin* triad used in the context-rich condition (Experiments 2-8).

Figure N9. Format of the *dvd player* triad used in the context-lean condition (Experiments 2-8).

Figure N10. Format of the *dvd payer* triad used in the context-rich condition (Experiments 2-8).

Figure N11. Format of the *bed* triad used in the context-lean condition (Experiments 2-8).

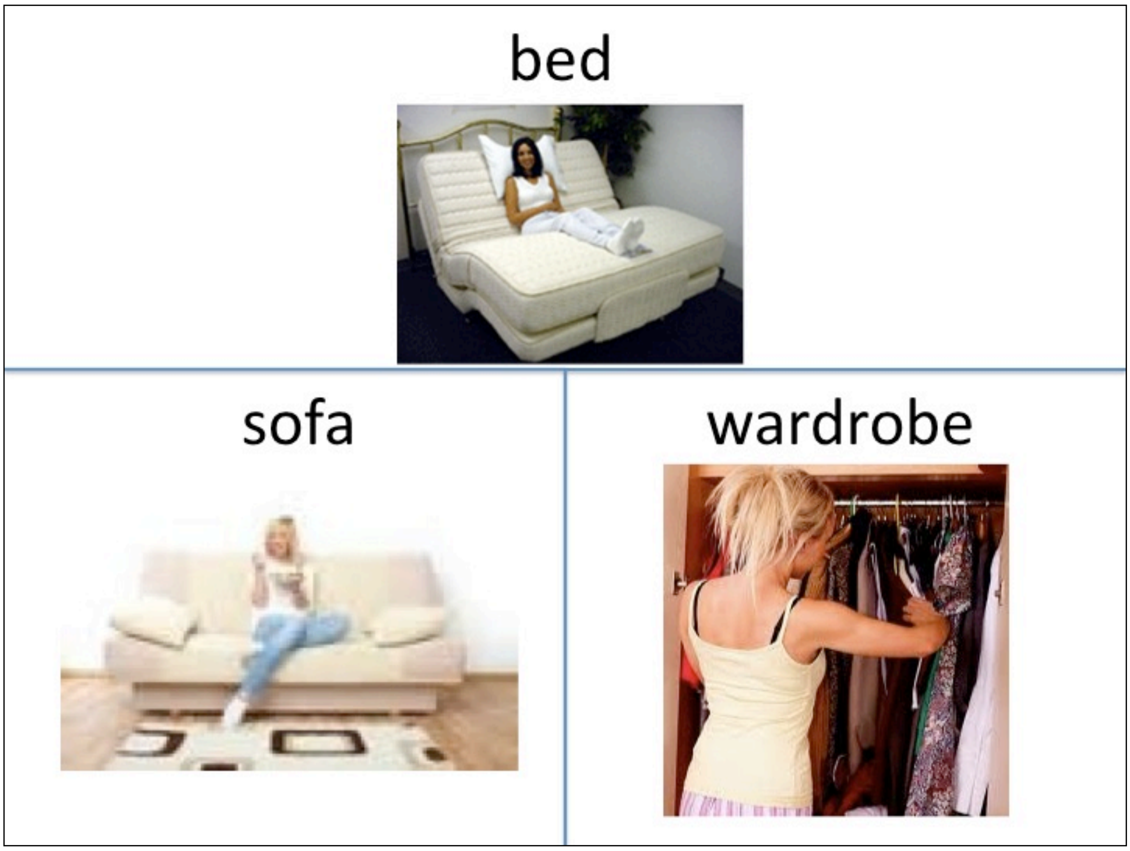


Figure N12. Format of the *bed* triad used in the context-rich condition (Experiments 2-8).

Figure N13. Format of the *leaflet* triad used in the context-lean condition (Experiments 2-8).

Figure N14. Format of the *leaflet* triad used in the context-rich condition (Experiments 2-8).

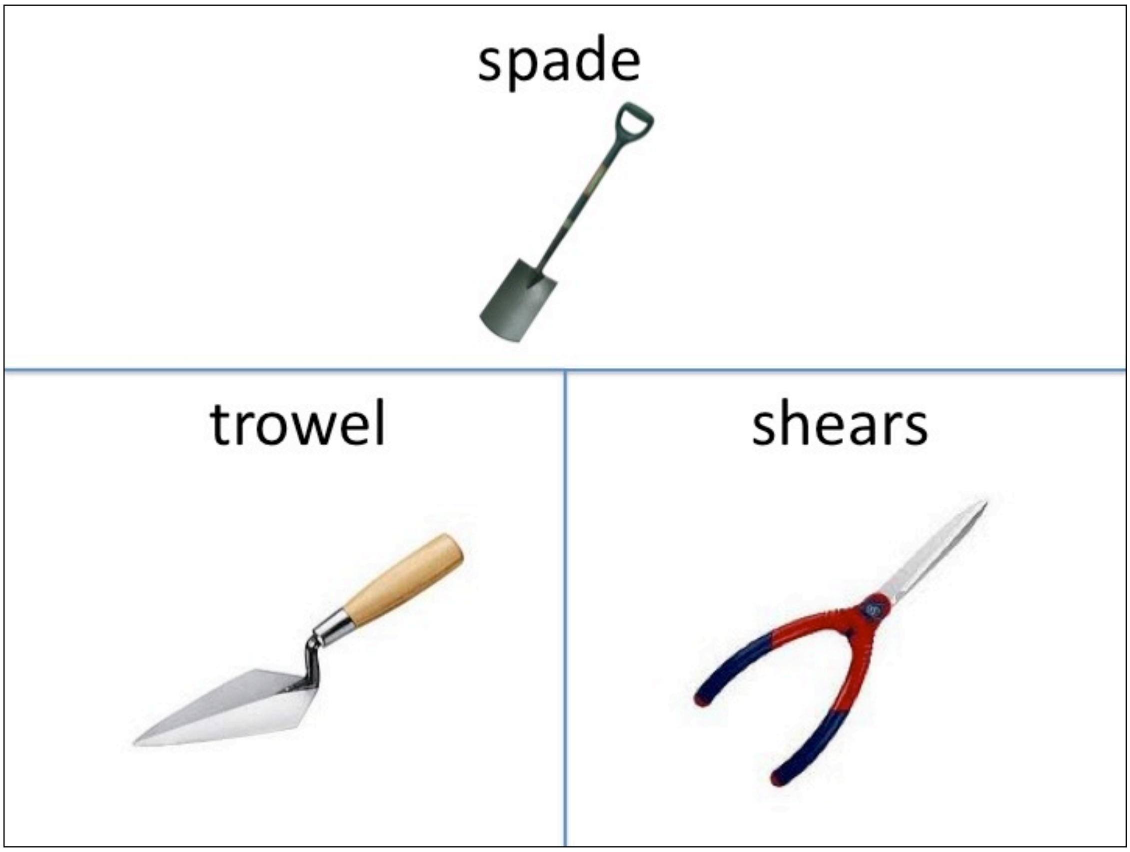


Figure 15. Format of the *spade* triad used in the context-lean condition (Experiments 2-8).

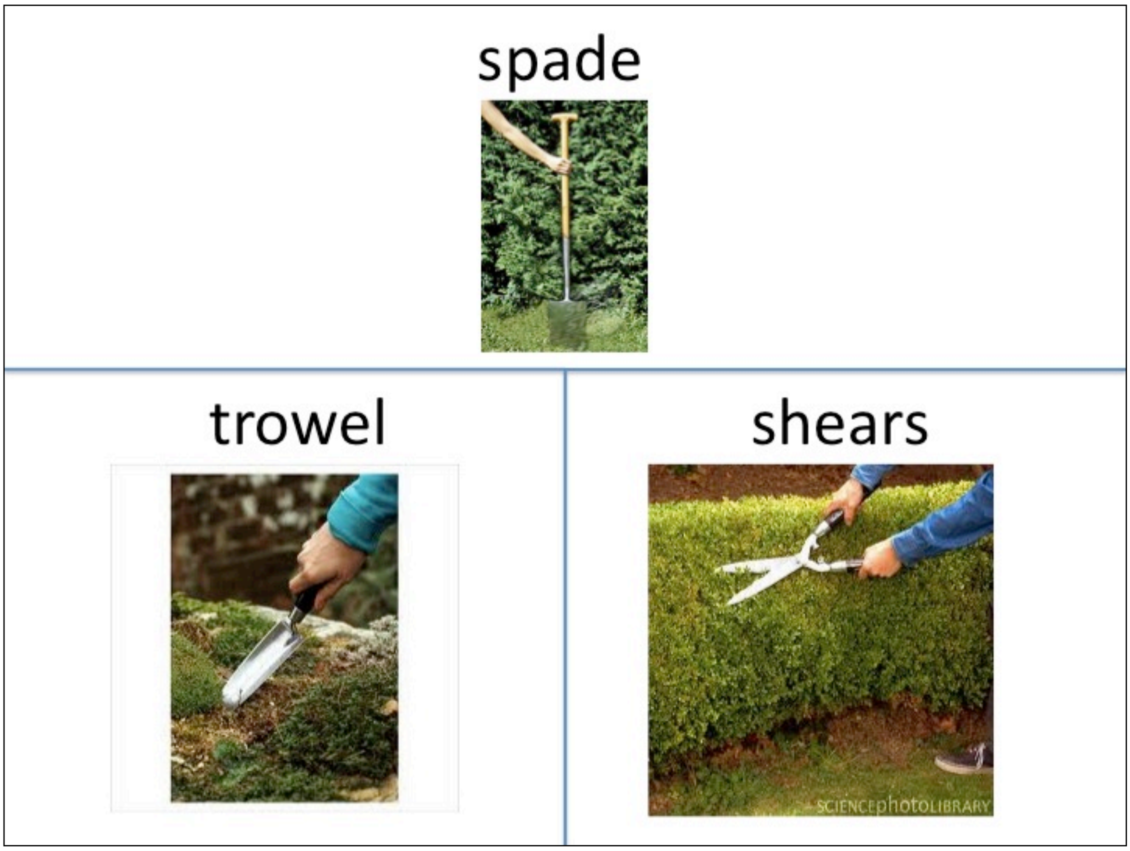


Figure N16. Format of the *spade* triad used in the context-rich condition (Experiments 2-8).

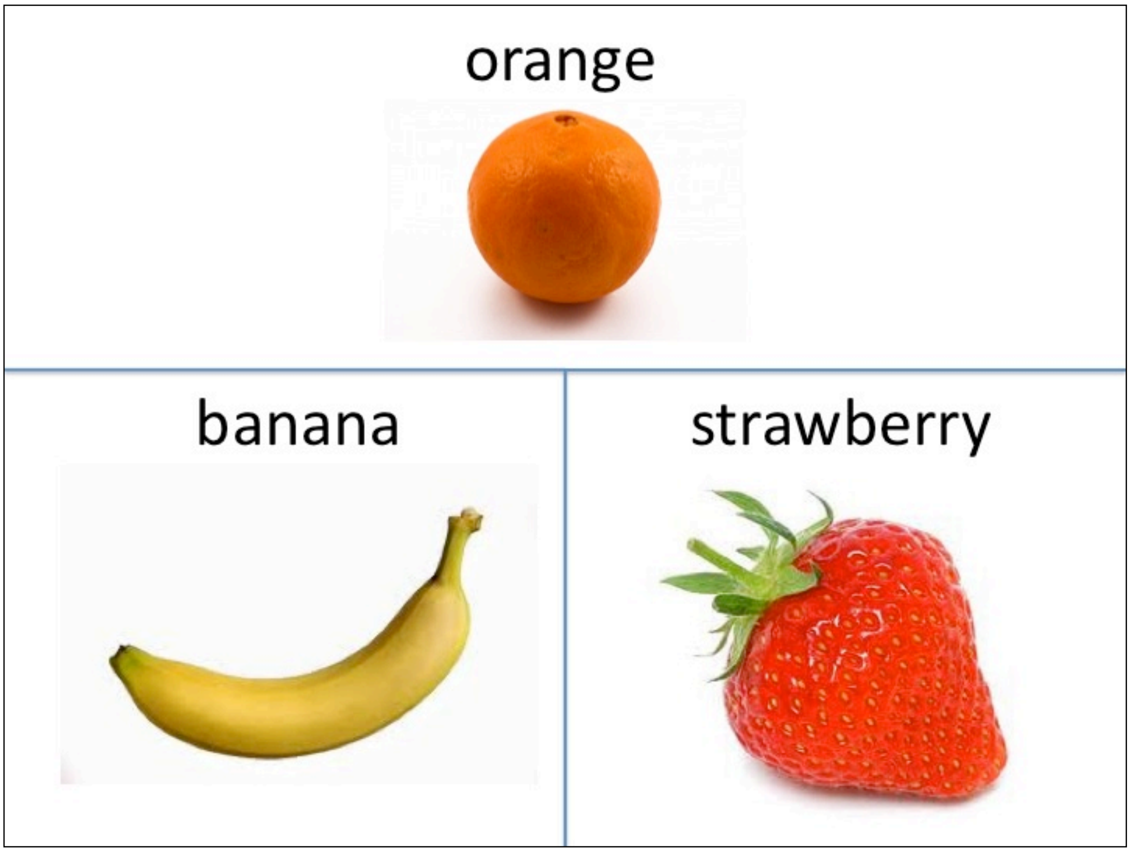


Figure N17. Format of the *orange* triad used in the context-lean condition (Experiments 2-8).

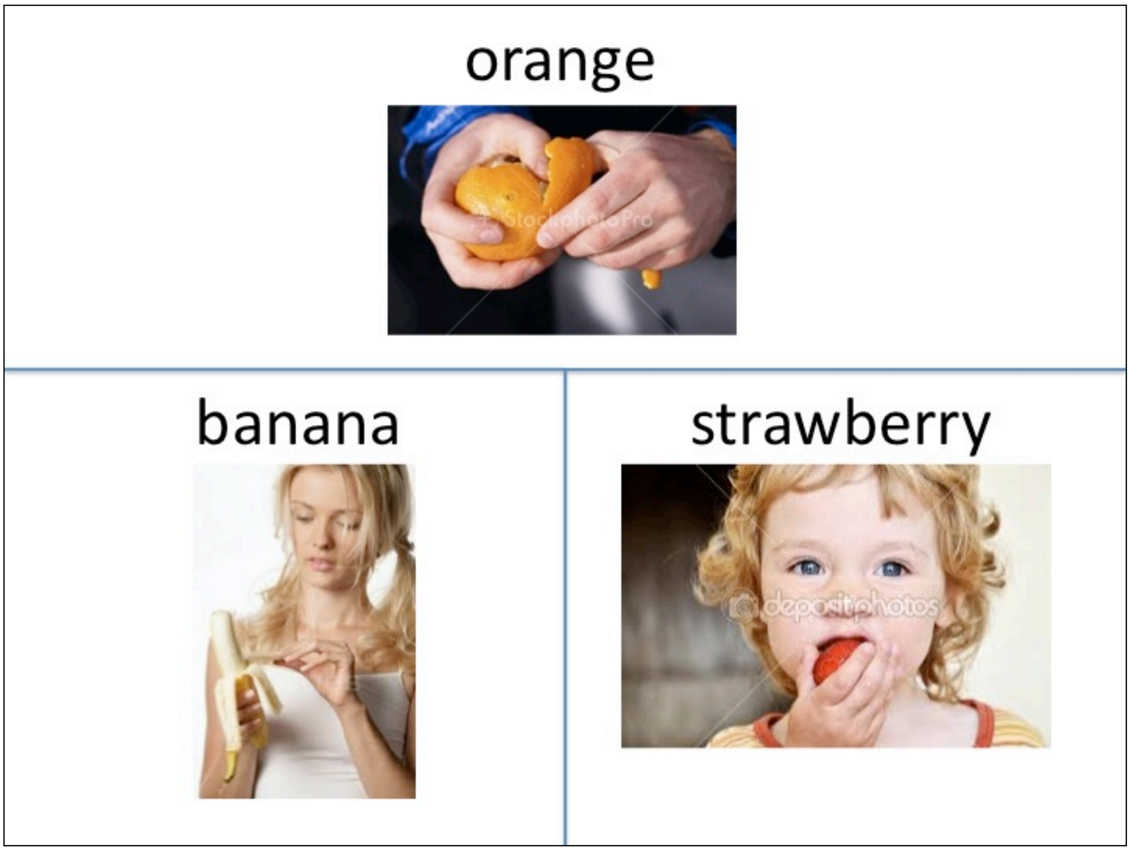


Figure N18. Format of the *orange* triad used in the context-rich condition (Experiments 2-8).

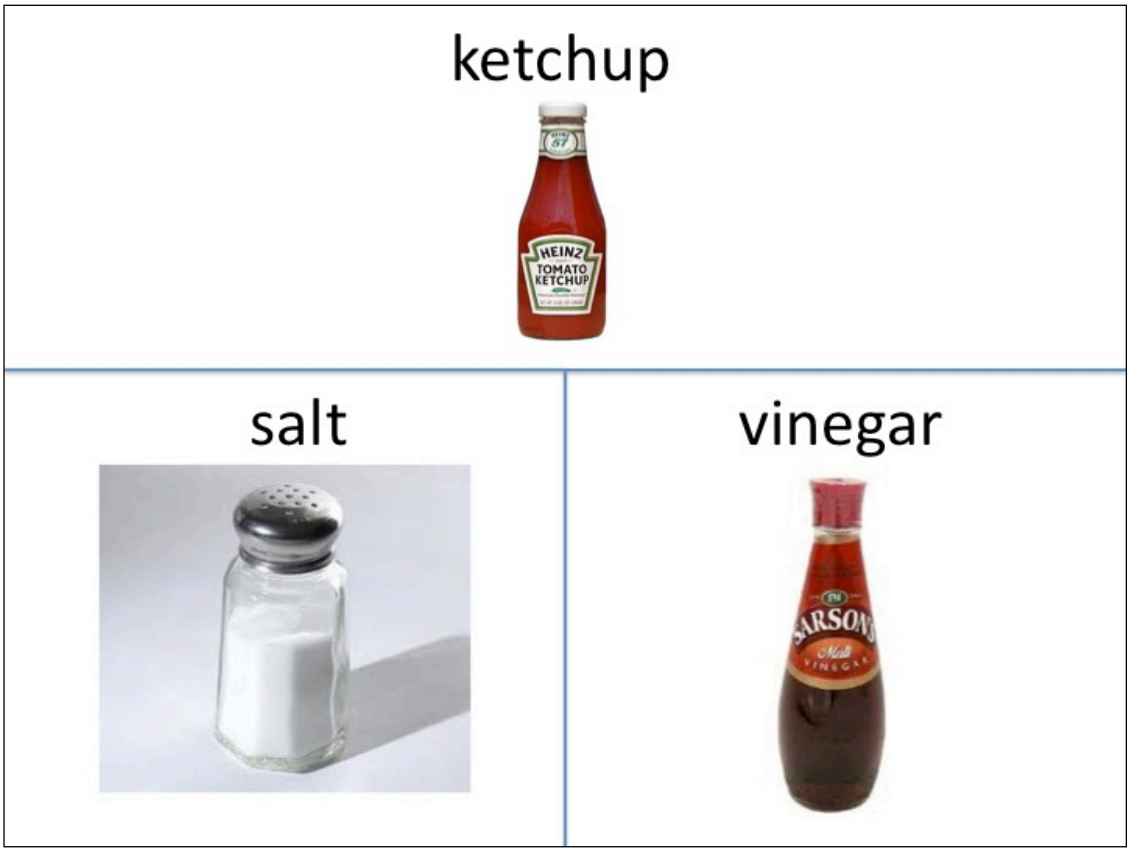


Figure N19. Format of the *ketchup* triad used in the context-lean condition (Experiments 2-8).

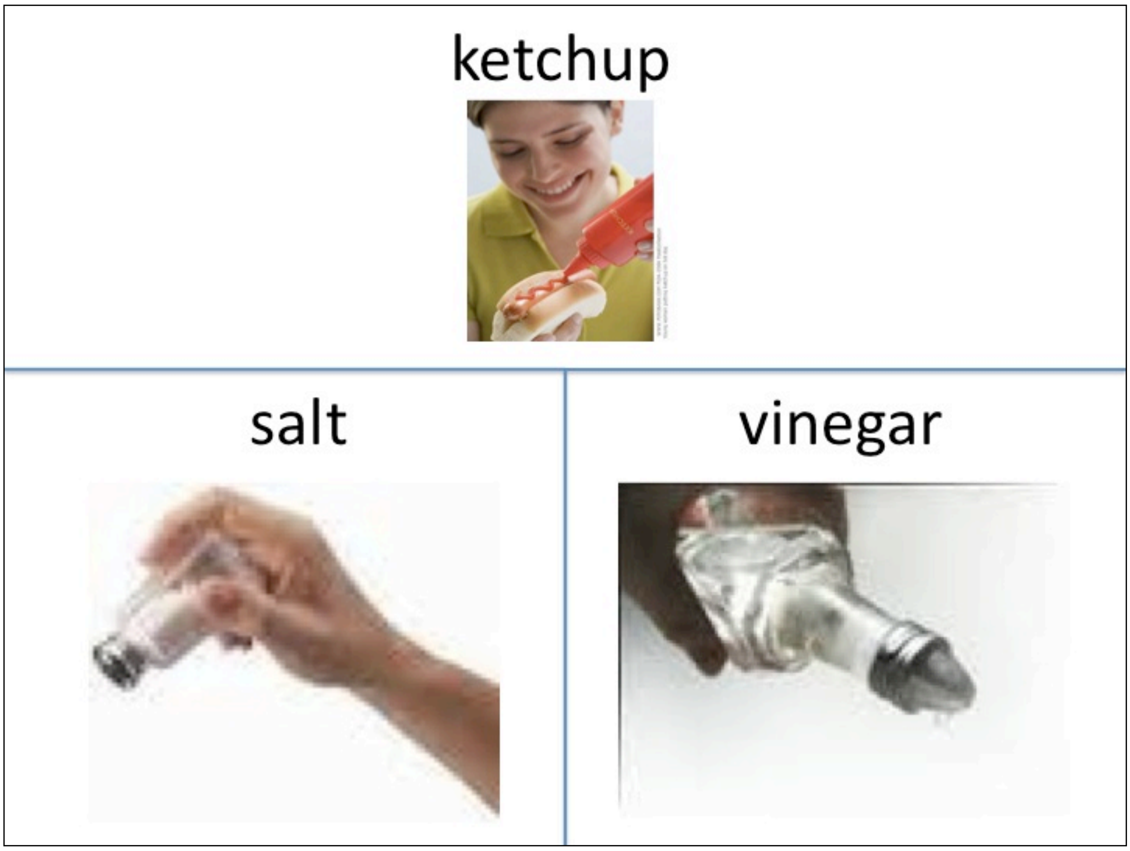


Figure N20. Format of the *ketchup* triad used in the context-rich condition (Experiments 2-8).

Figure O1. Format of the *screwdriver* triad used in the context-lean condition (Experiments 2-8).

Figure O2. Format of the *screwdriver* triad used in the context-rich condition (Experiments 2-8).

Figure O3. Format of the *drink bottle* triad used in the context-lean condition (Experiments 2-8).

Figure O4. Format of the *drink bottle* triad used in the context-rich condition (Experiments 2-8).

Figure O5. Format of the *rifle* triad used in the context-lean condition (Experiments 2-8).

Figure O6. Format of the *rifle* triad used in the context-rich condition (Experiments 2-8).

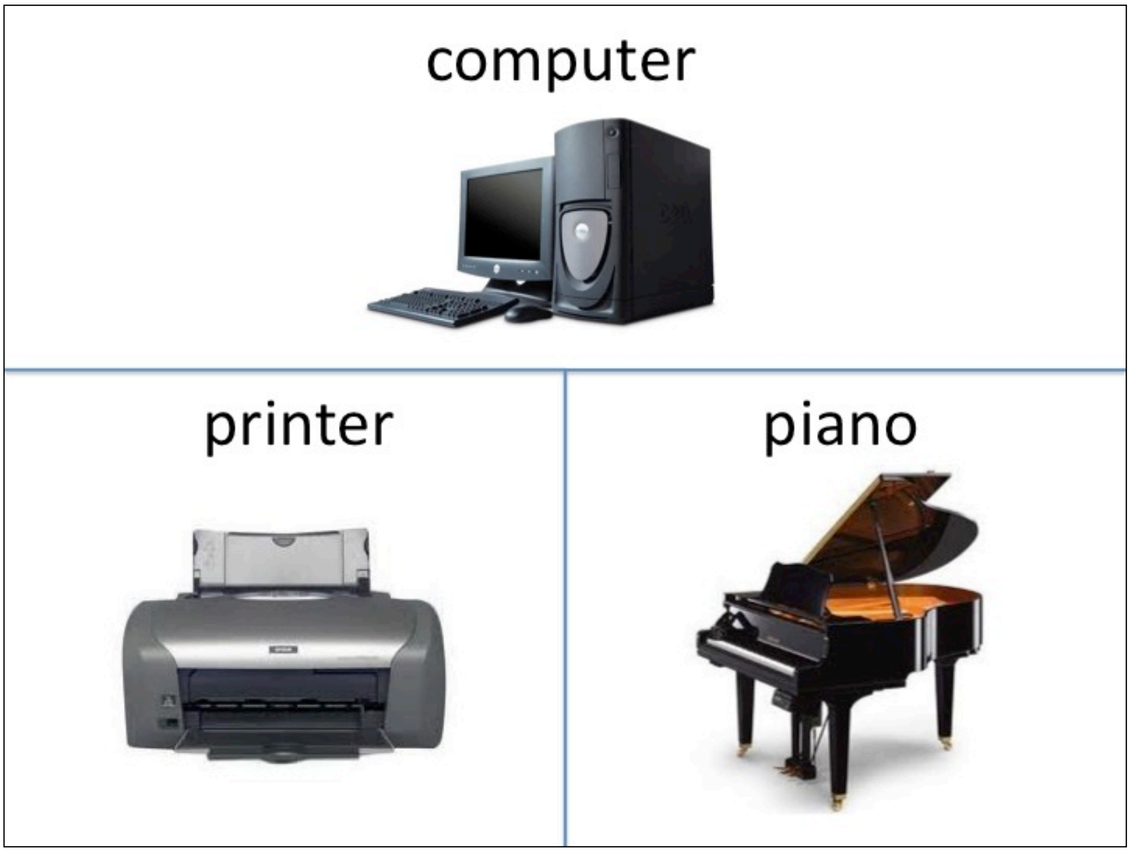


Figure O7. Format of the *computer* triad used in the context-lean condition (Experiments 2-8).

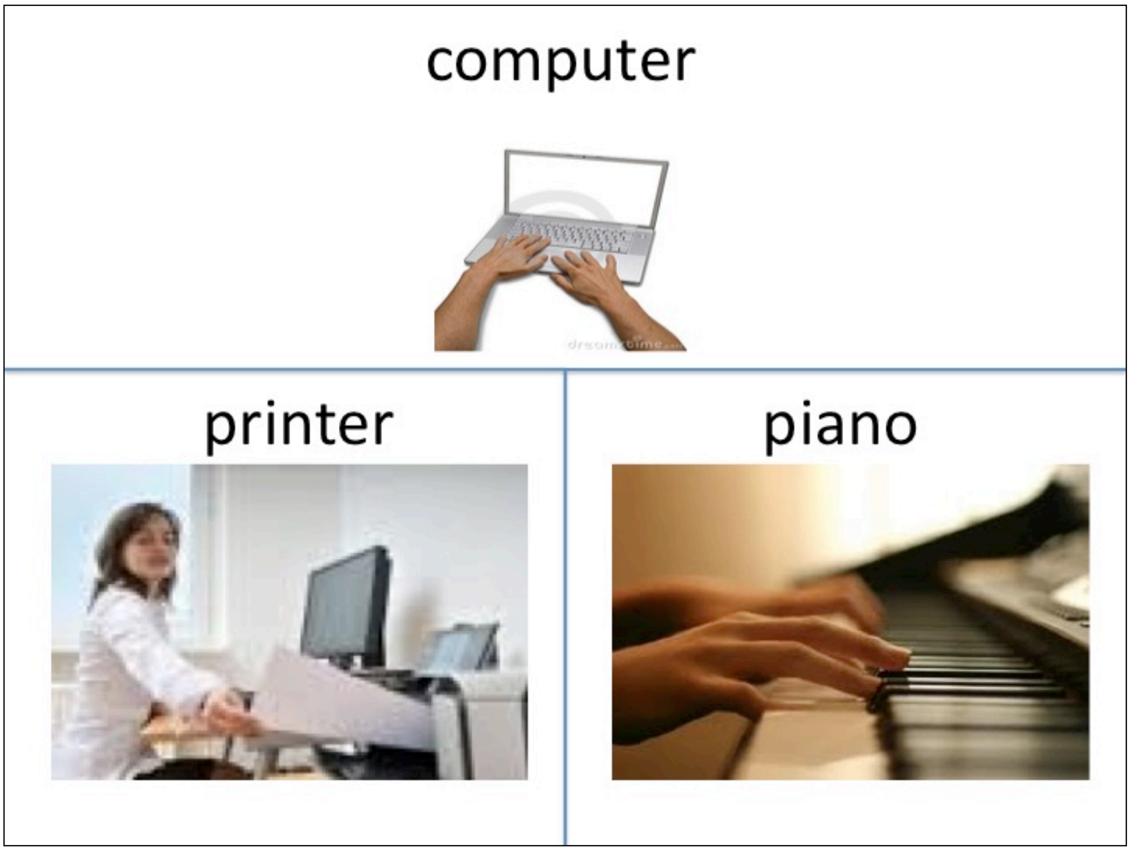


Figure O8. Format of the *computer* triad used in the context-rich condition (Experiments 2-8).

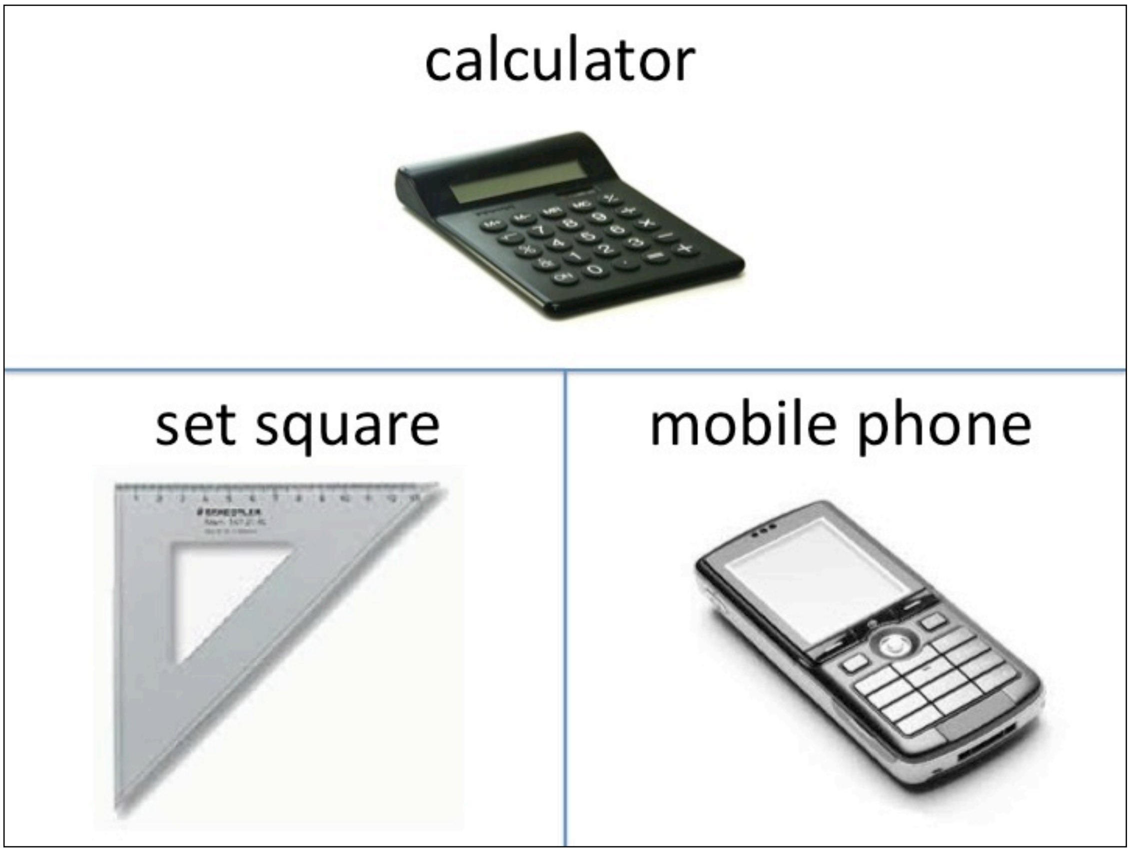


Figure O9. Format of the *calculator* triad used in the context-lean condition (Experiments 2-8).

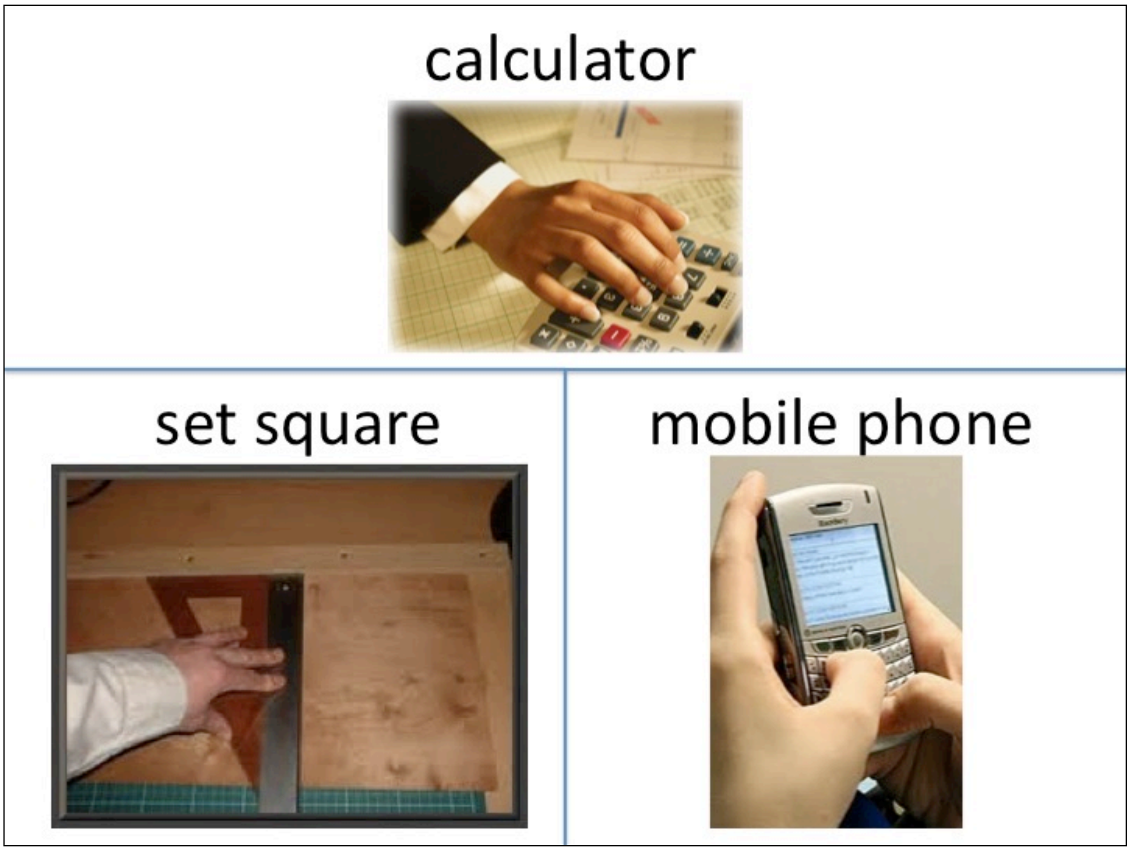


Figure O10. Format of the *calculator* triad used in the context-rich condition (Experiments 2-8).

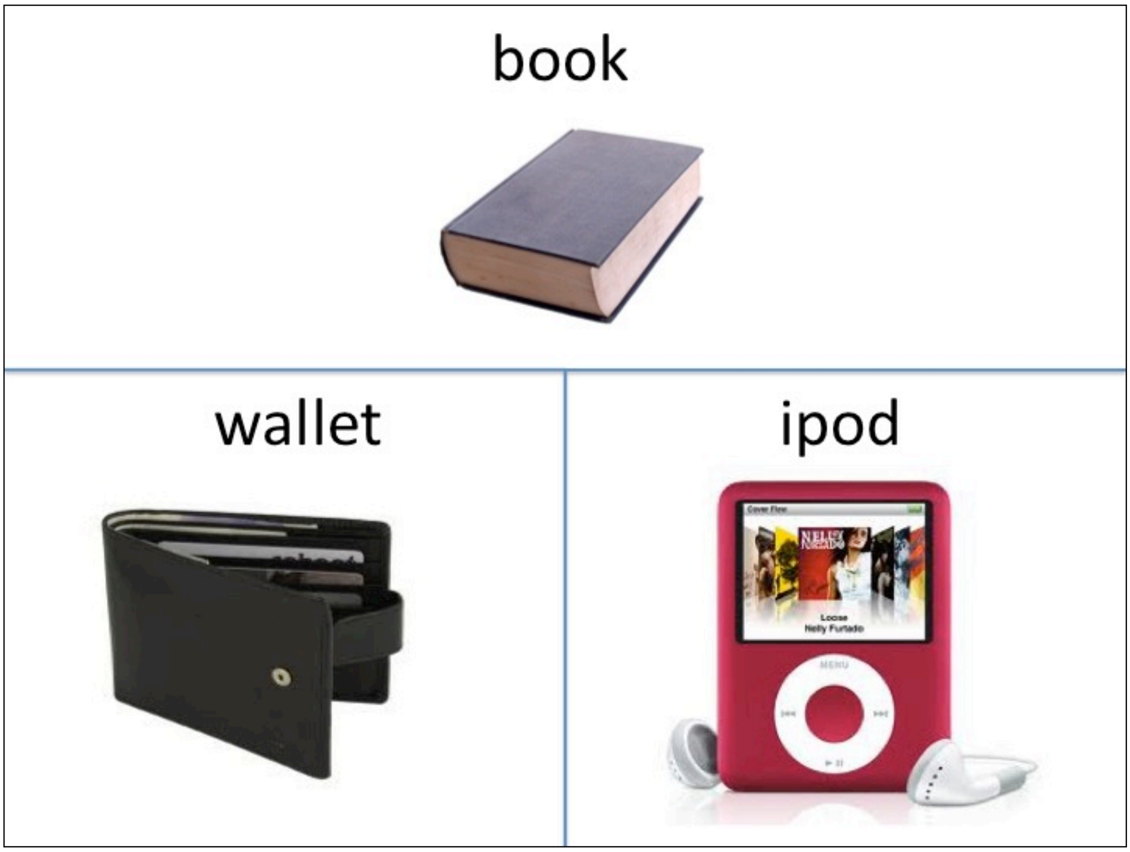


Figure O11. Format of the *book* triad used in the context-lean condition (Experiments 2-8).

Figure O12. Format of the *book* triad used in the context-rich condition (Experiments 2-8).

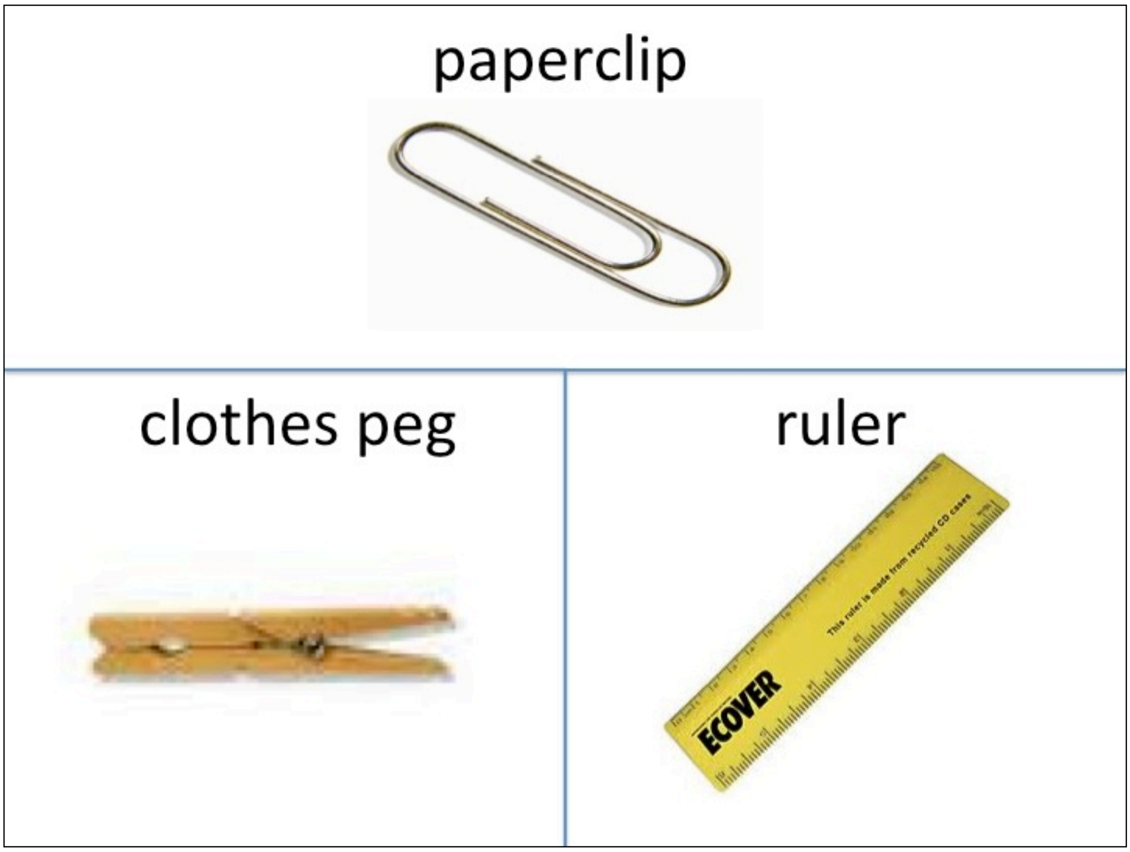


Figure O13. Format of the *paperclip* triad used in the context-lean condition (Experiments 2-8).

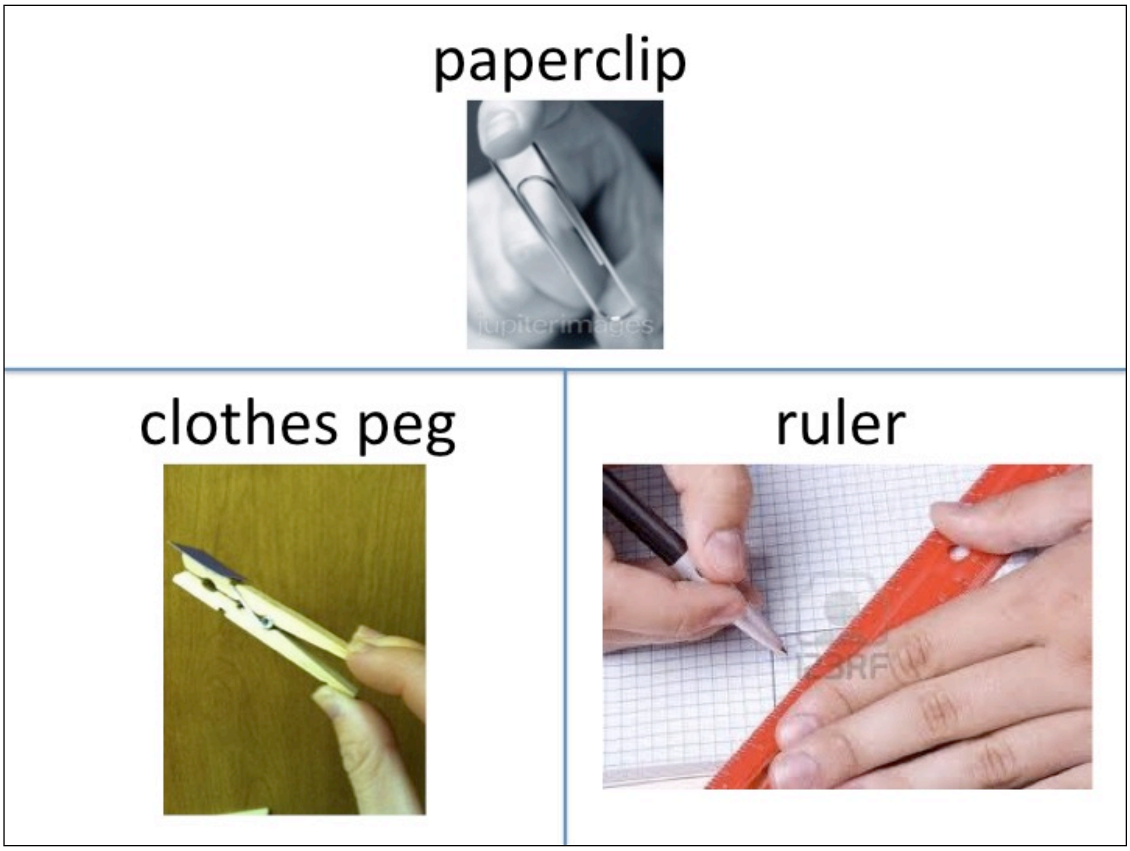


Figure O14. Format of the *paperclip* triad used in the context-rich condition (Experiments 2-8).

Figure O15. Format of the *deodorant* triad used in the context-lean condition (Experiments 2-8).

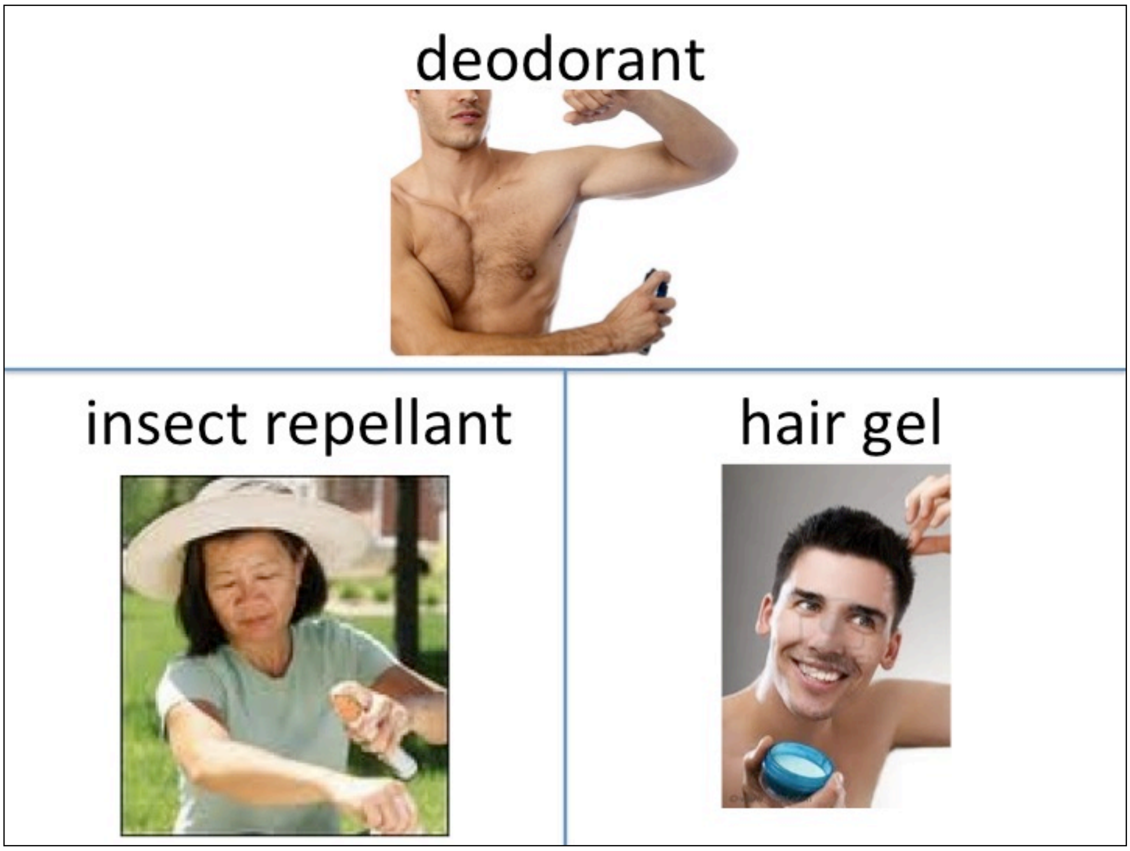


Figure O16. Format of the *deodorant* triad used in the context-rich condition (Experiments 2-8).

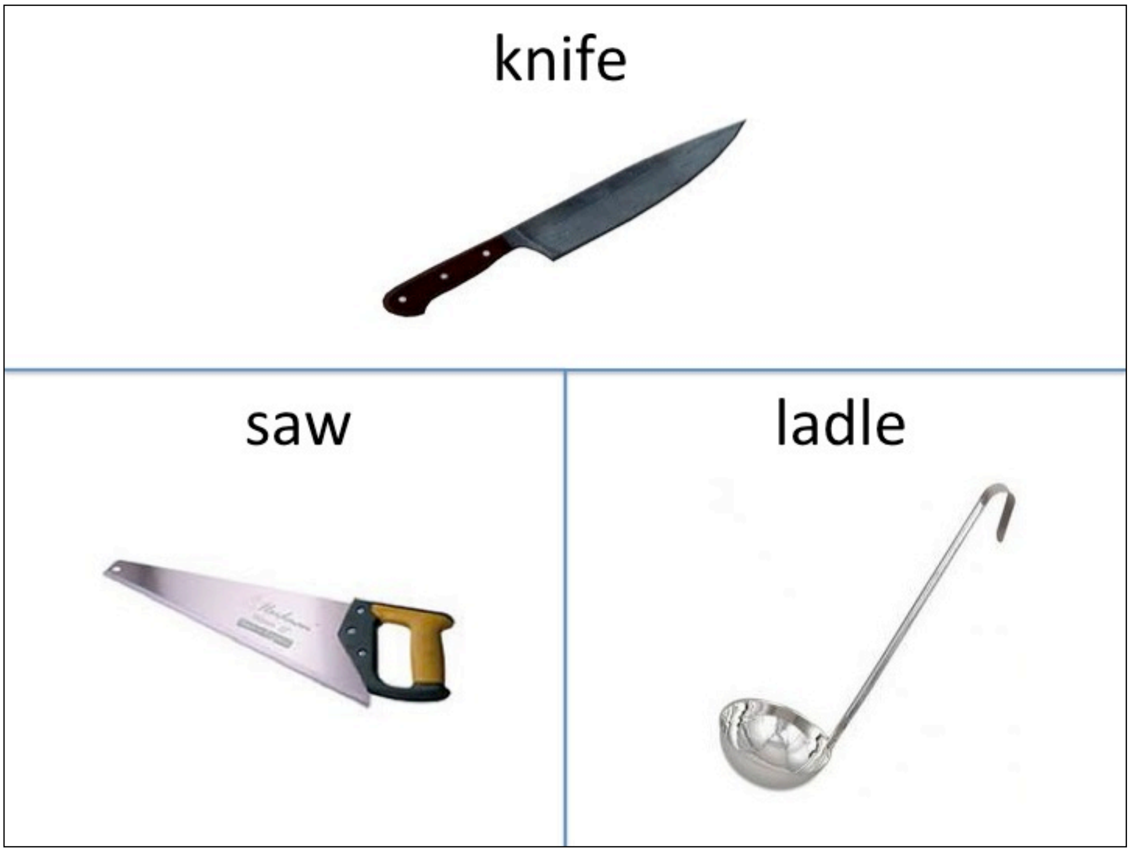


Figure O17. Format of the *knife* triad used in the context-lean condition (Experiments 2-8).

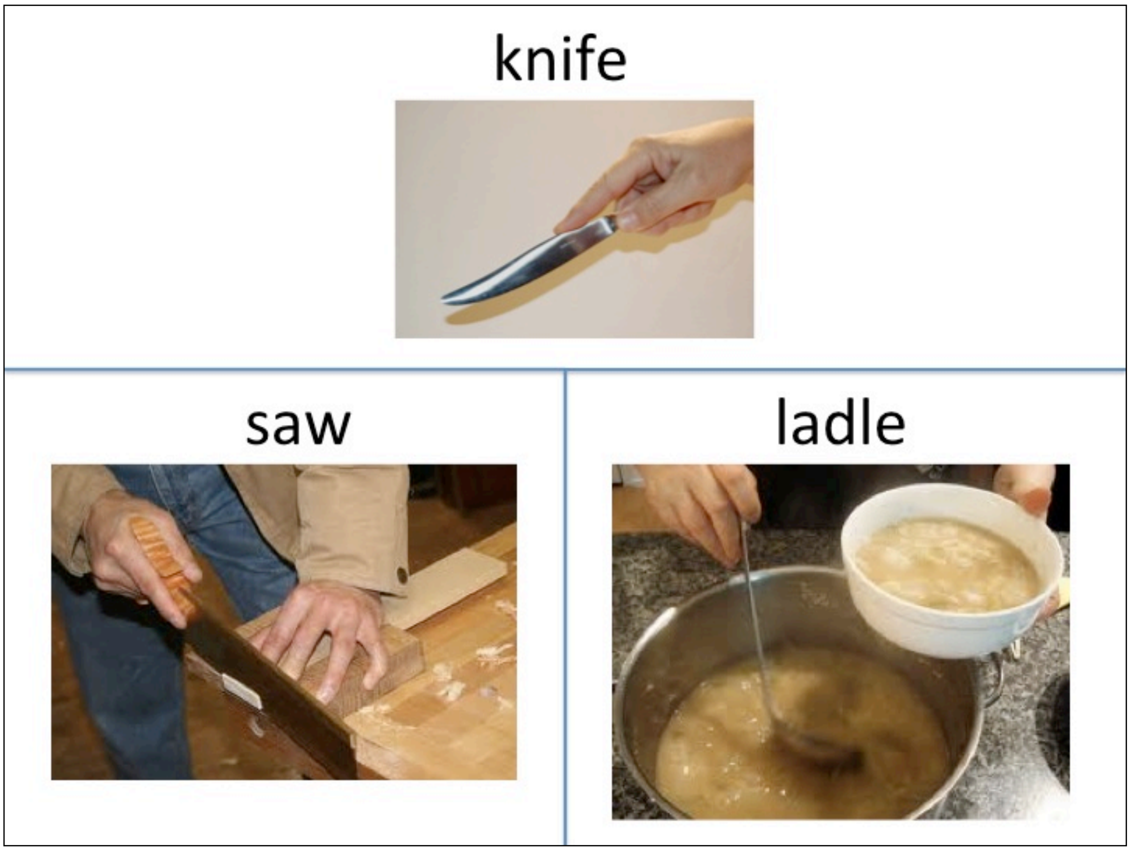


Figure O18. Format of the *knife* triad used in the context-lean condition (Experiments 2-8).

Figure O19. Format of the *fax machine* triad used in the context-lean condition (Experiments 2-8).

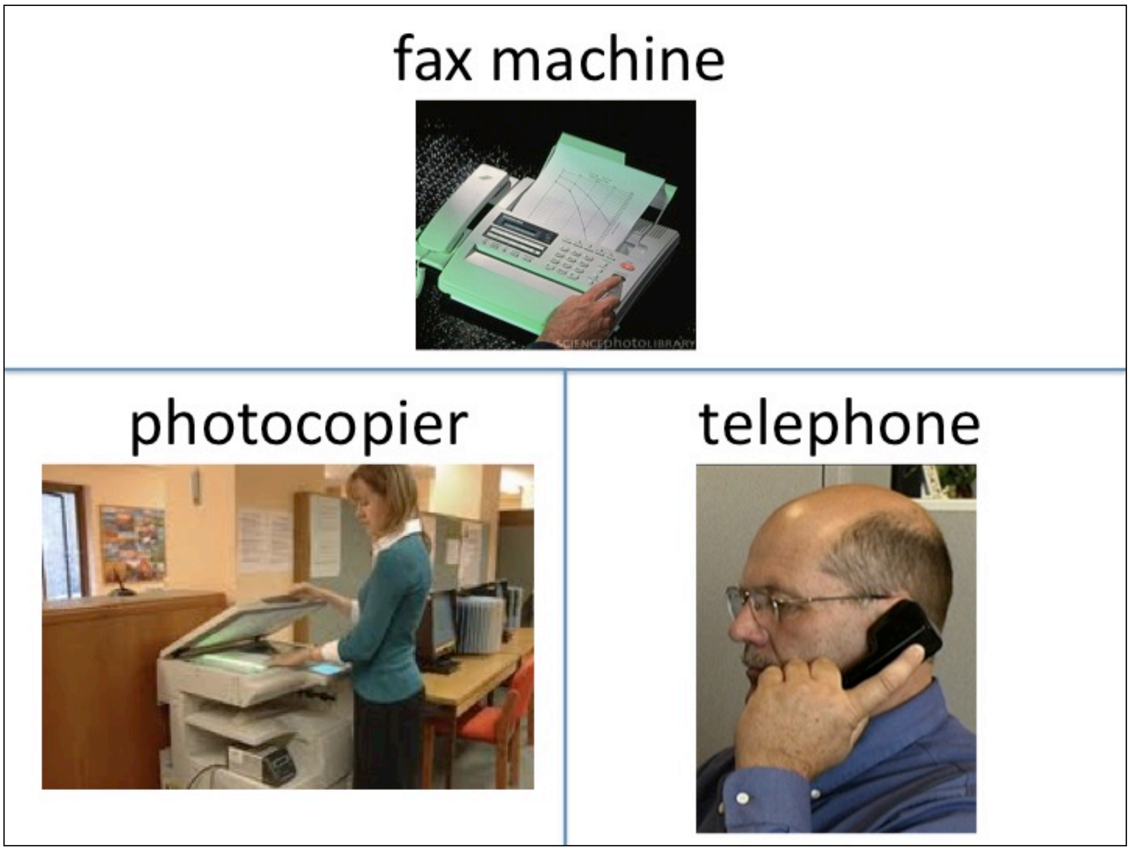


Figure 020. Format of the *fax machine* triad used in the context-rich condition (Experiments 2-8).

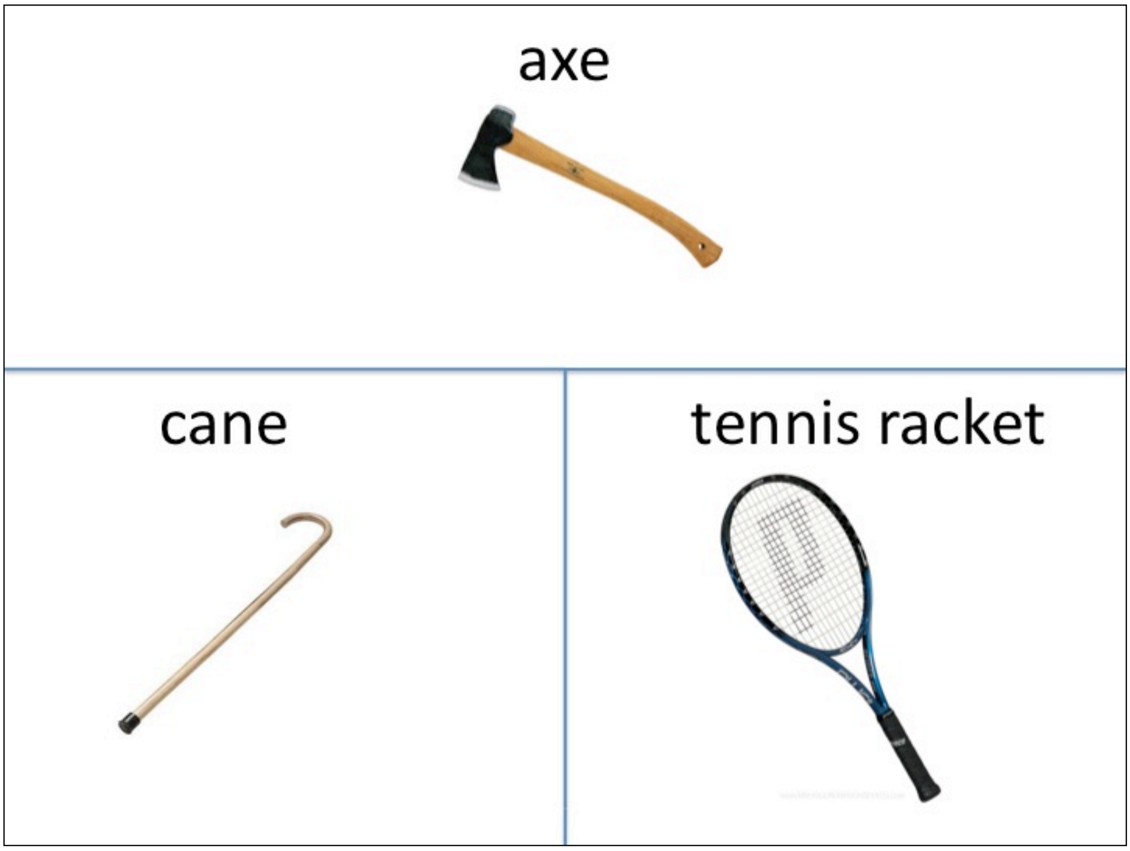


Figure P1. Format of the *axe* triad used in the context-lean condition (Experiments 2-8).

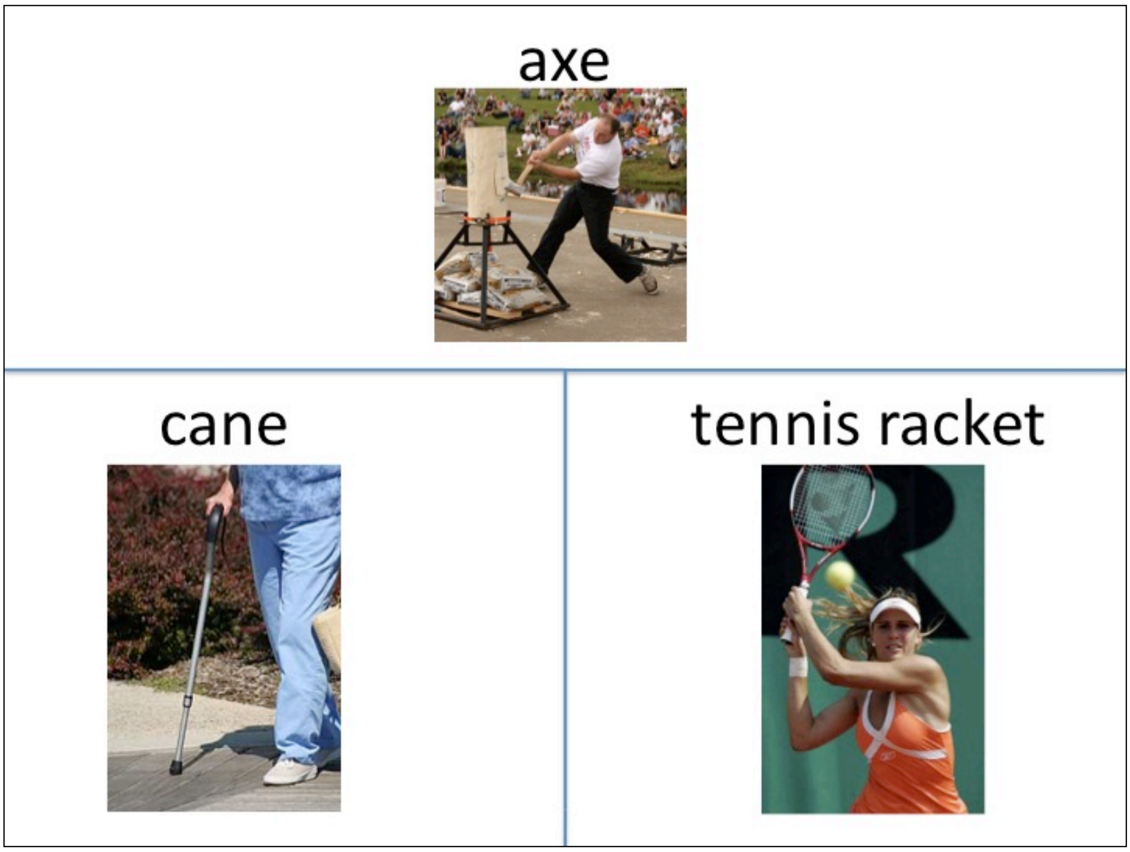


Figure P2. Format of the *axe* triad used in the context-rich condition (Experiments 2-8).

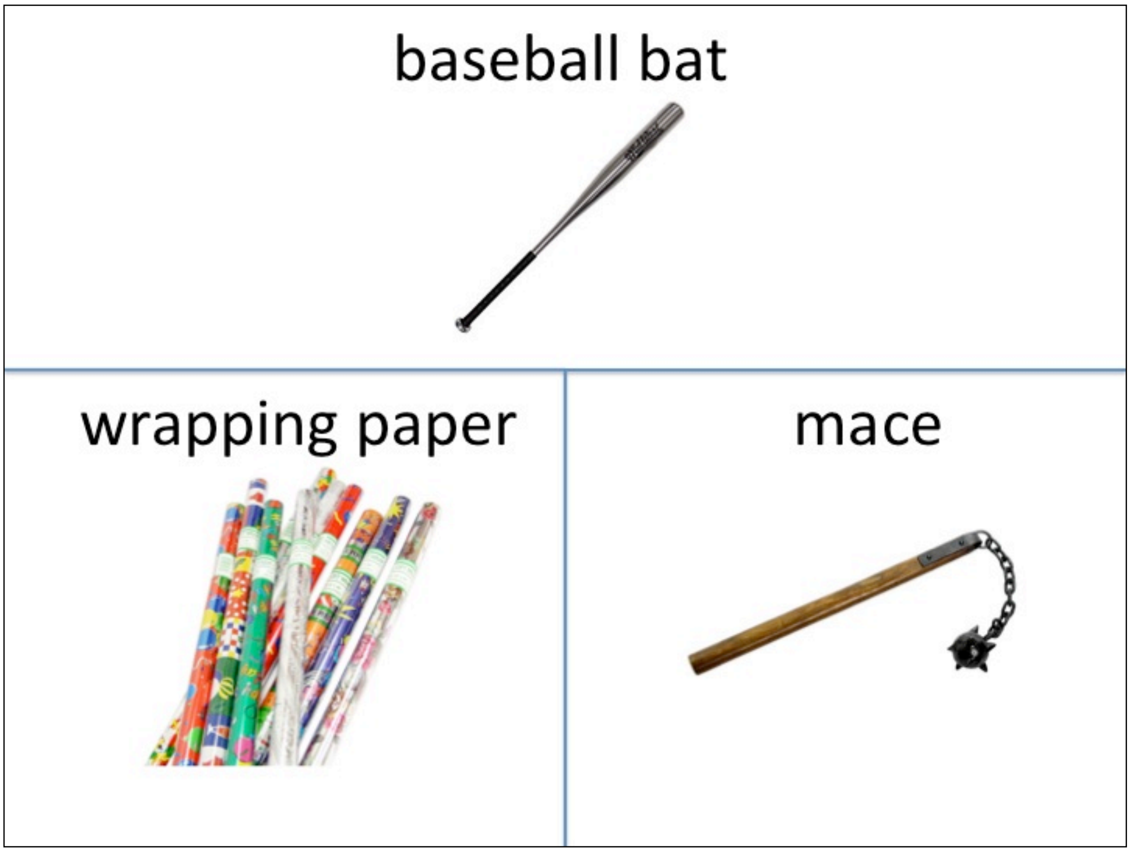


Figure P3. Format of the *baseball bat* triad used in the context-lean condition (Experiments 2-8).

Figure P4. Format of the *baseball bat* triad used in the context-rich condition (Experiments 2-8).

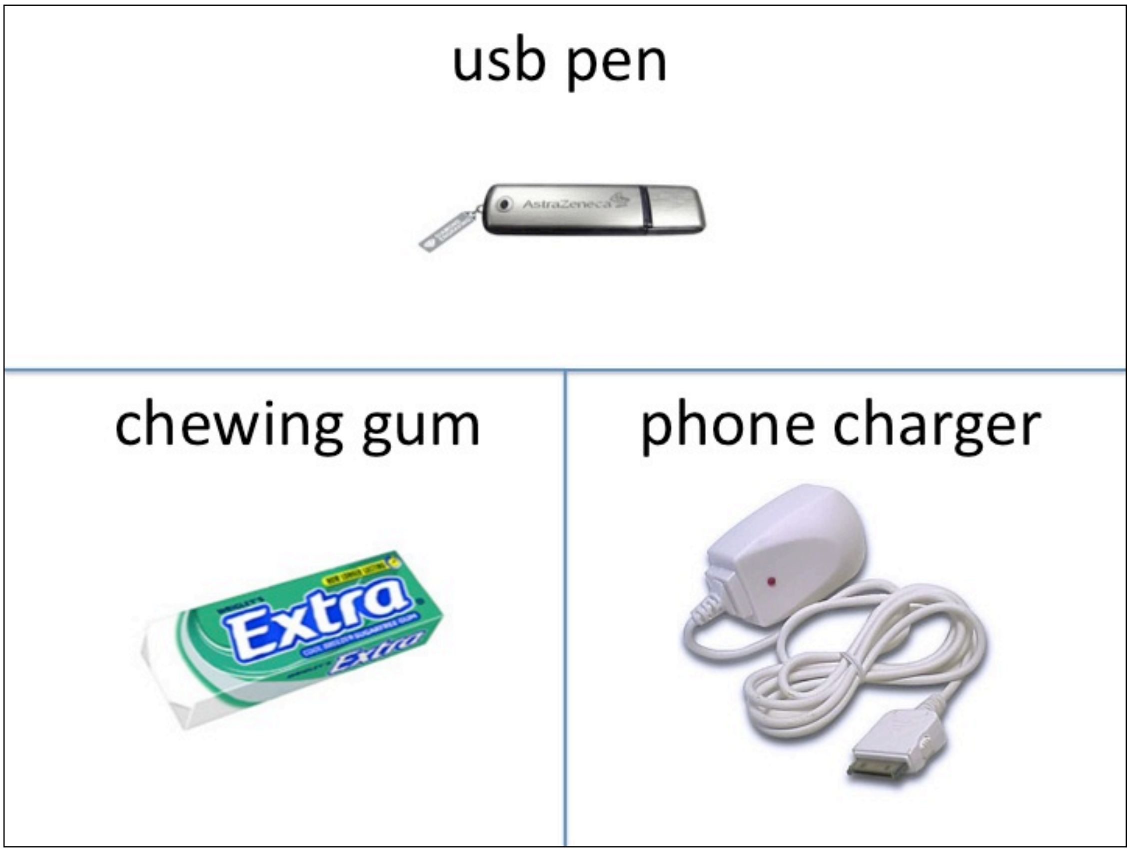


Figure P5. Format of the *USB pen* triad used in the context-lean condition (Experiments 2-8).

Figure P6. Format of the *USB pen* triad used in the context-rich condition (Experiments 2-8).

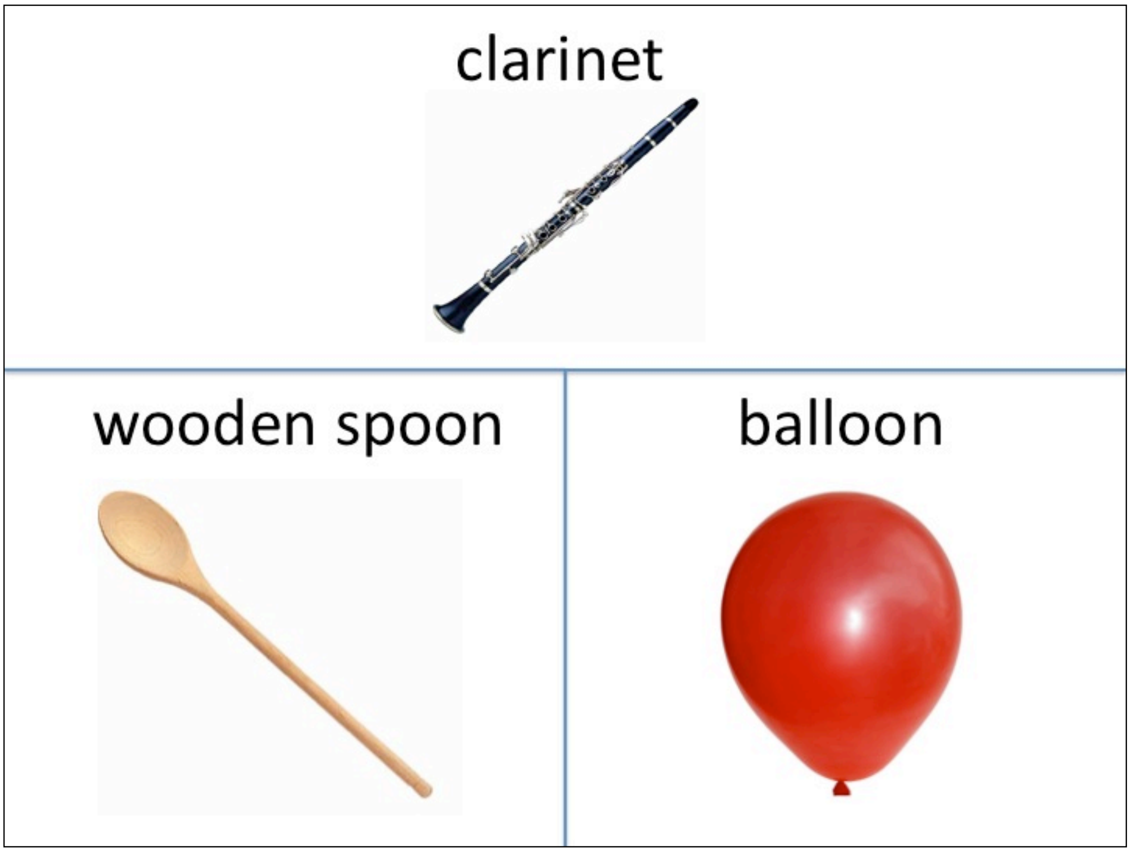


Figure P7. Format of the *clarinet* triad used in the context-lean condition (Experiments 2-8).

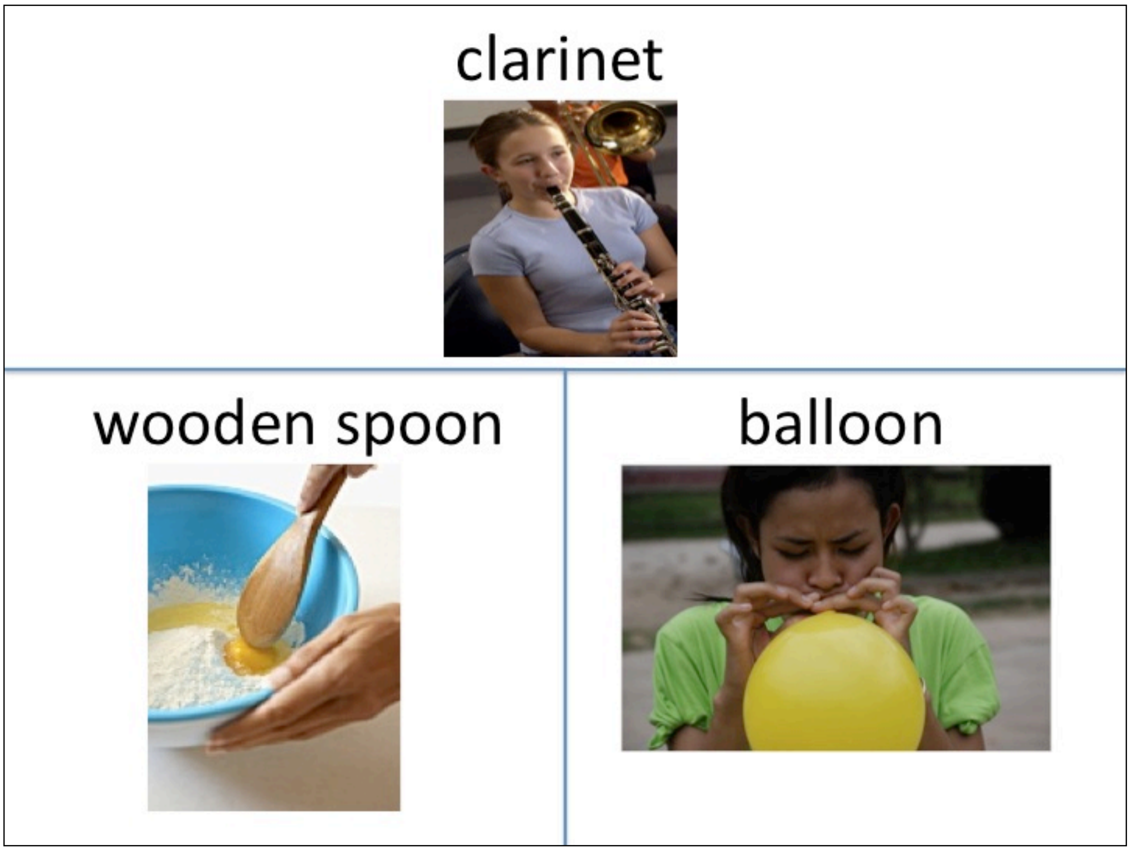


Figure P8. Format of the *clarinet* triad used in the context-rich condition (Experiments 2-8).

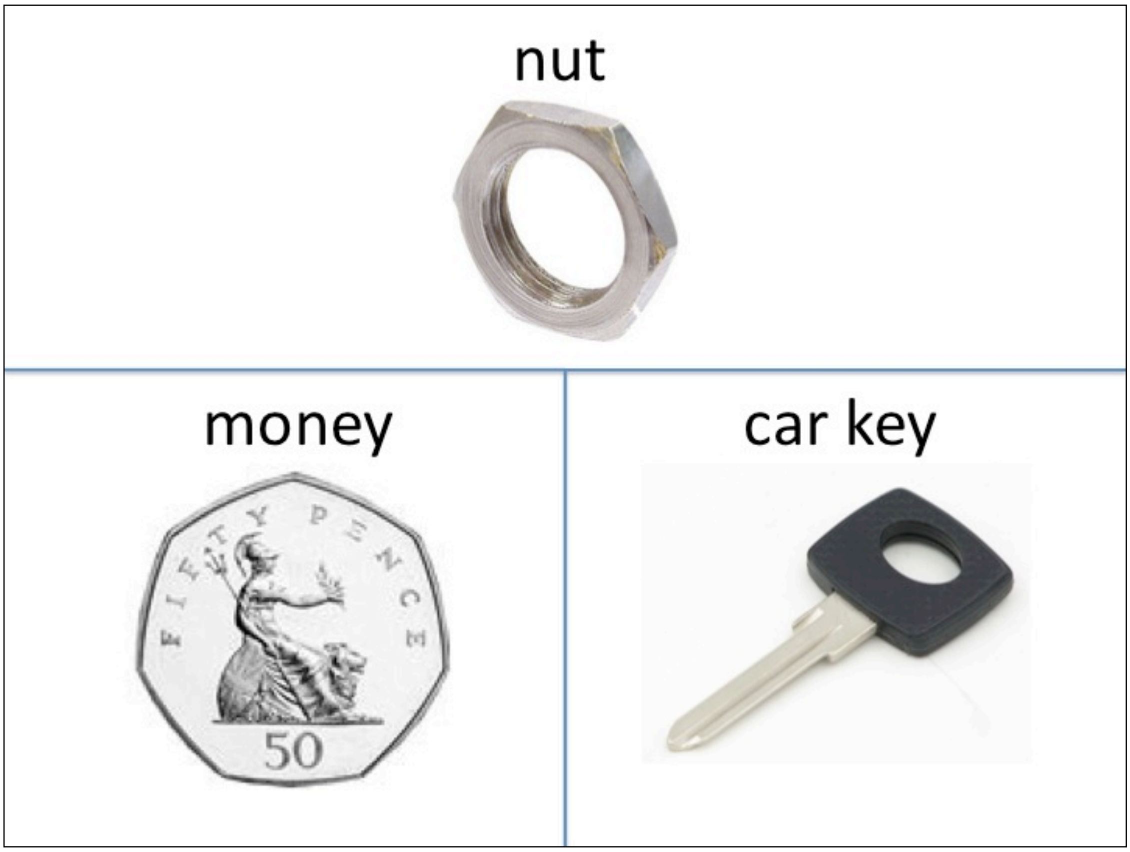


Figure P9. Format of the *nut* triad used in the context-lean condition (Experiments 2-8).

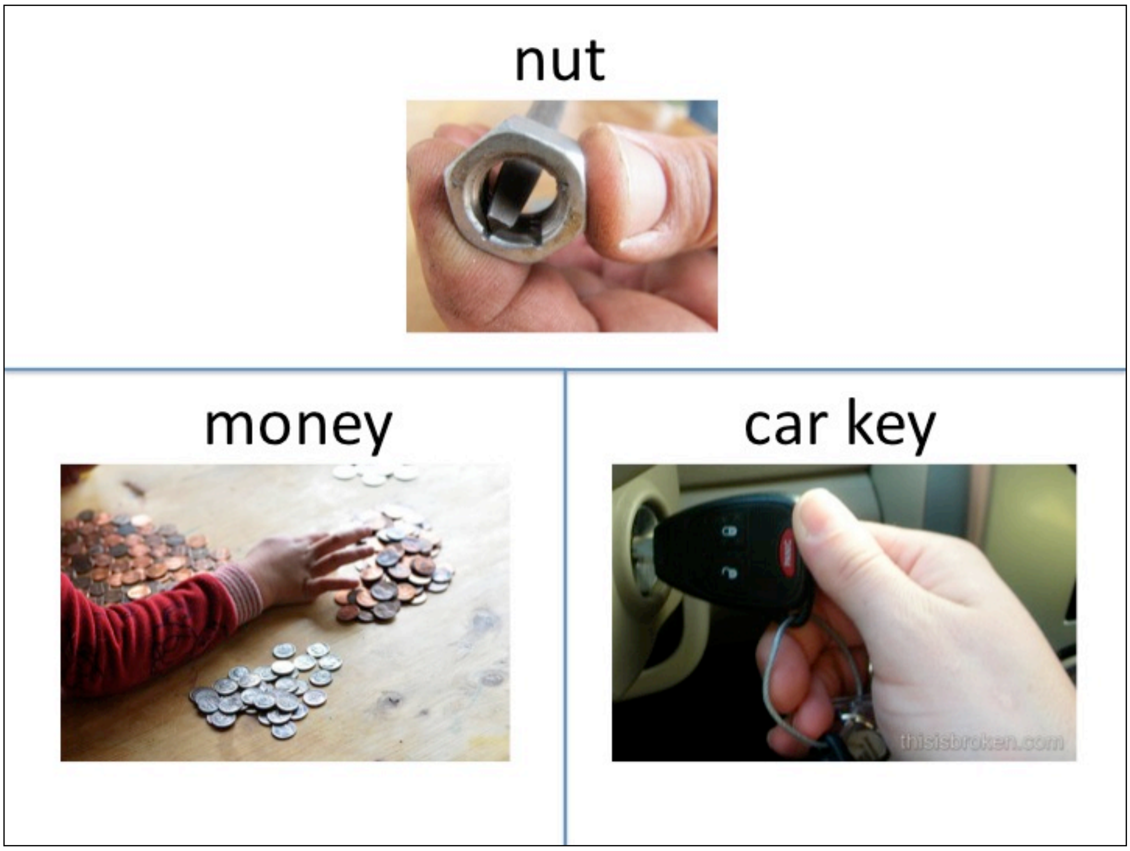


Figure P10. Format of the *nut* triad used in the context-rich condition (Experiments 2-8).

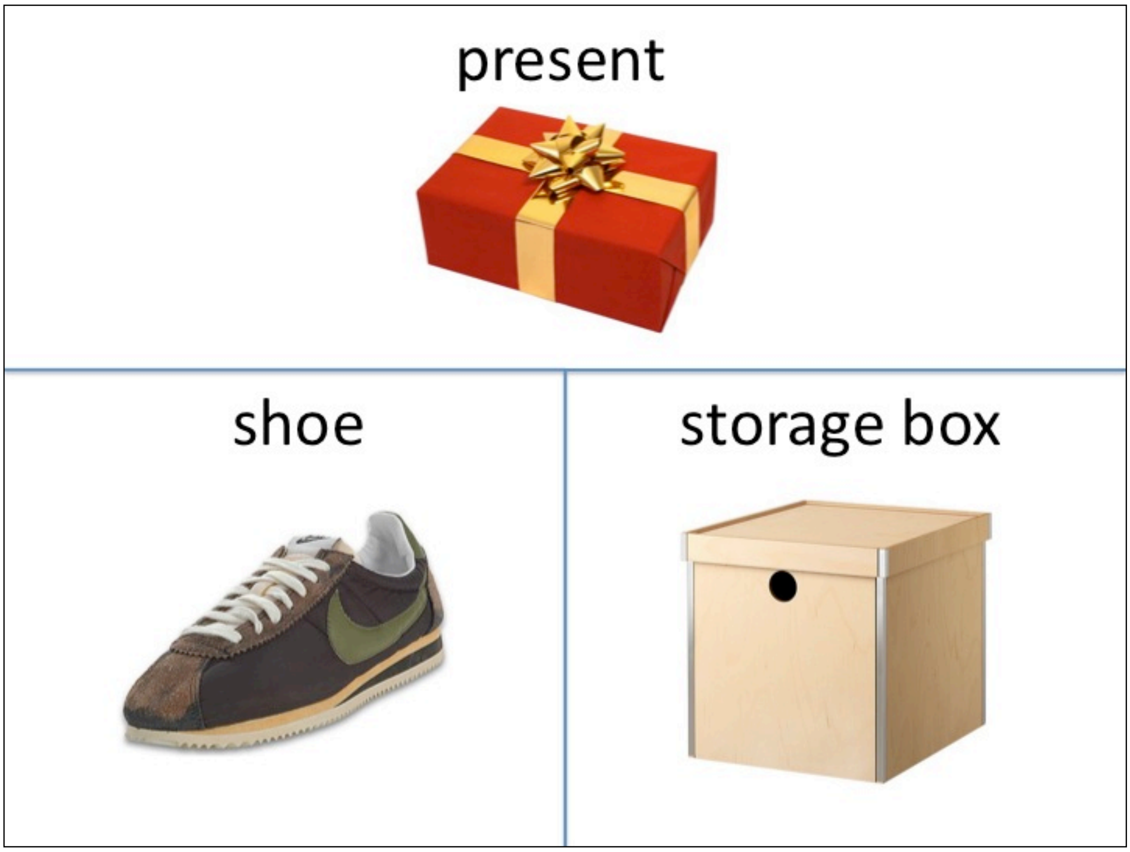


Figure P11. Format of the *present* triad used in the context-lean condition (Experiments 2-8).

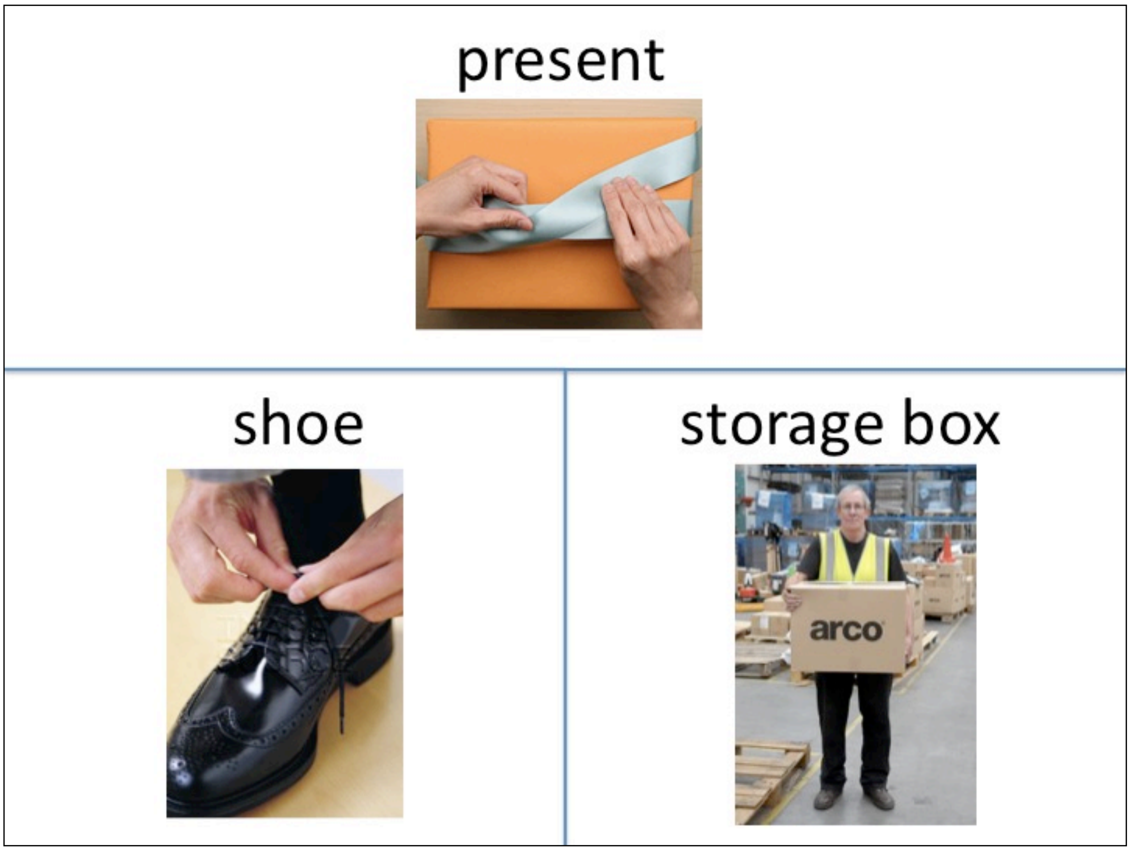


Figure P12. Format of the *present* triad used in the context-rich condition (Experiments 2-8).

Figure P13. Format of the *cocktail shaker* triad used in the context-lean condition (Experiments 2-8).

Figure P14. Format of the *cocktail shaker* triad used in the context-rich condition (Experiments 2-8).

Figure P15. Format of the *gun* triad used in the context-lean condition (Experiments 2-8).

Figure P16. Format of the *gun* triad used in the context-rich condition (Experiments 2-8).

Figure P17. Format of the *peppermill* triad used in the context-lean condition (Experiments 2-8).

Figure P18. Format of the *peppermill* triad used in the context-rich condition (Experiments 2-8).

Figure P19. Format of the *handbag* triad used in the context-lean condition (Experiments 2-8).

Figure P20. Format of the *handbag* triad used in the context-rich condition (Experiments 2-8).

FORM EC6: PARTICIPANT INFORMATION SHEET

Title of Research

Using an Online Questionnaire to Measure Object Typicality Ratings

Introduction

You are being invited to take part in a research study. Before you decide whether to do so, it is important that you understand the research that is being done and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask us anything that is not clear or for any further information you would like to help you make your decision. Please do take your time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of this study?

Previous research has shown that participants when asked to match objects together do so by making use of the taxonomic category that they come from. In addition to this, additional features such as action (Shipp, Vallée-Tourangeau & Anthony, in press) and thematic relations (Wisniewski & Bassok, 1997) when combined with taxonomic information make such items a better match. While Shipp et al. showed that items are a better match when they share both taxonomic information and a shared action relation, the possibility still remains that items were picked simply because they were better category members. For example participants might pick *drums* over *cello* as going better with *trumpet* simply because drums are more typical members of the category *instruments*. The aim of the current experiment is to collect ratings of typicality using a 10-point scale.

Do I have to take part?

It is completely up to you whether or not you decide to take part in this study. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw at any stage without giving a reason. A decision to withdraw at any time, or a decision not to take part at all, will not affect any treatment/care that you may receive (should this be relevant).

How long will my part in the study take?

If you decide to take part in this study, you will be involved in it for 15 – 25 minutes.

What will happen to me if I take part?

The first thing to happen is that you will be asked to sign the consent form if you agree to take part in this study. After this you will be presented with object names and asked to rate (on a scale of 1-10) how typical they are of the category they are drawn from. For example if you feel that *carrot* is very typical of the category *VEGETABLE* then you might give it a score of 10. If you feel that *carrot* is not at all typical then you might give it a score of 1.

What are the possible disadvantages, risks or side effects of taking part?

There are no disadvantages or side effects of taking part.

What are the possible benefits of taking part?

The gratitude of the researcher for assisting in the collection of data.

How will my taking part in this study be kept confidential?

Upon signing the consent form you will be asked to generate an anonymity number which all of your data will be kept under. No data will be stored under your own name and you will not be identifiable from your results.

What will happen to the results of the research study?

The results will be included within the PhD thesis of the principle investigator.

Who has reviewed this study?

This research has been reviewed by Dr Sue Anthony

Who can I contact if I have any questions?

If you would like further information or would like to discuss any details personally, please get in touch with me, in writing, by phone or by email: n.j.shipp@herts.ac.uk

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University Secretary and Registrar.

Thank you very much for reading this information and giving consideration to taking part in this study.

Appendix R: Consent form used in Experiments 3-9.

FORM EC3
CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS
The material contained in this form may be adapted for use in an alternative consent form, provided the principles of what is contained in the form are retained

I, the undersigned *[please give your name here*, *in BLOCK CAPITALS]*

…….
of *[please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

…..……… ..
hereby freely agree to take part in the study entitled *Using an Online Questionnaire to Measure Object Typicality Ratings*
…….

1 I confirm that I have been given a Participant Information Sheet (a copy of which is attached to this form) giving particulars of the study, including its aim(s), methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, and any plans for follow-up studies that might involve further approaches to participants. I have been given details of my involvement in the study. I have been told that in the event of any significant change to the aim(s) or design of the study I will be informed, and asked to renew my consent to participate in it.

2 I have been assured that I may withdraw from the study at any time without disadvantage or having to give a reason.

3 I have been given information about the risks of my suffering harm or adverse effects. I have been told about the aftercare and support that will be offered to me in the event of this happening, and I have been assured that all such aftercare or support would be provided at no cost to myself.

4 I have been told how information relating to me (data obtained in the course of the study, and data provided by me about myself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used.

5 I have been told what will be done if the study reveals that I have a medical condition which may have existed prior to the study, which I may or may not have been aware of, and which could affect the present or future health of myself or others. If this happens, I will be told about the condition in an appropriate manner and advised on follow-up action I should take. Information about the condition will be passed to my GP, and I may no longer be allowed to take part in the study.

6 I have been told that I may at some time in the future be contacted again in connection with this or another study.

Signature of
participant………………………………………………………………………………………Date…………………
……….

Signature of (principal) investigator: ………………………………………… Date:…………………

Appendix S: Debrief sheet used in Experiment 3.

Debrief

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to collect ratings of how typical objects are of their category. Research does show that objects do vary in how typical they are (Rosch, 1975; Rosch & Mervis, 1976). For example, an orange is more typical of the category *fruit* than a tomato. The aim of this experiment was to collect ratings of typicality for use in future experiments.

If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

FORM EC6: PARTICIPANT INFORMATION SHEET

Title of Research

Measuring the effects of instructional bias in tasks of categorical and similarity judgements.

Introduction

You are being invited to take part in a research study. Before you decide whether to do so, it is important that you understand the research that is being done and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask us anything that is not clear or for any further information you would like to help you make your decision. Please do take your time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of this study?

The aim of this study is measure the underlying assumptions of a well used cognitive task in the field of semantic memory. In this study you will see a Forced-Choice Triad task. In this task you will see a target image followed by two choice pictures and asked to match up the choice pictures with the target picture at the top.

Do I have to take part?

It is completely up to you whether or not you decide to take part in this study. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw at any stage without giving a reason. A decision to withdraw at any time, or a decision not to take part at all, will not affect any treatment/care that you may receive (should this be relevant).

How long will my part in the study take?

If you decide to take part in this study, you will be involved in it for approximately 10-15 minutes.

What will happen to me if I take part?

You will be shown a series of ‘triads’ consisting of a target image with two choice options. You will simply be asked to match one of the two choice options with the target image at the top as indicated by a left (a)/right (l) key press.

What are the possible disadvantages, risks or side effects of taking part?

There are no associated risks or side effects from taking part.

What are the possible benefits of taking part?

You will gain experience in participating in research and see a variety of the equipment and study procedures that the department can offer.

How will my taking part in this study be kept confidential?

You will be known to the experimenter only by an anonymity code and after completion of the project all confidential material will be destroyed.

What will happen to the results of the research study?

They will be used for the purposes of completing my PhD thesis.

Who has reviewed this study?

This research has been reviewed by Dr Sue Anthony and by the local ethics comitee.

Who can I contact if I have any questions?

If you would like further information or would like to discuss any details personally, please get in touch with me by email: n.j.shipp@herts.ac.uk

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University Secretary and Registrar.

Thank you very much for reading this information and giving consideration to taking part in this study.

DEBRIEFING

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate the underlying assumptions of a well-used cognitive task known as the Triad task. It is assumed that the triad task is measures categorical decisions however the possibility exists that participants simply pick the item that is most similar to the target, rather than the one that reflects a categorical choice. This is because research has shown that categorisation and similarity are closely linked and are often interdependent of each other (Goldstone, 1994; Rips, 1989; Sloman & Rips, 1998). In addition research has shown that even the nature of the instructions in such a task can alter how participants perform (Lin & Murphy, 2001). Therefore in the current experiment we are comparing the effects of the instructions to either select the choice item that “goes best”, “goes best to form a category” or “is most similar to the target” to measure the effects this has on performance. If participants are engaging in categorising the objects (as is assumed) then there should be no difference between selecting the item that goes best or goes best to form a category. In contrast if participants are selecting items based on overall similarity then there should be no difference between selecting the item that goes best or is most similar to the target.

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

FORM EC6: PARTICIPANT INFORMATION SHEET

Title of Research

Motor Routines in Everyday Object Categorising.

Introduction

You are being invited to take part in a research study. Before you decide whether to do so, it is important that you understand the research that is being done and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask us anything that is not clear or for any further information you would like to help you make your decision. Please do take your time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of this study?

The aim of this study is to look at what parts of a picture people look at when making categorical choices. In this study you will see a Forced-Choice Triad task. In this task you will see a target image followed by two choice pictures and asked to choose which of the bottom two pictures goes with the target image at the top. While doing this you will be asked to wear and fitted with eye tracking equipment so that it can be measured where on the images you spend most time looking.

Do I have to take part?

It is completely up to you whether or not you decide to take part in this study. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw at any stage without giving a reason. A decision to withdraw at any time, or a decision not to take part at all, will not affect any treatment/care that you may receive (should this be relevant).

How long will my part in the study take?

If you decide to take part in this study, you will be involved in it for approximately 30 minutes.

What will happen to me if I take part?

The first thing to happen is that you will be fitted with the mobile eye-tracking equipment to record where you are looking.

What are the possible disadvantages, risks or side effects of taking part?

There are no associated risks or side effects from taking part.

What are the possible benefits of taking part?

You will gain experience in participating in research and see a variety of the equipment and study procedures that the department can offer.

How will my taking part in this study be kept confidential?

You will be known to the experimenter only by an anonymity code and after completion of the project all confidential material will be destroyed.

What will happen to the results of the research study?

They will be used for the purposes of completing my PhD thesis.

Who has reviewed this study?

This research has been reviewed by Dr Sue Anthony.

Who can I contact if I have any questions?

If you would like further information or would like to discuss any details personally, please get in touch with me by email: n.j.shipp@herts.ac.uk

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University Secretary and Registrar.

Thank you very much for reading this information and giving consideration to taking part in this study.

DEBRIEFING

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate under what condition participants would group objects together based on a shared action interface rather than based on standard semantic knowledge such as how an object looks or its general function. In particular we wanted to look at whether people look at not just an object but how we interact with the objects, i.e. also looking at the hands and the body position. This is why you were fitted with eye-tracking equipment

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

Appendix X: Information sheet used in Experiment 6.

Information Sheet

I am a PhD student from the University of Hertfordshire undertaking a study into semantic knowledge.

If you agree to take part, you will be asked to complete a series of tasks involving everyday objects followed by completing a forced-choice task. The whole task should take no longer than 45 minutes.

As a participant you will be asked not to discuss the study with others until the study is completed in May 2012.

You will have an opportunity to ask questions now and at the end of the experiment.

Please note that any information you may supply today will only be used for the purposes outlined here. You may withdraw your assistance from this study at any time.

You may use the contact email address below, should any queries or concerns arise in the future.

Thank you for your participation.

Name of researcher: Nicholas Shipp

Email address: n.j.shipp@herts.ac.uk

Debriefing Sheet

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate whether prior actions related to direct object use influences how we perform in tasks based on categorisation of those objects. Research shows that our knowledge of objects is weighted in favour of how we use them.

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

Appendix Z: The 'checklist' task used in the action priming condition of Experiment 6.

The 'Checklist' Task

- ❑ Open the drink bottle and pour some into the plastic cup
- ❑ Open the hair wax
- ❑ Open the cookie jar and take out the contents
- ❑ Open the chewing gum and please pass me a piece
- ❑ Take a pencil and sign your name on a piece of paper
- ❑ Tie the shoelace on the shoe
- ❑ Open the book on any page and read the top line
- ❑ Use the hammer to bang the nail in on the wooden plank
- ❑ Plug the phone charger into the wall
- ❑ Connect the ipod to the phone charger
- ❑ Unlock the ipod and click on shuffle, tell me what the first song is that comes on
- ❑ Unlock the ipod and click on shuffle, tell me the first song that comes on
- ❑ Unravel the poster and tell me what it is of
- ❑ Use the ruler to draw a 20cm line on a piece of paper
- ❑ Open the handbag and take out the contents
- ❑ This is Timmy the bear, he is afraid of insects so can you please spray him with the insect repellent
- ❑ Demonstrate how you would use the cocktail shaker
- ❑ Place four pins into the notice board
- ❑ Open the leaflet that is on the table and tell me what it is of
- ❑ Open the food box and tell me what is inside
- ❑ Peel the banana and the orange
- ❑ Peel the grapes off the storks
- ❑ Play the maracas

Appendix Z: The 'checklist' task used in the action priming condition of Experiment 6.

- ❑ Open the wallet and tell me whose driving license is inside
- ❑ Open the jam jar
- ❑ Take the key and go out and lock the door, then unlock it and come back inside
- ❑ Insert the USB into the laptop
- ❑ On the calculator, work out 617 * 14
- ❑ Read out one of the headlines on the newspaper
- ❑ Light the candle
- ❑ Open the storage box and take out the contents
- ❑ Place the flower into the vase
- ❑ Use the paint to draw any line on the paper you wish
- ❑ Use the paperclip to clip some paper together
- ❑ Now clip the clothes peg onto it
- ❑ Use the set square to draw a 10cm line extending from the previous line you drew
- ❑ There is a screw in the plank of wood, use the screwdriver to screw it in a little further
- ❑ Grind some pepper into the bin
- ❑ Here is a mobile phone, dial the following number 01707 285051
- ❑ Pretend to pour water from the cup into the glass
- ❑ Now pretend to take a sip from each of the glass, the cup and the mug
- ❑ Open the present
- ❑ Timmy the bear is now worried that he does not smell nice, please spray some deodorant on him
- ❑ Use the elastic band to band the pencils together
- ❑ Grate some carrot into the bowl
- ❑ Please put some moisturiser into my hand

FORM EC6: PARTICIPANT INFORMATION SHEET

Title of Research

Manual Interference in Situated Simulation.

Introduction

You are being invited to take part in a research study. Before you decide whether to do so, it is important that you understand the research that is being done and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask us anything that is not clear or for any further information you would like to help you make your decision. Please do take your time to decide whether or not you wish to take part. Thank you for reading this.

What is the purpose of this study?

The aim of this study is measure the underlying assumptions of a well used cognitive task in the field of semantic memory. In this study you will see a Forced-Choice Triad task. In this task you will see a target image followed by two choice pictures and asked to match up the choice pictures with the target picture at the top. While engaging in this task you may be asked to perform a manual task at the same time.

Do I have to take part?

It is completely up to you whether or not you decide to take part in this study. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you have to complete it. You are free to withdraw at any stage without giving a reason. A decision to withdraw at any time, or a decision not to take part at all, will not affect any treatment/care that you may receive (should this be relevant).

How long will my part in the study take?

If you decide to take part in this study, you will be involved in it for approximately 10-15 minutes.

What will happen to me if I take part?

You will be shown a series of ‘triads’ consisting of a target image with two choice options. You will simply be asked to match one of the two choice options with the target image at the top as indicated by giving a verbal response of which object you feel goes best with the target. While doing this you may be asked to perform a manual task with your hands at the same time.

What are the possible disadvantages, risks or side effects of taking part?

There are no associated risks or side effects from taking part.

What are the possible benefits of taking part?

You will gain experience in participating in research and see a variety of the equipment and study procedures that the department can offer.

How will my taking part in this study be kept confidential?

You will be known to the experimenter only by an anonymity code and after completion of the project all confidential material will be destroyed.

What will happen to the results of the research study?

They will be used for the purposes of completing my PhD thesis.

Who has reviewed this study?

This research has been reviewed by Dr Sue Anthony and by the local ethics comitee.

Who can I contact if I have any questions?

If you would like further information or would like to discuss any details personally, please get in touch with me by email: n.j.shipp@herts.ac.uk

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University Secretary and Registrar.

Thank you very much for reading this information and giving consideration to taking part in this study.

DEBRIEFING

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate the theory behind what happens when participants engage in a triad task. It is believed that when we think about objects we mentally simulate them within a given situation (Barsalou, 1999, 2003, 2008). This simulation draws heavily on the motor cortex and causes a partial reactivation of the neurons that were active at the time of encountering the object. We believe that when participants engage in this task they simulate the objects, and then select the item that is most relevant to the target in terms of the physical action of using the object. Here we aimed to demonstrate that participants are in fact simulating the objects, by disrupting the simulation with a manual task. Should this result in lower action scores then this would provide support of disrupting the simulation.

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

Appendix AC: Example of the response sheet used in Experiment 8.

PSY1 Protocol Lab

Response sheet

Gender………………..

Age……………………

Group…………………..

Triad 1: Target Orange Choice………………………..

Reason for making this choice… what sort of things were you considering?

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Triad 2: Target Pencil Choice………………………..

Reason for making this choice… what sort of things were you considering?

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Protocol Analysis

Appendix AD shows the individual protocol scores and detailed analysis for each triad. The data reported below shows the results looking at the most commonly used reasons given in the protocols for when they picked the action or competitor item in the triads and across both conditions (lean vs rich). However, the tables below do not include the data from the "other" type of feature. Such reasons were removed from the overall data because they were not consistent and often reflected idiosyncratic choices from the individual participants. As such they are not reported in the tables below.

Table AD1

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Screwdriver Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (33.33%) Action (33.33%)	Perceptual (16.67%)	Mediating link (8.33%) Personal (8.33%)
	Taxonomic	Functional (34.88%)	Thematic (27.91%) Category (27.91%)	Perceptual (3.49%)
Rich	Action	Action (47.62%)	Functional (9.52%) Perceptual (9.52%)	Mediating link (4.76%) Same material (4.76%) Motion (4.76%) Autobiographical (4.76%)
	Taxonomic	Functional (33.33%) Thematic (33.33%)	Category (24.36%)	Perceptual (1.28%) Mediating link (1.28%) Personal (1.28%) Autobiographical (1.28%)

The data from Table AD1 above shows that participants were more likely to give shared actions as a reason when they selected the action item (*key*) with *screwdriver.* This occurred in both the context-lean and context-rich condition. In addition when they selected the action item they were also highly likely to report functional reasons such as “they both open things: and mediating links such as “they both go into holes”. However participants did report perceptual reasons for selecting the action item. This provides evidence for the notion put forward in Chapter 2 that participants focus on the perceptual characteristics evident between the target and action item as a result of design ergonomics. When selecting the taxonomic item (*hammer*) participants mostly relied on function (“both used in building and DIY”), thematic (“both found in a tool box”) and category (“both are DIY tools”) across both conditions in basing their choice. Other reasons were used such as perceptual and autobiographical but these were generally very few in number and accounted for less than 5% of their reasons.

Table AD2

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Drink Bottle Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (21.43%)	Functional (14.29%) Perceptual (14.29%) Personal (14.29%) Mediating link (14.29%)	-
	Taxonomic	Functional (82.54%)	Action (4.76%) Thematic (4.76%) Personal (4.76%)	-
Rich	Action	Action (53.13%)	Functional (12.50%)	Perceptual (6.25%) Personal (6.25%)
	Taxonomic	Functional (81.48%)	Thematic (5.56%)	Action (3.70%)

Table AD2 shows the percentage of reasons given in the *drink bottle* triad. It shows that in both the context-lean and context-rich condition participants were most likely to report shared actions for selecting the action choice (*jam*), particularly so in the context-rich condition. Participants also reported functional and perceptual reasons for selecting the action choice such as “they are both containers” and “they look more similar because they don’t have a handle”. When selecting the taxonomic choice (*mug*) participants were most likely to report functional reasons such as “they are used to drink from” but also reported thematic and action based reasons such as “you keep them in the kitchen” and “you raise them to your mouth to drink”. This shows that there may be some confounding aspects of the choice items in that they both share certain actions with the target. However it should be noted that in both conditions action protocols for the taxonomic item was less than 5% of the protocols.

Table AD3

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Rifle Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (32.14%)	Perceptual (21.43%)	Functional (17.86%)
	Taxonomic	Functional (31.08%)	Thematic (28.38%) Category (28.38%)	Perceptual (8.11%)
Rich	Action	Functional (26.83%)	Perceptual (24.39%)	Action (19.51%)
	Taxonomic	Functional (31.67%)	Category (30.00%)	Thematic (28.33%)

Table AD3 shows the percentage of reasons given in the *rifle* triad. It shows that when participants selected the action choice (*water pistol*) they did so because of the shared action and reported so in the protocols. Action reasons were most reported in the context-lean condition (32%). However while action was reported in the context-rich condition (19.51%) participants mostly reported functional and perceptual reasons for selecting *water pistol*. While the two objects do not share a function between them (one is a toy and one is a weapon) participants would often give them an ad hoc/goal related function in that they are “used to shoot people”. This supports the notion put forward from Experiment 4 in that participants use overall goals in grouping objects together in an “ad hoc” manner. The results further show that when selecting the taxonomic choice (*sword*) they did so commenting on function (“they are used to hurt/kill people”), thematic (“they are used on a battlefield”) and category reasons (“they are both weapons”).

Table AD4

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Book Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (50.00%)	Perceptual (14.71%) Mediating link (14.71%)	Functional (11.76%)
	Taxonomic	Functional (33.33%)	Personal (14.81%)	Mediating link (12.96)
Rich	Action	Action (37.04%)	Mediating link (22.22%)	Personal (14.81%)
	Taxonomic	Functional (62.00%)	Thematic (12.00%)	Category (6.00%) One can be the other (6.00%)

Table AD4 shows the percentage of reasons given in the *book* triad. It shows that when participants selected the action choice (*wallet*) they did so because of the shared actions between them in both the context-lean (50.00%) and the context-rich condition (33.33%). They also reported perceptual and mediating links between them such as “they look similar to each other” and “they both contain paper”. When participants selected the taxonomic choice (*iPod*) they did so mainly because of functional reasons such as “they keep you entertained”. Participants also reported personal reasons along with thematic reasons (“you take them on holiday with you”) and also commenting that “you can read books on an ipod” suggesting that one can be the other.

Table AD5

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Fax Machine Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Mediating link (41.82%)	Functional (23.64%)	Thematic (14.55%)
	Taxonomic	Functional (55.56%)	Perceptual (19.44%)	Mediating link (8.33%)

Rich	Action	Functional (28.79%) Mediating link (28.79%)	Perceptual (13.64%)	Thematic (9.09%)
	Taxonomic	Functional (52.38%)	Mediating link (19.05%)	One can be the other (7.14%)

Table AD5 shows the percentage of reasons given in the *fax machine* triad. Despite the choice results showing that participants were more likely to select the action choice (*photocopier*) they did not do so because of shared actions between them. Action reasons accounted for only 1.28% of the protocols in the context-lean condition and were not reported by any participants in the context-rich condition. Participants were more likely to report functional, mediating links and thematic reasons such as "you can use them to copy documents", "they both use paper" and "they are found in an office". When participants selected the taxonomic choice (*telephone*) they did so because of functional reasons ("you use them to communicate with people") and mediating links ("they both have a phone and buttons").

Table AD6

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Computer Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (20.00%)	Functional (13.33%) Personal (13.33%) Mediating link (13.33%)	Thematic (6.67%) Motion (6.67%) Autobiographical (6.67%)
	Taxonomic	Mediating link (64.94%)	Category (20.78%)	Functional (9.09%)
Rich	Action	Action (69.23%)	Functional (7.69%) Perceptual (7.69%) Thematic (7.69%)	-
	Taxonomic	Mediating link (51.72%)	Thematic (20.69%)	Category (17.24%)

Table AD6 shows the percentage of reasons given in the *computer* triad. Participants were most likely to select the taxonomic choice (*printer*), however when participants selected the action item (*piano*) they gave action reasons in their protocols. Participants also gave functional ("they play music"), mediating links ("they both have keys") and thematic reasons ("you find them both in a school"). When participants selected the taxonomic choice they do so because of mediating links ("you need paper to print on them"), category ("both electrical equipment") and thematic reasons ("you find them in an office").

Table AD7

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Calculator Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Perceptual (33.33%)	One can be the other (24.44%)	Mediating link (13.33%)
	Taxonomic	Thematic (76.47%)	Functional (13.73%)	Perceptual (1.96%) Category (1.96%) Personal (1.96%) Autobiographical (1.96%)
Rich	Action	One can be the other (47.22%)	Action (13.89%)	Category (11.11%)
	Taxonomic	Thematic (53.85%)	Mediating link (23.08%)	Same material (15.38%)

Table AD7 shows the percentage of reasons given in the *calculator* triad. The results show that when participants selected the action choice (*mobile phone*) they only reported the shared actions between them in the context-rich condition. The shared actions in the context-lean condition comprised of only 6.67% of protocols and were more likely to base their choices in perceptual reasons such as "they look similar and have a similar shape". In the context-rich condition participants reported that "mobile phones have a calculator on them" and therefore claimed that one can be the other. The strongest reason for basing selection of the taxonomic choice (*set square*) were thematic with participants reporting that "they are both used in maths classes".

Table AD8

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Paperclip Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (84.91%)	Perceptual (9.43%)	Thematic (3.77%)
	Taxonomic	Category (42.86%)	Thematic (31.43%)	Mediating link (5.71%) Autobiographical (5.71%)
Rich	Action	Functional (80.65%)	Action (9.68%)	Perceptual (6.45%)
	Taxonomic	Thematic (60.00%)	Category (30.00%)	Functional (10.00%)

Table AD8 shows the percentage of reasons given in the *paperclip* triad. When participants selected the action choice (*clothes peg*) they did so mainly because of functional reasons commenting that they “hold things together”. Participants also reported perceptual reasons stating that they “look similar”. Overall action accounted for very few of the protocols with no one reporting such in the context-lean condition and accounting for only 9.68% of protocols in the context-rich condition. When participants selected the taxonomic choice (*ruler*) they main reported thematic and category reasons stating that they are “both used in mathematics/maths classes” and are “both stationary”.

Table AD9

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Deodorant Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Category (29.27%)	Functional (21.95%)	Perceptual (17.07%)
	Taxonomic	Functional (38.18%)	Thematic (27.27%)	Category (16.36%)
Rich	Action	Functional (29.63%)	Action (22.22%)	Perceptual (18.52%)
	Taxonomic	Thematic (31.25%)	Category (18.75%)	Functional (6.25%) Perceptual (6.25%)

Table AD9 shows the percentage of reasons given in the *deodorant* triad. When participants selected the action choice (*insect repellent*) they reported action responses more in the action-rich context (22.22%) than in the context-lean (12.20%). In the context-lean condition participants were more likely to report functional and perceptual reasons such as “both keep something away” and “both look similar”. In addition participants would use category reasons in the context-lean condition such as “both are sprays”. When participants selected the taxonomic choice (*hair gel*) they mostly reported functional (“both make you attractive”), thematic (“you find them in the bathroom) and category reasons (”they’re grooming products).

Table AD10

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Knife Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (50.00%)	Perceptual (41.67%)	Thematic (2.78%)
	Taxonomic	Thematic (45.24%)	Category (23.81%)	Functional (19.05%)
Rich	Action	Functional (59.46%)	Perceptual (24.32%)	Action (10.81%)
	Taxonomic	Thematic (77.78%)	Category (22.22%)	-

Table AD10 shows the percentage of reasons given in the *knife* triad. When participants selected the action choice (*saw*) very few participants reported the shared actions between them as a reason for doing so. In the context-rich condition action protocols only accounted for 10.81% of responses, and only 1.39% in the context-lean condition. Participants were most likely to report functional and perceptual reasons such as “they are both used to cut things” and “they both look sharp”. When participants selected the taxonomic choice (*ladle*) they reported thematic (“you find them in a kitchen”) and category reasons (“both are kitchen utensils”).

Table AD11

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Pencil Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Perceptual (34.85%)	Functional (28.03%)	Action (14.39%)
	Taxonomic	Thematic (25.00%)	Functional (12.50%) Action (12.50%)	-

			Category (12.50%)	
			Personal (12.50%)	
Rich	Action	Functional (46.30%)	Thematic (14.81%)	Action (13.89%)
	Taxonomic	Thematic (25.00%)	Category (12.50%) Personal (12.50%) Autobiographical (12.50%)	-

Table AD11 shows the percentage of reasons given in the *pencil* triad. While action reasons were used in selecting the action choice (*paintbrush*) in both conditions it was not the primary reason for select. Participants favoured functional ("you can draw with both"), perceptual ("they look similar") and thematic reasons ("they are used in art"). When participants selected the taxonomic choice (*elastic band*) they mainly reported thematic reasons such as "you find them in an office" or "can be found in a stationary cupboard". Participants who selected the taxonomic item also reported functional reasons ("elastic bands hold pencils together"), category ("both are stationary"), and action reasons ("you tie the elastic bands around pencils").

Table AD12

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Glass Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (65.71%)	Action (8.57%) Perceptual (8.57%)	Thematic (5.71%) Same material (5.71%) Personal (5.71%)
	Taxonomic	Functional (33.33%)	Perceptual (30.30%) Same material (30.30%)	Action (1.52%) Thematic (1.52%) Personal (1.52% Motion (1.52%)
Rich	Action	Functional (63.46%)	Action (9.62%)	Perceptual (5.77%) Thematic (5.77%)
	Taxonomic	Same material (33.96%)	Functional (24.53%)	Perceptual (15.09%)

Table AD12 shows the percentage of reasons given in the *glass* triad. Participants who selected the action choice (*cup*) did report action reasons for doing so, but were more likely to use function to group them together ("you can drink out of both of them"). When participants selected the taxonomic choice (*jug*) participants reported functional ("you pour the jug into the glass"), same material ("made of glass"), and perceptual reasons ("they're see through").

Table AD13

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Spatula Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Thematic (38.89%)	Functional (29.63)	Perceptual (9.26%)
	Taxonomic	Category (37.14%)	Functional (20.00%) Thematic (20.00%)	Perceptual (14.29%)
Rich	Action	Thematic (41.51%)	Functional (37.74%)	Personal (3.77%)
	Taxonomic	Category (36.71%)	Thematic (17.02%)	Functional (10.64%)

Table AD13 shows the percentage of reasons given in the *spatula* triad. When participants selected the action item (*saucepan*) they did not because of the shared actions between the objects. Participants in the context-rich condition did not report any action based protocols, and those in the context-lean condition only accounted for 1.85% of protocols. Rather when the action choice was selected it was mainly done because of thematic ("you find them in the kitchen") and functional reasons ("you cook with them"). When participants selected the taxonomic item (*can opener*) they reported category ("both are kitchen utensils"), functional ("you cook with them") and thematic reasons ("you find them in the kitchen").

Table AD14

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Pin Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (25.00%)	Same material (16.67%)	Mediating link (8.33%) Motion (8.33%)

				Word feature (8.33%) Autobiographical (8.33%)
	Taxonomic	Functional (45.26%)	Perceptual (40.00%)	Same material (5.36%)
Rich	Action	Action (35.71%)	Same material (14.29%) Word feature (14.29%)	Perceptual (7.14%) One can be the other (7.14%) Autobiographical (7.14%)
	Taxonomic	Functional (41.51%)	Perceptual (33.02%)	Action (11.32%)

Table AD14 shows the percentage of reasons given in the *pin* triad. When participants selected the action choice (*plug*) they mostly reported action protocols. Participants also reported that the object were made of the same materials along with word-based features ("both begin with the letter p"). When participants selected the taxonomic choice (*screw*) they mostly reported functional ("they hold things together") and perceptual ("they are small"). However some participants in the context-rich condition did report action as a method for selecting the taxonomic item. However the protocols referred to how to pick up the objects rather than use them with comments such as ("you pick them up in your fingers").

Table AD15

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Ketchup Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Perceptual (24.36%)	Same material (21.79%)	Functional (16.67%)
	Taxonomic	Personal (33.33%)	Functional (23.81%)	Thematic (19.05%)
Rich	Action	Perceptual (35.38%)	Functional (18.46%)	Category (12.31%)
	Taxonomic	Personal (47.62%)	Functional (11.90%) Thematic (11.90%)	Mediating link (4.76%) Category (4.76%)

Table AD15 shows the percentage of reasons given in the *ketchup* triad. The results show that when participants selected the action choice (*vinegar*) they did not do so because of the shared actions between them. Action protocols accounted for only 2.56% of protocols in the context-lean condition and 3.08% in the context-rich. When they did select the action choice mainly because of perceptual ("the bottles look the same"), functional ("they make food taste better"), thematic ("they're both in the kitchen") and because they are made of the same material ("they are both made of vinegar"). When participants selected the taxonomic choice (*salt*) they mainly did so because of personal reasons such as "I prefer salt with ketchup on my chips" or "I don't like vinegar". They also reported functional ("they make food taste better"), thematic ("you find them in the kitchen"), category reasons ("they're both condiments") and because of mediating links ("you put them on chips").

Table AD16

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Orange Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (21.15%)	Personal (19.23%)	Category (15.38%) Biological (15.38%)
	Taxonomic	Perceptual (71.05%)	Biological (13.16%) Personal (13.16%)	Category (2.63%)
Rich	Action	Action (58.33%)	Perceptual (8.33%) Thematic (8.33%) Biological (8.33%) Personal (8.33%)	Category (5.56%)
	Taxonomic	Perceptual (28.57%) Biological (28.57%)	Category (21.43%)	Personal (14.29%)

Table AD16 shows the percentage of reasons given in the *orange* triad. When participants selected the action choice (*banana*) they did so primarily because of the shared actions between them, particularly so in the context rich condition where action accounted for more than half (58.33%) of the protocols. In addition when selecting the action choice participants also reported personal ("I prefer bananas/I don't like strawberries"), category ("both are fruit"), thematic ("you keep them in a fruit bowl") and biological reasons ("they both grow on trees"). When participants selected the taxonomic choice (*strawberry*) they mainly reported perceptual reasons such as "they are both small and round". In addition participants reported biological ("both have seeds"), personal ("I prefer strawberries to bananas") and category reasons ("both are fruit"). In this triad participants rarely reported category reasons on their own, but often used this in conjunction with other reasons. Particularly because as all three items in the triad are fruit such reasoning cannot be used on its own to distinguish between the selected choice and its counterpart.

Table AD17

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the DVD Player Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (38.46%)	Mediating link (30.77%)	Action (12.82%)
	Taxonomic	Mediating link (75.51%)	Perceptual (6.12%) Personal (6.12%)	Functional (4.08%)
Rich	Action	Mediating link (62.16%)	Functional (16.22%)	Perceptual (13.51%)
	Taxonomic	Mediating link (42.86%)	Thematic (28.57%)	Personal (14.29%) Autobiographical (14.29%)

Table AD17 shows the percentage of reasons given in the *DVD player* triad. The results show that action reasons were not common when participants selected the action choice (*CD player*). Participants favoured functional and mediating links between the objects such as "they play disks" and "you need disks to work them". While action was reported in the context-lean condition (12.82%) this dropped in the context-rich condition (2.70%) suggesting that the context does not increase saliency towards the shared actions. When participants selected the taxonomic choice (*television*) they mainly reported mediating links such as "you use the tv and the dvd player to watch films". Participants also reported functional ("you use them to watch things") and thematic reasons ("they're in the living room").

Table AD18

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Bed Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (62.82%)	Perceptual (25.64%)	Personal (3.85%)
	Taxonomic	Thematic (77.27%)	Category (9.09%) Personal (9.09%)	Functional (4.55%)
Rich	Action	Functional (33.33%)	Action (20.51%) Thematic (20.51%)	Category (7.69%)
	Taxonomic	Thematic (80.00%)	-	-

Table AD18 shows the percentage of reasons given in the *bed* triad. The results show that participants reported action based reasons for selecting the action choice (*sofa*) in the context-rich condition, but not in the context-lean condition (0%). In the context-lean condition they selected *sofa* mainly because of functional reasons such as "they provide somewhere to sit and relax" along with perceptual ("the sofa and the bed look comfy") and personal reasons ("I like to have naps on the sofa"). When participants selected the taxonomic choice (*wardrobe*) they did so because of shared thematic reasons. Participants said that "you find them in the bedroom" and such comments dominated more than three quarters of their protocols in both the context-lean and context-rich condition.

Table AD19

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Leaflet Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (55.56%)	Perceptual (16.67%)	One can be the other (11.11%)
	Taxonomic	Functional (56.90%)	Perceptual (27.59%)	Personal (5.17%)
Rich	Action	Action (53.85%)	Functional (30.77%)	Perceptual (7.69%) Same material (7.69%)
	Taxonomic	Functional (59.26%)	Perceptual (25.93%)	Autobiographical (11.11%)

Table AD19 shows the percentage of reasons given in the *leaflet* triad. The table shows that when participants selected the action choice (*newspaper*) they mainly reported action as the reason for doing so in the context-rich condition, but not in the context-lean where action only accounted for 5.56% of the protocols. In the context-lean condition functional reasons accounted for the most protocols given with comments such as “they both convey important information” but also reported perceptual reasons (“the newspaper looks like a big leaflet/the leaflet looks like a small newspaper”) and stated that one can be the other (“a leaflet can show the news”). When participants selected the taxonomic choice (*poster*) they primarily did so because of shared functional information such as “both show important information” but also commented on shared perceptual features between them (“posters and leaflets are both very colourful”).

Table AD20

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Taxonomic Choices in the Spade Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (54.84%)	Perceptual (19.35%)	Autobiographical (12.50%)
	Taxonomic	Functional (25.00%) Category (25.00%)	Perceptual (12.50%) Thematic (12.50%) Autobiographical (12.50%)	-
Rich	Action	Functional (53.85%)	Perceptual (32.69%)	One can be the other (5.77%)
	Taxonomic	-	-	-

Note. There were no reasons provided for *shears* in the context-rich condition because no participant selected this in the triads.

Table AD20 shows the percentage of reasons given in the *spade* triad. Analysis of the protocols showed that when participants selected the action choice (trowel) in the triads they did not do so because of the shared actions. Action protocols accounted for only 3.23% in the context-lean and 1.92% in the context-rich conditions. Rather when they did select it they did so because of shared functions (“you can dig with them both”), perceptual (“a trowel is a mini spade”) and autobiographical reasons (“I remember helping out my dad win the garden when I was younger”). In the present experiment no participant selected the taxonomic choice (*shears*) in the context-rich condition and as such no protocol data exists for this choice. However when they did select it in the context-lean they commented on the shared functions (“you use them to dig and make the garden look nice”), perceptual (“they look sharp/they look shiny”), thematic (“you find them in the garden shed”) and autobiographical.

Table AD21

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Clarinet Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (48.84%)	Perceptual (11.63%)	Thematic (9.30%) Mediating link (9.30%)
	Perceptual	Perceptual (72.34%)	Same material (12.77%)	Functional (2.13%) Action (2.13%) Thematic (2.13%) Category (2.13%) Autobiographical (2.13%)
Rich	Action	Action (88.57%)	Mediating link (5.71%)	Perceptual (2.86%) Thematic (2.86%)
	Perceptual	Personal (66.67%)	Autobiographical (33.33%)	-

Table AD21 shows the percentage of reasons given in the *clarinet* triad. The results show that when participants selected the action choice (*balloon*) they reported action as being the primary reason for doing so in both the context-lean and rich conditions, with higher responses in the latter. Participants also reported perceptual reasons (“they both come to a point”), mediating links (“they both need air to work”) and thematic reasons (“you might find both at a party”). When participants selected the perceptual choice (*wooden spoon*) they mainly reported the shared perceptual features (“they are both long and thin”) in both contexts. Participants also reported autobiographical responses and reported that they were made of the same material.

Table AD22

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Cocktail Shaker Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (50.00%)	Perceptual (22.97%)	Thematic (16.22%)
	Perceptual	Perceptual (50.00%)	Functional (33.33%)	Mediating link (5.56%) Personal (5.56%)
Rich	Action	Action (85.71%)	Perceptual (5.71%) Autobiographical (5.51%)	-
	Perceptual	Functional (60.00%)	Perceptual (20.00%) Same material (20.00%)	-

Table AD22 shows the percentage of reasons given in the *cocktail shaker* triad. The table shows that when participants selected the action choice (*maracas*) they mainly reported action as being the reason for doing so in both contexts, with higher responses in the context-rich condition. Participants also reported perceptual reasons for selecting the action choice, but these were not related to the visual aspects of the objects but participants reported that "both objects are noisy" and "both make a loud noise". When participants selected the perceptual choice (*vase*) in the context-lean condition they mainly reported perceptual reasons ("they both have the same shape") followed by functional reasons ("they both contain things"). This pattern was reversed in the context-rich condition where functional reasons accounted for the majority of responses.

Table AD23

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Gun Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action (48.78%)	Perceptual (21.95%)	Functional (9.76%)
	Perceptual	Perceptual (71.70%)	Action (15.09%)	Functional (3.77%)

Rich	Action	Action (70.00%)	Perceptual (10.00%)	Autobiographical (6.67%)
	Perceptual	Perceptual (78.57%)	Action (7.14%) Thematic (7.14%)	-

Table AD23 shows the percentage of reasons given in the *gun* triad. The results hear appear confounded. When participants selected the action choice (*cleaning spray*) they mainly reported action as being the primary reason for doing so. However they also reported perceptual reasons in that some participants believed they looked similar because of the 'trigger' mechanism of operating both. In addition when participants selected the perceptual choice (*hairdryer*) they mainly reported perceptual reasons for doing so ("they both look similar"), but also reported action based on the general grip of the object such as "you have to hold them by the handle". Therefore the *gun* triad is confounded in that participants reported both reasons for selecting both choices.

Table AD24

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Peppermill Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Personal (40.00%)	Action (30.00%)	Functional (10.00%) Thematic (10.00%)
	Perceptual	Perceptual (61.43%)	Functional (12.86%)	Mediating link (5.71%)
Rich	Action	Action (84.62%)	-	-
	Perceptual	Action (14.29%)	Perceptual (9.52%) Functional (9.52%)	Word feature (4.76%)

Table AD24 shows the percentage of reasons given in the *peppermill* triad. The results show that when participants selected the action choice (*hair wax*) they did so because of the shared actions between them ("you have to hold the bottom and twist the top") in both contexts, but primarily in the context-rich condition. In the condition-lean condition participants were most likely to report personal reasons, often selecting the action choice simply because they preferred it ("I prefer hair wax") or having never used the other ("I've never used spray-paint"). When participants selected the perceptual choice (*spray-paint*) they did so reporting different reasons in both contexts. In the context-lean condition they reported perceptual reasons ("they are both tall and thin") and functional reasons ("they release stuff"). In the context-rich condition participants mainly reported action based on the grip of the objects ("can be picked up in one hand") along with perceptual and functional reasons.

Table AD25

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Handbag Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (66.67%)	Action (9.09%) Perceptual (9.09%)	-
	Perceptual	Perceptual (85.42%)	Personal (4.17%)	Functional (2.08%) Action (2.08%)
Rich	Action	Functional (60.53%)	Action (26.52%)	Autobiographical (5.26%)
	Perceptual	-	-	-

Note. There were no reasons provided for *grater* in the context-rich condition because no participant selected this in the triads.

Table AD25 shows the percentage of reasons given in the *handbag* triad. the table shows that when participants selected the action choice (*cookie jar*) they did not do so because of the shared actions. While participants did report actions they were much more likely to report functional reasons such as "they both contain things". When participants selected the perceptual choice (*grater*) in the context-lean condition they mainly reported the shared perceptual reasons for doing so ("they look similar and both have a handle").

Table AD26

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Axe Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Action/Motion (48.48%)	Functional (21.21%)	Perceptual (9.09%) Personal (9.09%)
	Perceptual	Perceptual (34.33%)	Same material (28.36%)	Functional (21.21%)

Rich	Action	Action/Motion (66.66%)	Functional (16.67%)	Perceptual (5.56%) Thematic (5.56%)
	Perceptual	Perceptual (30.00%)	Functional (20.00%)	Category (15.00%)

Table AD26 shows the percentage of reasons given in the *axe* triad. For the coding of the protocols, separate protocols were given based on the action of the object and the motion (e.g. often swinging objects). Within the *axe* triad these represent the same thing because it was designed with that in mind (that the object requires holding with two hands and swinging). Therefore for the current protocols here the action and motion protocols were combined to give an overall action/motion score. The results show that when participants selected the action choice (*tennis racket*) they mainly reported such action/motion reasons which accounted for the majority of their reasons in both contexts. Participants also reported functional reasons ("you use them to hit something") and perceptual ("they make a loud noise when they hit their target"). When participants selected the perceptual choice (*cane*) they reported the shared perceptual characteristics for doing so claiming that the objects "look similar". Participants also reported functional reasons ("you can hit something with it"), said that both were the same material and also stated that both were the same category, particularly that "both can be used as weapons".

Table AD27

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Baseball Bat Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Functional (34.62%)	Action/Motion (20.52%)	Perceptual (19.23%)
	Perceptual	Perceptual (50.00%)	Functional (13.33%)	Thematic (6.67%) Mediating link (6.67%)
Rich	Action	Action/Motion (38.15%)	Perceptual (16.49%)	Functional (13.40%)
	Perceptual	Thematic (25.00%) Autobiographical (25.00%)	Perceptual (12.50%)	-

Table AD27 shows the percentage of reasons given in the *baseball bat* triad. As with the *axe* triad the action and motion scores were combined to provide an overall score. When participants selected the action choice (*mace*) in the context-lean condition some participants did report the shared actions as being the reason to do so, but the majority of participants selected the shared functions between the items as their primary reason ("you use them to hit something/both can be used as weapons"). The majority of participants in the context-rich condition selected the action choice because of the shared actions, but also stated perceptual ("both are long") and because of functional reasons. When participants selected the perceptual choice (*wrapping paper*) in the context-lean condition they mainly did so because of the shared perceptual characteristics between them. However in the context-rich condition perceptual reasons did not account for the majority of responses, rather participants stated thematic ("you could wrap a baseball bat and give it as a Christmas present") and autobiographical ("I remember a birthday party where my parents gave me a baseball bat").

Table AD28

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the USB Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Category (35.44%)	Mediating link (29.11%)	Functional (10.13%)
	Perceptual	Perceptual (55.55%)	Action (10.00%) Personal (10.00%)	Functional (5.00%)
Rich	Action	Action (37.72%)	Category (26.52%)	Functional (9.65%) Mediating link (9.65%)
	Perceptual	-	-	-

Note. There were no reasons provided for *chewing gum* in the context-rich condition because no participant selected this in the triads.

Table AD28 shows the percentage of reasons given in the *USB* triad. When participants selected the action choice (*phone charger*) the shared actions only became a dominant reason to do so in the context-rich condition. Action did not account for a lot of protocols in the context-lean condition (8.86%). Rather participants selected the action choice mainly because of shared category information ("both are electronics") and mediating links between them ("they can both connect to a computer"). This means that this triad is problematic as they were designed with the intention of not sharing category information, and yet participants have assigned them a superordinate category membership. When participants selected the perceptual choice (*chewing gum*) in the context-lean condition they mainly reported the shared perceptual characteristics, but also reported action ("you can easily pick them up"), personal reasons ("I keep my USB and chewing gum in my bag") and functional reasons ("chewing gum helps while I'm doing my coursework").

Table AD29

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Nut Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	Mediating link (29.41%)	Action (23.53%)	Perceptual (17.65%)
	Perceptual	Perceptual (72.73%)	Same material (21.21%)	Functional (1.53%)
Rich	Action	Mediating link (22.22%)	Functional (18.52%) Action (18.52%)	Thematic (11.11%) Same material (11.11%)
	Perceptual	Perceptual (46.33%)	Same material (36.00%)	Thematic (2.67%)

Table AD29 shows the percentage of reasons given in the *nut* triad. when participants selected the action choice (*car key*) they did report action as being a reason for doing so in both contexts, but were more likely to report mediating links between the items stating that "both are related to cars" or "you find them both in cars". When participants selected the perceptual choice (*money*) the majority of their reasons was because of the shared perceptual characteristics ("both are small and round") and the fact that they are made of the same material ("both are made of metal"). The majority of participants reported these in conjunction with one another and were highly likely to give both reasons within their protocols.

Table AD30

The Top Features Used Accounting for the Highest Percentage of Protocols Given for the Action and Perceptual Choices in the Present Triad

Context	Choice	Top Three Features Used		
		1	2	3
Lean	Action	One can be the other (54.55%)	Perceptual (15.15%)	Autobiographical (12.12%)
	Perceptual	Perceptual (38.33%)	Functional (26.67%)	One can be the other (23.33%)
Rich	Action	One can be the other (42.86%)	Action (25.00%)	Autobiographical (7.14%)
	Perceptual	One can be the other (27.27%)	Perceptual (24.24%)	Functional (22.73%)

Table AD30 shows the percentage of reasons given in the *present* triad. When participants selected the action choice (*shoe*) they only reported the shared action in the context-rich condition, but this was not the primary reason for doing so. Participants mostly reported that one can be the other, i.e. “you can give shoes as a present”. When participants selected the perceptual choice (*storage box*) they reported the shared perceptual features between them (“a present box looks like a storage box”), functional reasons (“you can keep things like presents in a storage box”) and also reported that one can be the other (“presents come in boxes”).

Information Sheet

I am a PhD student from the University of Hertfordshire undertaking a study into semantic knowledge. Semantic knowledge is one form of long term memory which stores information regarding the world around us and objects which exist in that world.

If you agree to take part, you will be asked to complete a triad choice task. The whole task should take no longer than 15 minutes.

As a participant you will be asked not to discuss the study with others until the study is completed in March 2012.

You will have an opportunity to ask questions now and at the end of the experiment.

Please note that any information you may supply today will only be used for the purposes outlined here. You may withdraw your assistance from this study at any time.

You may use the contact email address below, should any queries or concerns arise in the future.

Thank you for your participation.

Name of researcher: Nicholas Shipp

Email address: n.j.shipp@herts.ac.uk

Ethics protocol number: PSY/04/11/NS

Appendix AF: Debrief sheet used in Experiment 9.

Debriefing Sheet

Thank you very much for your time and co-operation in taking part in this experiment.

The purpose of this study was to investigate whether knowledge of action influence how we select objects as being in the same category. Research shows that our knowledge of objects is weighted in favour of how we use them.

Once again thank you for participating in this study. If you have any further questions or would like to hear of the outcome of this study, please use the contact details below.

Name of Researcher: Nicholas Shipp

Contact email address: n.j.shipp@herts.ac.uk

Appendix AG: Context-lean similarity task used in Experiment 9.

INSTRUCTIONS

The task here is a similarity judgement task whereby you have to indicate on a scale of 1 to 7 how similar two items are. Below is an example of how the scale will be set out;

1	2	3	4	5	6	7

A score of 1 means that the two items are not at all similar to each other. A score of 7 means that they are highly similar to each other.

Each page of this booklet has at the top a picture of an object (the target object). Beneath this you will see two further objects, each with its own scale of 1 to 7. Your task is to compare how similar each of these objects is to the target object.

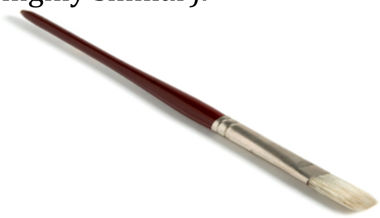
Please turn the page to begin the experiment.

PENCIL

How similar on a scale of 1 to 7 is *ELASTIC BAND* to *PENCIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PAINTBRUSH* to *PENCIL* (1 = not at all similar, 7 = highly similar).



1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

SCREWDRIVER

How similar on a scale of 1 to 7 is *HAMMER* to *SCREWDRIVER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *KEY* to *SCREWDRIVER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

AXE

How similar on a scale of 1 to 7 is *CANE* to *AXE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TENNIS RACKET* to *AXE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

GLASS

How similar on a scale of 1 to 7 is *JUG* to *GLASS* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *CUP* to *GLASS* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

DRINK BOTTLE

How similar on a scale of 1 to 7 is *MUG* to *DRINK BOTTLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *JAM* to *DRINK BOTTLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

BASEBALL BAT

How similar on a scale of 1 to 7 is *WRAPPING PAPER* to *BASEBALL BAT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *MACE* to *BASEBALL BAT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

SPATULA

How similar on a scale of 1 to 7 is *CAN OPENER* to *SPATULA* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *SAUCEPAN* to *SPATULA* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

RIFLE

How similar on a scale of 1 to 7 is *SWORD* to *RIFLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *WATER PISTOL* to *RIFLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

USB PEN

How similar on a scale of 1 to 7 is *CHEWING GUM* to *USB PEN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PHONE CHARGER* to *USB PEN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

PIN

How similar on a scale of 1 to 7 is *SCREW* to *PIN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PLUG* to *PIN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

COMPUTER

How similar on a scale of 1 to 7 is *PRINTER* to *COMPUTER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PIANO* to *COMPUTER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

CLARINET

How similar on a scale of 1 to 7 is *WOODEN SPOON* to *CLARINET* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *BALLOON* to *CLARINET* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

DVD PLAYER

How similar on a scale of 1 to 7 is *CD PLAYER* to *DVD PLAYER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TELEVISION* to *DVD PLAYER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

CALCULATOR

How similar on a scale of 1 to 7 is *SET SQUARE* to *CALCULATOR* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *MOBILE PHONE* to *CALCULATOR* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

NUT

How similar on a scale of 1 to 7 is *MONEY* to *NUT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *CAR KEY* to *NUT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

BED

How similar on a scale of 1 to 7 is *SOFA* to *BED* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *WARDROBE* to *BED* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

BOOK

How similar on a scale of 1 to 7 is *WALLET* to *BOOK* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *IPOD* to *BOOK* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

PRESENT

How similar on a scale of 1 to 7 is *SHOE* to *PRESENT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *STORAGE BOX* to *PRESENT* (1 = not at all similar, 7 = highly similar).

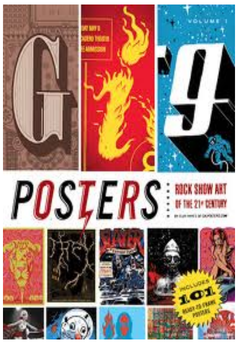
1 2 3 4 5 6 7

LEAFLET

How similar on a scale of 1 to 7 is *NEWSPAPER* to *LEAFELT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *POSTER* to *LEAFLET* (1 = not at all similar, 7 = highly similar).



1 2 3 4 5 6 7

PAPERCLIP

How similar on a scale of 1 to 7 is *CLOTHES PEG* to *PAPERCLIP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *RULER* to *PAPERCLIP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

COCKTAIL SHAKER

How similar on a scale of 1 to 7 is *MARACAS* to *COCKTAIL SHAKER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *VASE* to *COCKTAIL SHAKER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

SPADE

How similar on a scale of 1 to 7 is *TROWELL* to *SPADE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *SHEARS* to *SPADE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

DEODORANT

How similar on a scale of 1 to 7 is *INSECT REPELLANT* to *DEODORANT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TENNIS RACKET* to *AXE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

GUN

How similar on a scale of 1 to 7 is *CLEANING SPRAY* to *GUN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *HAIRDRYER* to *GUN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

KETCHUP

How similar on a scale of 1 to 7 is *SALT* to *KETCHUP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *VINEGAR* to *KETCHUP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

KNIFE

How similar on a scale of 1 to 7 is *SAW* to *KNIFE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *LADLE* to *KNIFE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

PEPPERMIL

How similar on a scale of 1 to 7 is *HAIRWAX* to *PEPPERMIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *SPRAYPAINT* to *PEPPERMIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

ORANGE

How similar on a scale of 1 to 7 is *BANANA* to *ORANGE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *STRAWBERRY* to *ORANGE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

FAX MACHINE

How similar on a scale of 1 to 7 is *PHOTOCOPIER* to *FAX MACHINE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TENNIS RACKET* to *AXE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AG: Context-lean similarity task used in Experiment 9.

HANDBAG

How similar on a scale of 1 to 7 is *COOKIE JAR* to *HANDBAG* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *CHEESEGRATER* to *HANDBAG* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

INSTRUCTIONS

The task here is a similarity judgment task whereby you have to indicate on a scale of 1 to 7, how similar the two items are. Below is an example of how the scale will be set out;

1	2	3	4	5	6	7

A score of 1 means that the two items are not at all similar to each other. A score of 7 means that they are highly similar to each other.

Each page of this booklet has at the top a picture of an object (the target object). Beneath this you will see two further objects, each with its own scale of 1 to 7. Your task is to compare how similar each of these objects is to the target object.

Please turn the page to begin the experiment.

PENCIL

How similar on a scale of 1 to 7 is *ELASTIC BAND* to *PENCIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PAINTBRUSH* to *PENCIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

SCREWDRIVER

How similar on a scale of 1 to 7 is *HAMMER* to *SCREWDRIVER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *KEY* to *SCREWDRIVER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

AXE

How similar on a scale of 1 to 7 is *CANE* to *AXE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TENNIS RACKET* to *AXE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

GLASS

How similar on a scale of 1 to 7 is *JUG* to *GLASS* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *CUP* to *GLASS* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

DRINK BOTTLE

How similar on a scale of 1 to 7 is *MUG* to *DRINK BOTTLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *JAM* to *DRINK BOTTLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

BASEBALL BAT

How similar on a scale of 1 to 7 is *WRAPPING PAPER* to *BASEBALL BAT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *MACE* to *BASEBALL BAT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

SPATULA

How similar on a scale of 1 to 7 is *CAN OPENER* to *SPATULA* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *SAUCEPAN* to *SPATULA* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

RIFLE

How similar on a scale of 1 to 7 is *SWORD* to *RIFLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *WATER PISTOL* to *RIFLE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

USB PEN

How similar on a scale of 1 to 7 is *CHEWING GUM* to *USB PEN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PHONE CHARGER* to *USB PEN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

PIN

How similar on a scale of 1 to 7 is *SCREW* to *PIN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PLUG* to *PIN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

COMPUTER

How similar on a scale of 1 to 7 is *PRINTER* to *COMPUTER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *PIANO* to *COMPUTER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

CLARINET

How similar on a scale of 1 to 7 is *WOODEN SPOON* to *CLARINET* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *BALLOON* to *CLARINET* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

DVD PLAYER

How similar on a scale of 1 to 7 is *CD PLAYER* to *DVD PLAYER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TELEVISION* to *DVD PLAYER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

CALCULATOR

How similar on a scale of 1 to 7 is *SET SQUARE* to *CALCULATOR* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *MOBILE PHONE* to *CALCULATOR* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

NUT

How similar on a scale of 1 to 7 is *MONEY* to *NUT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *CAR KEY* to *NUT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

BED

How similar on a scale of 1 to 7 is *SOFA* to *BED* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *WARDROBE* to *BED* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

1 *BOOK*

How similar on a scale of 1 to 7 is *WALLET* to *BOOK* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *IPOD* to *BOOK* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

PRESENT

How similar on a scale of 1 to 7 is *SHOE* to *PRESENT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *STORAGE BOX* to *PRESENT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

LEAFLET

How similar on a scale of 1 to 7 is *NEWSPAPER* to *LEAFELT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *POSTER* to *LEAFLET* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

PAPERCLIP

How similar on a scale of 1 to 7 is *CLOTHES PEG* to *PAPERCLIP* (1 = not at all similar, 7 = highly similar).

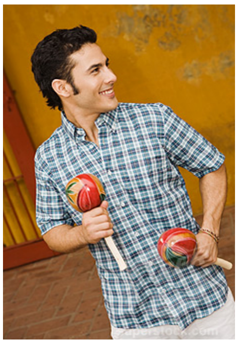
1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *RULER* to *PAPERCLIP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

COCKTAIL SHAKER

How similar on a scale of 1 to 7 is *MARACAS* to *COCKTAIL SHAKER* (1 = not at all similar, 7 = highly similar).



1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *VASE* to *COCKTAIL SHAKER* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

SPADE

How similar on a scale of 1 to 7 is *TROWELL* to *SPADE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *SHEARS* to *SPADE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

DEODORANT

How similar on a scale of 1 to 7 is *INSECT REPELLANT* to *DEODORANT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *HAIR GEL* to *DEODORANT* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

GUN

How similar on a scale of 1 to 7 is *CLEANING SPRAY* to *GUN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *HAIRDRYER* to *GUN* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.

ORANGE

How similar on a scale of 1 to 7 is *BANANA* to *ORANGE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *STRAWBERRY* to *ORANGE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

KNIFE

How similar on a scale of 1 to 7 is *SAW* to *KNIFE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *LADLE* to *KNIFE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

PEPPERMIL

How similar on a scale of 1 to 7 is *HAIRWAX* to *PEPPERMIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *SPRAYPAINT* to *PEPPERMIL* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

KETCHUP

How similar on a scale of 1 to 7 is *SALT* to *KETCHUP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *VINEGAR* to *KETCHUP* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

FAX MACHINE

How similar on a scale of 1 to 7 is *PHOTOCOPIER* to *FAX MACHINE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *TELEPHONE* to *FAX MACHINE* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

HANDBAG

How similar on a scale of 1 to 7 is *COOKIE JAR* to *HANDBAG* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

How similar on a scale of 1 to 7 is *CHEESEGRATER* to *HANDBAG* (1 = not at all similar, 7 = highly similar).

1 2 3 4 5 6 7

Appendix AH: Context-rich similarity task used in Experiment 9.