Methodological Issues of Quantifying Everyday Memory Phenomena with Paper and Electronic Diaries

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Abstract

Capturing life as it is lived is an important goal in psychology, and diary methods are commonly used for this purpose. They capture events near the time of their occurrence and are less prone to retrospective biases associated with questionnaire, interview and survey methods. However, participants in diary studies must remember to carry the diary with them, and find it convenient to make entries in timely fashion. New approaches, replacing paper diaries with technology (e.g. personal digital assistants), can overcome forgetting to make entries and retrospective filling of data. However, until recently technology had its own problems (e.g. unreliability and cost of devices, the need for training, biases of technical competence, etc.). The research described in this dissertation arose from the anticipation that the rapid, worldwide growth of smartphone ownership would overcome many of these limitations since participant-owned smartphone diaries can eliminate associated costs and facilitate increased rates of compliance.

Six diary studies were conducted on two transient cognitive phenomena. Initially, a smartphone app was developed and compared with a paper diary in the study of involuntary autobiographical memories. Although participants in the smartphone-diary condition demonstrated significantly better compliance than those in the paper-diary condition by reliably carrying their smartphones, and promptly completing diary entries in the app, they recorded significantly fewer events than paper diary users. To test that this unexpected finding was not specific to involuntary autobiographical memories, the method was tested with everyday memory failures, and the same unexpected finding was obtained. Further studies manipulated the length of diary-keeping period and demonstrated a diary entry rate reduction effect with longer diary keeping periods, an effect seen in both paper- and participant-owned smartphone-diaries. For involuntary autobiographical memories, the effect was demonstrated by comparing 1-day and 7-day diaries, and also by using a 30-40 minute-long digital audio recording method. With everyday memory failures, the effect was demonstrated by comparing 7-day and 28-day diaries.

The audio recording method was used to capture involuntary autobiographical memories while driving. It was also used on a campus walk and compared with a 1-day paper diary within-subjects, finding a higher rate of recording in the shorter period, and consistency of memory counts across two modes of recording. This novel audio-recording method facilitated much more detailed analysis of involuntary memory cues and chaining and enabled the evaluation of potential instances of priming. Finally, a telephone and postal-based

diary study of everyday memory failures demonstrated the feasibility of recruitment and measurement of participants remotely, which can be particularly useful with older adults.

Taken together, the results of this research make a significant methodological contribution to research on transient everyday cognitive phenomena by showing that (1) care is needed when using participant-owned smartphone diaries, (2) paper diaries may be more reliable than currently given credit, and (3) diary-recording periods can be substantially reduced without compromising the quantity and the quality of data obtained. In addition, results increase our theoretical understanding of two specific phenomena studied in this dissertation: involuntary autobiographical memories and everyday memory failures. The findings indicate that involuntary memories are much more frequent than previously thought, may represent a stable characteristic of a person and, in addition to immediately present cues, can be elicited by internal memory chaining process and more distant priming of events and thoughts. Finally, the absence of age effects in the frequency and nature of recorded everyday memory failures, together with significant negative age effects in laboratory tests of memory and cognition, is a novel finding that has significant implications for research on cognitive ageing.

Keywords: diary method, smartphone, apps, methodology, involuntary autobiographical memory, everyday memory failures

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CHAPTER 1: Diary Methods: A Review

1.1 Introduction

Psychologists studying memory phenomena have a variety of methods available to them, ranging from highly objective biological and physical testing, through laboratory-based experiments and observation, to almost entirely subjective self-ratings and evaluations. The use of diaries falls at the latter end of this spectrum, and as the most naturalistic method, is a way of getting as close as possible to measuring "life as it is lived" by participants outside the laboratory.

In many areas of psychological research, diary methods are becoming increasingly popular as ecological and naturalistic data are sought to complement laboratory findings. We are also witnessing growth in the importance and use of diaries in cognitive psychology. The emergence and continual development of technologies has allowed new diary methods to evolve, and facilitated the testing of new theories. These methods are applicable to clinical practice, as well as being used purely in research, and can blur the lines from research tools into diagnostic and even therapeutic uses.

While early diary research used pencil and paper, the pace of technological advancement has facilitated the collection of data in more creative and sophisticated ways (Bolger, Davis, & Rafaeli, 2003). Technology changes first brought augmented techniques to paper, namely prompting or signalling, and subsequently electronic collection of data (Shiffman, Stone, & Hufford, 2008). Advancing to the present day, smartphones are ubiquitous and offer the potential for use as electronic diaries, and it is even possible to integrate data from peripheral devices such as smartwatches and heart-rate monitors, using the smartphone to accumulate and transmit data to researchers.

Two main areas of cognitive psychology were addressed in research reported in this dissertation to evaluate the use of various diary methods in the measurement of spontaneous and transient psychological phenomena. The first was involuntary autobiographical memory, and the second, everyday memory failures. These are quite different psychological phenomena, but share some practical characteristics that make them suitable for some types of diary methods.

Using these two growing areas of psychological research, two major methodological issues were addressed. The first concerned comparing the effectiveness of standard paper diary methods and the use of novel electronic diaries on participant-owned smartphones. The second theme concerned the study of some of the key characteristics of the diary method (e.g. the duration of the diary-keeping period), and the effects that different recording media and methods have on the data collected.

Adopting new technology to improve the research is attractive, both in terms of the quantity and quality of data collected, not only in theory-driven research, but also in clinical practice to mitigate the increasing pressure on resources in providing support, for example in mental health services. Therefore, research findings reported in this dissertation are directly applicable to cognitive research and clinical practice, but will also be generalizable to other areas of psychology seeking to use diary methods, and beyond to other academic disciplines, and potentially commercial uses.

1.2 Context

In this chapter, I first outline a brief history of the diary method, its use in research in general, in psychology in particular, and its uptake in cognitive psychology. I then describe different types of diary methods available to researchers such as paper, technology-assisted paper, and electronic diaries, and review their strengths and weaknesses, with particular emphasis on studies that directly compared paper and electronic diaries. This is followed by a description of how the growth of smartphone ownership can change the way we conduct psychological research in the future. Finally, I outline the studies that are reported in the following chapters.

1.3 History of the Diary Method

Motivated individuals have always journaled, or kept a diary of activities, thoughts or ideas and personal reflections, for later recollection or perhaps for sharing or publication. However, diaries used for research purposes may collect more structured information for use by other parties. Early documented use of diaries for research included the monitoring of family health starting in the 1930s (Verbrugge, 1980), and the use of personal time and consumer spending or food intake in the 1950s (Steele, Franklin, Smudski, & Young, 1951; Stonborough, 1942; Warnick, Brimg, & Woods, 1955).

The early diaries of health and wellbeing are perhaps more relevant to psychology. In her historical review of health diaries, Verbrugge (1980) examined 19 diary studies from 1938 (the Baltimore study of individual and household health, reported by the nominated "family informant") through to a 1978 study where individuals self-reported their own symptoms, underlying conditions, routine and *ad hoc* visits to doctors and dentists, and their mood. She noted the value of diaries, which can potentially capture all medical events, whereas health records were considered poorer sources of data, because they acknowledge only events that create an interaction with a medical professional. Compared with diaries, retrospective interviews tended to miss medical events unless they were significant enough to restrict activity or required medical attention. Interviewing techniques often missed the small medical events that were self-treated or required no treatment.

Verbrugge (1980) identified three uses of health diaries: 1) methodological, to compare diary data with retrospective reporting; 2) as memory aids for subsequent retrospective interviews with the researcher or physician (and in these cases, the diary data were often not kept and analysed); and 3) as a primary data source. Of the 19 studies she reviewed she reported that six were methodological, six used diaries as memory aids, and seven were to gather primary data. The first "methodological study" that she noted was in

1952, where respondents kept a diary for 2 or 4 months and were interviewed once a month (Allen, Breslow, Weissman, & Nisselson, 1954). This was a pre-test for a planned larger survey, and the methodological studies compared diary data with various retrospective procedures, such as different interview subject areas and techniques (e.g. the degree of probing, and face-to-face versus telephone interviewing). Verbrugge (1980) noted it was only in the 1960s that diaries started to be used as primary data sources.

The diary-keeping periods in Verbrugge's (1980) review ranged from one week to 10 years, with the most common period being four weeks. Entries were usually only made on days where there was something to report. Researchers generally reported that a health diary reduced errors of recall, but they expressed concern about the burden on the participants. However, despite this concern, people generally agreed to do diary studies, and if attrition occurred it tended to be early in the study. The benefits included good recording and reporting compared with interview alone, and improved validity of data because events were recorded sooner. Even a structured interview, with detailed probes did not get close to the level of reporting in diaries. Conversely, interviews proved superior in studying chronic medical conditions, because people did not continually report an ongoing condition in the diary. This observation supports the idea of using diaries for transient, discretely identifiable events, as explored in my research.

Disadvantages of diaries included the increased need for participant cooperation, conditioning effects, sensitisation, fatigue, and costs. The method was seen to make data collection more complicated, and added to the complexity of analysis as diaries produce time series data, although this was when computers, software and statistical techniques were considerably less advanced. We would see this now as a rich source of data and, with increased computing power and modern analytical techniques, of little concern.

Verbrugge (1980) also commented on errors of recall in interviews. She observed that, while forgetting to report events was the most common, two other types of error occurred. One she termed “telescoping”, where a genuine event was retrospectively recalled but not attributed to the correct time window. The second she called the “iceberg” effect to indicate that only the “tip of the iceberg” was recalled in interviews, or found in medical records, and diaries were therefore perceived as getting closer to the truth, particularly for minor, self-medicated events.

Allen et al. (1954) compared interviewing with diary keeping for collecting morbidity (health) data. Their study, the San Jose household sample survey, compared households completing diaries for a period versus being interviewed at the end of the period (approximately 400 households in each group). The information collected included health information which was, by nature, not in medical records, such as minor illnesses and injuries. They recognised that different procedures elicited different information, and that the diary method captured information closer to the event, whereas interviews tended to under-report less serious conditions and, as identified by Verbrugge (1980), could incorrectly assign reports to the wrong time period. They were alert to variations that might occur due to different lengths of diary keeping periods, but did not observe any in their own study. They also noted practical difficulties of illegible writing and missing data when conducting diary studies which, at that time, were necessarily implemented using paper and pen.

In summary, initial reviews of research using diary methods showed diaries were good for capturing transient rather than continuous events. Furthermore, low impact events were detected in diaries, whereas they often were missed in interviews. As such, diaries allowed a more comprehensive view of whatever was being studied.

1.4 History of Diary Studies in Psychology

Diary studies were slower to appear in psychology. In an early example in organisational psychology, Burns (1954) used diaries to monitor interactions between managers and staff in a manufacturing company. Four factory executives were asked to keep records of their daily activities. When interviewed retrospectively, they overestimated the time they spent on factory production problems, and underestimated the time they spent on personnel problems, compared with their contemporaneous records, confirming the risk of relying on interviews.

More generally, Wheeler and Reis (1991) suggested that the rise of behaviourism led to a moratorium on the study of inner experience from 1920 to 1960, and as such introspection was rejected and diary measurement was considered too subjective in the cognitive domain. However, with the cognitive revolution in the 1960s, research took a major new direction and standpoint against behaviourism, leading to cognitive psychology. Even so, 10-15 years on, Neisser's (1978) opening address to the first International Conference on Practical Aspects of Memory, expressed frustration with the lack of applicability of laboratory approaches, and this led to an increased interest in ecological measurement. Mehl and Conner (2012, p.68) concur that the use of diary self-recording techniques has increased in psychology since the 1970s, coinciding with the end of behaviourism.

Behaviourism demanded laboratory rigour. In contrast, naturalistic studies offer ecological validity, a term first introduced by Brunswik (1947). There is therefore a "tension between the need for control and the need to preserve the essence of the phenomenon under investigation" (Baddeley, 1989, p. 104). Further, Reason and Mycielska (1982) argued that "Laboratory tests do not always prove to be good predictors of a person's performance in the outside world. The attempt to bridge this gulf between the highly specific and easily manipulatable laboratory task and the uncontrollable and myriad concerns of actual day-to-day living remains one of psychology's most difficult challenges. Both modes of inquiry are necessary and important; but reconciling their findings is not easy'' (p. 233). While there were occasional skirmishes arguing for the return to laboratory methods, such as "The Bankruptcy of Everyday Memory" by Banaji and Crowder (1989), the debate was largely over by the mid-1990s (Kvavilashvili & Ellis, 2004), establishing the trend towards ecological reform (Gibbs, 1979), or the ecological approach (Neisser, 1985), and diary studies became part of the new way of research and data collection.

1.5 Examples of Diary Studies in Cognitive Psychology

In the 1970s and 1980s the diary method was famously used by Marigold Linton (Linton, 1975, 1986), who kept diaries over six years, recording the most memorable events of her day. She obtained interesting information about autobiographical memories, long before the academic interest in involuntary autobiographical memories developed. Linton tested herself on events previously recorded in her diary. Her method overcame the limitations of the previously used cue word method, which is flawed because there is no way of validating participants' reports of particular events in their lives (but see Mace, Atkinson, Moeckel, & Torres, 2011). This technique was later extended by White (1982) and Wagenaar (1986).

The method was arguably improved upon by Brewer (1988), who asked psychology students to carry a beeper (for 17 days on average), which sounded at random, and to record what they were doing on response cards (time, location, actions and thoughts) when it sounded. Participants also recorded, at the end of each day, the most memorable event of that day. These samples of recorded memories were then subsequently used to test the students' recall at three times in the future (at nine days, 78 days and 149 days), using either the thought or the action description. This method overcame the potential selection bias of the events recorded by Linton and Wagenaar, who were measuring themselves.

A number of cognitive diary studies were conducted by Reason and Mycielska in the late 1970s and early 1980s (Reason, 1977, 1979, 1982; Reason & Mycielska, 1982) in the study of absent-mindedness, while in the 1990s the diary method was used in two studies of the tip of the tongue (TOT) phenomenon (Burke, MacKay, Worthley, & Wade, 1991; Heine, Ober, & Shenaut, 1999), which refers to situations where individuals fail to retrieve a word, but feel that retrieval is close. Further examples of diary studies include prospective memory, which involves remembering to carry out intended actions at some point in the future (e.g. make a phone call at 2:00pm). For example, Ellis and Nimmo-Smith (1993) asked participants to list their intentions for the day, and then keep a diary of thoughts about these intentions coming to mind throughout the day. Participants completed a page for each recollection as soon as possible after it occurred, including the time of the thought and the time they recorded it.

In summary, diaries have become particularly popular in cognitive psychology with a resurgence of interest from the beginning of the 21st century, having seen a dip from the popularity in the 70s and 80s. The renewed interest, coupled with recent advances in participant-owned technology makes the review of the method highly relevant.

1.6 The Value of Diaries in Psychological and Clinical Research

In psychological and medical research, participants, or patients, are often asked to recall and rate events or episodes from their daily life, reflecting back over a period of time after these events have occurred, using questionnaires, surveys or interview methods. However, these are prone to error as participants may incorrectly recall, or even fail to recall the events or episodes of interest to the researchers. Recognising this problem of recall bias (Coughlin, 1990; Schwarz, 2007; Schwarz & Sudman, 1994), diary methods are considered the most appropriate tool for studying transient phenomena (e.g. in changes in mood, intrusive thoughts or memories etc.), which are often difficult, if not impossible, to capture and measure in controlled laboratory conditions (Morris, 1984, p.153). Wheeler and Reis (1991) observed that "Much of life and daily attention is filled with these little experiences which are hard to study in the laboratory" (p. 339), describing self-recording as the "new science of recording small events".

The current state of the person can dictate how they recall earlier events (Bower, 1981), so care is needed when asking participants to recollect past events. In the classic study of pain in colonoscopy, patients were more likely to remember peak pain, and particularly pain at the end of the procedure (Redelmeier & Kahneman, 1996). Stone, Broderick, Shiffman, and Schwartz (2004) similarly showed that patients, with pain, probed with a sampling technique rated pain differently from those who were questioned about their pain at the end of the week. In a review of self-monitoring in medicine, Barton, Blanchard, and Veazy (1999) also found studies where retrospective ratings of pain were higher than daily ratings, and Wilson and Vitousek (1999) describe eating disorder studies with higher rates of events reported in self-monitoring compared with retrospective recall. While in a recent study of patient reported outcome (PRO) in gastroesophageal reflux disease, patients who completed diary at the end of a seven-day period slightly over-estimated the intensity of symptoms, but markedly under-estimated their frequency, compared with patients who completed a diary twice daily (Rydén, Leavy, Halling, & Stone, 2016).

Particularly in a clinical context, relying on retrospective recall can have serious implications. For example, De Beurs, Lange, and Van Dyck (1992) found that patients estimated more panic attacks retrospectively than were recorded in a diary, which could potentially lead to incorrect treatment regimes, such as over-prescribing of medication.

A key strength of diaries is that they record events at the time they happen, so they can reveal patterns not seen in interviews. This provides the opportunity to detect changes over time, for example hourly, daily, or weekly changes etc., (Affleck, Zautra, Tennen, &

Armeli, 1999; Tourangeau, Rips, & Rasinski, 2000). Using this form of data, it is possible to observe the total number of days when something occurred, or observe patterns of consecutive days, or high frequency days, clustering effects, and the ability to see sequences, links between events, and cause and effect. Diaries are also useful in revealing what came before, or what followed the event being measured.

In addition to data-gathering for research and diagnostic purposes, there is a growing body of evidence for the therapeutic benefits of keeping a diary (Boals, Hathaway, & Rubin, 2011; Kvavilashvili & Brewin, 2013; Pennebaker, 1997; Watson, Berntsen, Kuyken, & Watkins, 2012). This observation makes the exploration of diary methods even more valuable, with their potential for use in clinical and mental health applications. Other researchers (Kazdin & Blase, 2011; Proudfoot, 2013) have observed that these methods can support treatment in mental health. For example, the use of self-monitoring in cognitive behavioural therapy (CBT) is a key part of the therapy (Cohen, Edmunds, Brodman, Benjamin, & Kendall, 2013). Also, self-monitoring of autobiographical memory has importance in studying depression (Watson, Berntsen, Kuyken, & Watkins, 2013). Patient diaries can be employed as a way of reducing interaction with healthcare providers, or researchers (e.g. in chronic conditions, Lupton, 2013), which can be of benefit when resources are limited.

Self-recording via diaries is therefore a key component of any research into spontaneous naturally occurring events such as thoughts and memories (Wheeler & Reis, 1991). However, it must be compared with other measures for convergent validity, and considered alongside data from other sources such as laboratory results and interview, to map out the broader research picture. Consequently, further research into the characteristics and uses of different diary methods is of key importance.

1.7 Types of Diary Study Methods

Several methods of using diaries have evolved over time. There are three key types of diary method: interval-contingent, signal-contingent and event-contingent (Wheeler & Reis, 1991). The interval-contingent method is most consistent with traditional personal diaries or journals, and requires participants to report in the diary at regular, pre-agreed intervals, for example at the end of the day, or at certain times of the day. This relies on the participant remembering to complete the task. To overcome the potential of participants forgetting, the signal-contingent or experience sampling method evolved. This method depends on some means of alerting the participants that they should make a diary entry. This signal may be on a fixed, random, or pseudo-random basis, and generally requires an immediate response in the diary. Finally, event-contingent studies ask participants to notice specific events (e.g. onset of migraine, intrusive thoughts) and record them as soon as possible. The event-contingent diary-keeping method is particularly appropriate for less frequent, specific, and discrete events, but it would quickly become tedious for events occurring every few minutes.

Event- and interval-contingent studies place additional demands on participants' prospective memory, vigilance and ultimately their compliance. Not only do they have to remember to carry a diary with them, but they also have to remember to make a diary entry at a particular time, or in response to an event (Takarangi, Garry, & Loftus, 2006). In contrast, a signal-contingent approach is more appropriate for moment to moment experiences such as tracking mood. The signalling schedule needs to match the experiment, or the theory being tested, such that sampling occurs around the time that the phenomenon being measured is likely to change, rather than frequent sampling while the phenomenon is constant.

These different techniques can be combined. For example, a study may prompt participants from time to time (signal-contingent), but also allow them to make spontaneous entries of events they notice (event-contingent). Examples of this hybrid approach have included alcohol consumption (Mohr et al., 2001) and smoking cessation (McCarthy, Piasecki, Fiore, & Baker, 2006) or cravings to smoke (Shiffman et al., 1997).

Neither interval- nor signal- contingent methods are appropriate for randomly occurring and transient events because these are unpredictable phenomena that need to be logged as soon as they occur. Therefore the event contingent diary method has been increasingly used to study a variety of transient phenomena such as involuntary autobiographical memories, intrusive memories, musical imagery or earworms and cognitive failures in everyday life, to name a few (Beaman & Williams, 2010; Berntsen, 1996; Kleim, Graham, Bryant, & Ehlers, 2013; Kvavilashvili & Mandler, 2004; Unsworth, Brewer, & Spillers, 2012). Any delay in recording such events should be minimised because these are otherwise easily forgotten. Furthermore, any attempts to prompt participants to recall recent examples may result in spurious entries, through invention or additional introspection to find an example to satisfy the prompt. For example, in a study of musical earworms using a signal contingent sampling method, participants reported music in their head on 40% of occasions when they were randomly probed several times a day (Floridou, Williamson, & Stewart, 2016). It is possible that the signal was prompting the internal music instead of measuring the true frequency of earworms in everyday life.

In event-contingent studies, such as those described in this dissertation, where participants are not prompted, they must be carefully briefed on the specific events they need to notice and record. A single type, or class, of event measured at one time is best, otherwise the burden on the participant is greater, leading to potential dilution of recordings, or reduction in accuracy, through confusion or divided attention (Hayes & Cavior, 1977). With the event-contingent approach there is a danger that participants will not record all events, either because they are not sufficiently motivated, or because they are delayed and then forget to record, or they do not notice all events and only capture the more memorable events.

1.8 General Issues, Considerations and Limitations with Diary Studies

While diary studies open up research opportunities, they also have a number of limitations. These limitations need to be understood and addressed, or at least acknowledged in the research. Clear disadvantages of diary studies include the efforts of conducting them compared with the simplicity of issuing questionnaires which, in many cases, can now be conducted online without any need to meet the participants. Diary studies must be run for a period of time to collect sufficient data, or to observe the phenomenon of interest. This can be from a few days to years. With diary studies running over days, weeks or longer, there can be a delay in the researcher seeing the data, and it may not be possible to monitor whether participants are correctly following instructions, which may result in lapses of quality through errors of understanding, or missing data due to lack of compliance, until it is too late to put things right.

When conducting diary studies, researchers should be aware of a multitude of issues, such as how well the target event is defined, how trainable the participants are, whether accuracy checks are possible and whether the participants are aware that accuracy checks will, or might occur. Related issues involve explaining to participants the importance of accuracy, whether contemporaneous responses are required, or how promptly after the target event the recording is achieved. To achieve the highest data quality, participants must be thoroughly briefed on the nature of the phenomenon being measured, and on how to answer the questions. The diary should be easy to use. Participants must understand, and be able to do the tasks required of them. However, this training consumes participant and researcher time.

Diary studies also require motivation and commitment on the part of the participants. Researchers can increase this by developing good relationships with participants, and by minimising the burden of keeping the diary, so reducing the effects of the diary by having a few carefully chosen questions, focussed on the area of interest, on each diary page.

There are several effects the diary may have on the participants, including reactivity and habituation. Reactivity is where individuals change behaviour or performance due to awareness of observation (French & Sutton, 2010). This may also lead to increased sensitivity to the phenomenon (i.e. sensitization), where diary-keeping results in greater than usual observation of the event (de Shalit & Fattal, 1990), or the diary becomes a cue of the event that it is measuring (Kleim et al., 2013).

In contrast, habituation is the diminishing response to a repeated stimulus (Bouton, 2016; Burton, Weller, & Sharpe, 2007). It could be considered a reduction in motivation where, as the study progresses, participants begin to skip parts of the diary form, or neglect to make entries altogether. Similarly, fatigue, or tiring of keeping the diary may also cause the participant to stop making entries although they are aware of events they should log (e.g. Strickland, Crawford, Shen, & Wilkins, 2006). When this occurs, it manifests as an initial higher rate and then a decline in recording. It is therefore worthwhile to reduce the intrusiveness, and ease the burden of diary-keeping.

In summary, considering these issues, it is clear that while diary methods are useful tools, further research is warranted. In the conclusion of their review of diary methods, Bolger et al. (2003) commented “that these and other potential effects of diary methods should be investigated both for methodological and theoretical reasons” (p. 592).

1.9 Particular Problems with Paper Diaries

Pencil and paper diaries are still common, and a valid means of conducting diary studies. Participants are trained and then sent away with supplies, usually a booklet or pack of forms. The limitations of this method, however, are quite apparent. Firstly, there is an issue of compliance (or adherence, as it is sometimes called in clinical studies). Participants may forget to respond at the scheduled time (in interval-contingent studies) or forget to keep a diary with them (for interval-, signal- and event-contingent). They may then try to complete the diary later with genuine (but retrospectively biased) entries, or even feel obliged to create fictional entries. Bolger et al. (2003) described compliance as the number of entries, and their validity. In the present dissertation, compliance also refers to the timeliness of entries, i.e. how soon the event-contingent item was recorded after it occurred. This matters because delays in recording that lead to introspection and reappraisal should be avoided. Secondly, backfilling (the practice of completing diary entries that have been neglected) is also a concern, which in paper diaries is virtually impossible to prevent, and may require sophisticated techniques to detect. This is a major criticism of paper diaries for clinical studies (Lauritsen et al., 2004; Stone, Shiffman, Schwartz, Broderick, & Hufford, 2002).

Poor compliance is especially problematic for measuring fleeting or transient, and less frequent events. One way of mitigating this problem is to debrief the participants at the end of the diary-keeping period to assess their ability to capture these, or by using other people to corroborate the entries. Good design of diaries (e.g. small and portable) with instructions and the researcher's contact details can help with compliance. Participants can be encouraged to value accuracy over quantity, and where appropriate, no indication of expected numbers of entries should be given, mitigating any demand characteristics. Diary pages pre-printed with date and time may be helpful in some circumstances for participants to comply with the protocol. Participants may be allowed to mark where an entry was made on time, without any penalty for those times where inevitably that was not possible. Testing the diary and user understanding by piloting also makes sense to avoid wasted effort.

In completing self-measurement forms (diaries), participants may want to skip questions, or may do so inadvertently. This is hard to prevent on paper but electronic solutions, described later, can enforce mandatory fields, and validate entries, if required. Data collection and checking at interim points is also a sensible approach particularly in longer studies. Finally, several authors have emphasised the value of maintaining goodwill with participants, and expressing encouragement and gratitude for supporting research.

For researchers, data entry for diary studies can become a considerable burden as data volumes can expand even with few participants and, with that, the increased risk of transcription errors. Additionally, as paper diaries are hand-written, information can be lost through inability to read the handwriting of participants. Furthermore, because there is little or no control on how, or whether participants completed the pages, there are frequently missing data. Although this is not unique to diaries, in the case of questionnaires, completed when participants and researchers meet, the researcher can check for missing data before the participant leaves.

1.10 Introduction of Devices Alongside Paper Diaries

As technological advances were made from the 1970s onwards, psychology researchers began to use electronic signalling devices (pagers, programmable watches, phone calls, text messages etc.) to complement the use of paper diaries, by prompting participants to make an entry, thus overcoming forgetfulness and potentially delayed responses. Data were still collected in the traditional way with pen and paper. While the signalling initially served simply as a reminder, this in time led to the development of the experience sampling method (ESM) and ecological momentary assessment techniques (EMA) (Csikszentmihalyi, Larson, & Prescott, 1977; Hurlburt, 1979; Klinger, 1978; Shiffman, Stone, & Hufford, 2008). Csikszentmihalyi was studying what he called “flow”, the balance of challenge and skill in tasks, and found that measuring the quality of daytime experiences at the end of the day was not successful because it was difficult for participants to recall, so to alleviate this problem he introduced alerting beepers to signal when to record. In a study by Hurlburt (1979) participants had to record the thoughts that they were having, and what they were doing each time they heard a “beep”, for three days. As most people were surprised at the results he concluded that people were not good estimators of the relative frequency of different types of thoughts experienced in daily life.

The ESM and EMA approaches are useful in studies where people can reasonably assess the phenomenon of interest at the moment they are prompted, and potentially looking back just a short period in time, such as assessing mood or pain. If, however, participants have to report on a phenomenon which has occurred in the last 2-3 hours, the retrospective element returns and there is still scope for error in reporting, although it is better than asking at the end of the day, end of the week or later (Takarangi et al., 2006).

1.11 Handheld Electronic Data Gathering

After decades of using pen-and-paper diaries for studies, fully electronic diaries became feasible, using bespoke devices, or personal digital assistants (PDAs) lent to participants for the duration of the study. These are small, hand-held computers allowing participants to complete diary entries via various user interfaces, such as tapping a plastic pen (stylus) on the touch sensitive screen or a small physical keyboard (e.g. Henker, Whalen, Jamner, & Delfino, 2002).

Electronic methods of data collection appeared in psychology from the 1990s (Shiffman, 2000). These have the advantage of built-in signalling (if required), automatic date and timestamping, with the ability to measure the entry time versus the signal time. Depending on the study design, options include allowing the participants to delaying entry if inconvenient (“snoozing”), and enforcing a time window when an entry is allowed, after which that entry is barred. A key feature is the prevention of backfilling and even forward-filling (anticipating events that have not yet occurred). Other possibilities might be to exclude multiple entries within close time proximity (if desired), and to allow flexible question paths. It is also possible to collect metadata about how participants complete the data entry, for example how long they take to make an entry. Data validation on entry, dynamic scheduling of the next prompt, and randomising question order are among a huge range of flexible options available with electronic data gathering. Furthermore, entries can be locked or versioned, and made editable or not, as defined by the experimenter.

Another major advantage is that researchers are spared the manual data entry after the diaries have been gathered in. While online web and phone-based data capture has been a possibility for some time, it requires participants to be on a network (Internet or mobile). With a device, data may be stored for the duration of the study, or can be transmitted to the researchers at intervals, for interim analysis, or simply to confirm participant compliance with the study.

Even in 2003, there was some anticipation of a time when participants might use their own devices for research studies (Bolger et al., 2003). However, at that time the authors were likely predicting the wider ownership of PDAs, rather than anticipating smartphones. The use of such electronic diaries became increasingly common and indeed in medical studies, and particularly in clinical trials evaluated by regulatory bodies, electronic diary methods are considered *de rigueur* (Arnera, 2009; Coons et al., 2014). The number of studies using PDA-based diaries in psychological and mental health research has also been increasing. For example, in a study by Rubin et al. (2011), Palm PDAs were used by participants to record involuntary autobiographical memories as they occurred. Kleim et al. (2013) used a similar event-based recording method to capture intrusive memories in the daily life of trauma survivors. Other studies have used electronic diary methods with people with ADHD (Whalen, Odgers, Reed, & Henker, 2011), and psychosis (Ben-Zeev, McHugo, Xie, Dobbins, & Young, 2012; Kimhy, Myin-Germeys, Palmier-Claus, & Swendsen, 2012; Kimhy, Vakhrusheva, Liu, & Wang, 2014; Oorschot, Lataster, Thewissen, Wichers, & Myin-Germeys, 2012).

Another significant shift in the use of electronic diaries has occurred in the past few years where PDA diaries have been replaced with pre-programmed Android smartphones (Ainsworth et al., 2013; Kimhy et al., 2012; Palmier-Claus et al., 2012; Poerio, Totterdell, & Miles, 2013; Rasmussen, Ramsgaard, & Berntsen, 2015; Whalen et al., 2011). This shift has occurred with the emergence of smartphone technology (iPhones in 2007 followed by Android phones in 2008), which has enabled researchers to loan cheap Android smartphone models that have many more features than PDAs, including for example the ability to capture photographs, or use the participant's location to ask appropriate questions.

1.12 Limitations of electronic data capture

A key limitation with electronic data capture is the expense of the software. The software must be purchased, or commissioned, or developed in-house. Similarly, hardware must be purchased and maintained, and processes are needed to handle the coordination of distributing and recovering the devices. Then participants must be trained in the use of unfamiliar devices. There is a burden on participants who have to carry and look after potentially valuable electronic devices, and keep them charged. There is potentially a bias toward the more technically able and motivated, and against those with poorer eyesight or dexterity. Face-to-face training may also be necessary. Early devices were not good at text entry, limiting data capture to check boxes and Likert scales. Technical difficulties and failures, loss of data, training burden, inappropriateness (e.g. for older people) were often reported.

Some argued the saved costs of not having to key data, and improved data quality (no illegible writing) offsets the cost of using electronic technology. However, loaned devices, PDAs and latterly smartphones are not the panacea. As Bolger et al. (2003) indicated "clearly we need more published studies on the feasibility of using electronic diary studies in a broader range of special populations" (p. 598).

1.13 Comparing paper versus electronic diaries

Given the positive and negative features of electronic and paper diaries, research is needed that directly compares paper and electronic diaries, using between or within-subject designs, and adopting equivalent procedures to study the same phenomena with both modes of data collection. While several such studies have been reported in clinical and healthcare literature, there is remarkable lack of research on this topic in psychological literature. One exception was a target paper by Green et al. that elicited a considerable debate in 2006 (Broderick & Stone, 2006; Green, Rafaeli, Bolger, Shrout, & Reis, 2006; Takarangi et al., 2006; Tennen, Affleck, Coyne, Larsen, & DeLongis, 2006).

Green et al. (2006) described two studies that directly compared interval-contingent paper and electronic (PDA) diaries in terms of participant compliance with diary entry times and the characteristics of collected data. In one study (Study 2), which used a between-subjects design, participants had to complete a mood questionnaire every three hours for seven days[1]. Despite some discrepancies (e.g. the PDA group completed more questionnaires than the paper group), the percentage of compliant responses and the nature of recorded data were fairly similar across the two groups. Data equivalence and similar compliance rates were also obtained in Study 3, in which a group of participants completed a lengthy questionnaire every day before bedtime using either a paper or electronic diary for six days (the order in which each type of diary was kept was counterbalanced). It is also interesting that there were almost equivalent levels of preference in participants for electronic versus paper mode of data collection with 47% preferring electronic and 53% the paper diary. In a study by Kajander, Lätti, Hatakka, and Korpela (2007), which also used a within-subjects

[1] Green et al. (2006) conducted a secondary data analysis on the data originally collected by Rafaeli et al. (2007) for another study.

design, fewer participants preferred the electronic diary (33%), which highlights the problems that some participants may have with using newest technological devices.

In contrast to Green et al.'s (2006) study, other findings from medical and clinical research that directly compared paper and PDA diaries are more mixed with some favouring electronic over paper diaries and others finding no differences (Lam et al., 2010; McKenzie, 2004; Weiler, Christ, Woodworth, Weiler, & Weiler, 2004). One of the major issues in this research, highlighted by Tennen et al. (2006), is that the paper and electronic diary conditions can differ from each other on a variety of dimensions. For example, in Study 2 of Green et al. (2006), participants in the electronic diary condition received reminder beeps after three hours from a previous entry, when no such reminders were present in the paper diary condition. Similarly, in a study by Stone, Shiffman, Schwartz, Broderick, and Hufford (2003), participants received reminder beeps and were made aware of being monitored for compliance, while these features were absent in the paper diary conditions. However a counter view argued that signalling did not adequately improve diary compliance (Broderick, Schwartz, Shiffman, Hufford, & Stone, 2003). In a study by Lam et al. (2010), electronic diaries had attractive colour interfaces, which were absent in the paper diary condition.

Due to these and other methodological issues threatening internal validity, Dale and Hagen (2007) were able to include only nine papers in their systematic review of studies that compared paper and PDA diaries in patient reported outcomes. The number of studies using within or between-subjects design was roughly equal (four and five, respectively), but only three studies used event-contingent rather than interval contingent data collection methods. The studies were assessed in terms of feasibility of paper and electronic diary methods used, participant compliance, data accuracy and participants' preferences for the two methods.

For six out of seven studies, users showed greater protocol compliance with PDA than paper diaries, while no difference in compliance was observed in one study (two studies did not report comparable compliance data). The other benefits of electronic diaries included fewer data entry errors, and greater patient preference for using a PDA. In addition, in four studies there was some evidence of potential data fabrication (e.g. fictional data) in the paper diary method[2]. However, in all five studies (out of nine) which examined the feasibility of methods, significant technical problems were reported for PDAs involving battery problems or breakage in a substantial number of participants (between 14% to 29% in some studies), resulting in the loss of some of the PDA data.

The overall consensus emerging from the Dale and Hagen (2007) review and the general debate about "paper or plastic" (Green et al 2006) was that the paper diary method should not be universally replaced by electronic diaries, despite the advantages of PDA diaries in terms of compliance and data accuracy. Rather, the nature of data collected, the characteristics of populations tested and particular research questions asked should dictate which method is adopted in a particular study (Bolger, Shrout, Green, Rafaeli, & Reis, 2006; Broderick, 2008; Dale & Hagen, 2007; Tennen et al., 2006). For example, some participants may have a preference for using a paper diary, and the studies requiring free text answers would prefer a paper diary method due to difficulties of text entry on PDAs (Dale & Hagen, 2007; Green et al., 2006). It was also acknowledged that more systematic research was needed to further evaluate and compare different types of diary methods across the paper and electronic modes of data collection.

1.13.1 **Rise of the Smartphone**

From the early days of the mobile (cell) phone with, in particular the SMS (text) messaging services, there have been initiatives to use them in research. As technology developed, more features were added (e.g. the ability to take and send photographs), the

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[2] It is important to distinguish between outright fabrication and backfilling of genuine, but recall-biased, data.

ability to take notes, to make audio recordings, keep calendars and contact lists and then to access the Internet and send and receive email, and terms like “feature phone” and “smartphone” emerged.

It was soon recognised that mobile technology and increasingly sophisticated phones could make an impact on research methods. Even these earlier “feature phones” were seen as having the potential to revolutionise mobile and participatory healthcare (Boulos, Wheeler, Tavares, & Jones, 2011). The early cell phones were limited to text messaging (SMS) functionality, but even that added sufficient new technology to start changing the way sampling research could be achieved. Participants could be sent text messages seeking a reply or prompting an entry in a paper diary.

The advent of “apps” resulted in smartphones as we know them today – the Apple iPhone, and phones running the Google Android operating system. Apps are software applications for smartphones, written by third-parties, rather than the phone manufacturers, that can be installed on the phone by the owner and can use the features of the device, store data locally and transmit and receive data when network connectivity is available. Participants in a recent study of smartphone use in everyday life spontaneously referred to their smartphones as an electronic “Swiss army knife” (Barkhuus & Polichar, 2011).

Smartphones are thus changing the way psychologists conduct research, but are also becoming a subject for study in their own right. There is a growing literature on the psychology of smartphone use: separation anxiety (Clayton, Leshner, & Almond, 2015), the effects of smartphone use in family situations (Oduor et al., 2016), effects on psychological health (Sleek, 2014), how smartphone use affects cognitive function, for example, with the attentional cost of cell phone notifications (Stothart, Mitchum, & Yehnert, 2015), and concern about “phantom phone syndrome”, where smartphone owners spuriously think there was an alert and look at their phones, leading to formation of checking habits (Oulasvirta, Rattenbury, Ma, & Raita, 2012). As the more mainstream Time Magazine put it, the concern is: "Are my devices messing with my Brain?" (Heid, 2015).

The most comprehensive vision for the potential for smartphones to change the way psychological research will be conducted came in 2012 with the publication of the "Smartphone Manifesto" (Miller, 2012) in which Miller proposed that "smartphones could transform psychology even more profoundly than PCs and brain imaging did" (p. 221). It remains to be seen how true that prediction will prove, but there is little doubt, given the influence of smartphones in all aspects of life, that their effect will be profound.

1.13.2 **Smartphones as Electronic Diaries**

The evolution of paper to PDA to smartphone diaries raises several important questions about the diary method in general and specifically, with regard to the cost of studies, compliance factors and qualities of the data collected. In just a decade after the "paper or plastic" debate, the smartphone ownership worldwide has been growing rapidly, approaching two billion in 2016 ('2 Billion Consumers Worldwide to Get Smart(phones) by 2016 - eMarketer', 2015). This creates a novel and unprecedented opportunity to conduct psychological research using participants' *own smartphones* as electronic diaries.

Some psychological research has already been reported where participants use their own smartphones, for example, in a study of mind-wandering (Killingsworth & Gilbert, 2010), the effects of location on happiness (MacKerron & Mourato, 2013) or the daily alcohol consumption (Monk, Heim, Qureshi, & Price, 2015). However, while these studies took advantage of this new opportunity, they made no comparison with existing techniques. While paper diaries have been compared with early electronic PDA diaries, as described above, no research has yet been carried out comparing paper diaries with electronic diaries installed on participants' own smartphones. Making use of participants' own smartphones for research is very different from lending equipment and this raises some issues that need to be clarified before the approach becomes mainstream and widely adopted. In many respects a loaned device, although new technology, is analogous to paper diary since both are items the participant would not normally carry.

There are good reasons for exploiting participant-owned smartphones. Participants take responsibility for purchasing and learning to use their devices, and are very familiar with them, significantly addressing the issues and technical problems reported for PDA diaries. Researchers used to talk about the learning curve of PDAs and early phones (Burdette, Herchline, & Oehler, 2008), but it is no longer an issue. Smartphone owners know how to use their devices, or quickly find out using social support networks, and web searches. YouTube videos quickly show how to do things, fix annoyances or change settings.

When participants use their own smartphones, they can be expected to take more care of their devices, and given the security and reassurance that carrying a smartphone provides, will carry the phones all the time, keep them charged, and constantly consult them. Recent data from Apple showed that users unlock their phones on average 80 times per day (Statt, 2016). Further, participants could reasonably be expected to be willing to use their own smartphone rather than having to carry a second device, since many people now manage their work and social lives, and their social interactions, on their smartphones. So, we can anticipate high compliance in carrying the device. Finally, smartphones also improve on an issue often overlooked, namely increased ease of entering free text, which is essential for capturing the participant's free-text descriptions of phenomena.

1.14 Aims of the Research

The general aim of this research was to clarify several outstanding issues in relation to the current methodology of studying involuntary transient phenomena and the best way of recording and quantifying these events. This general methodological aim was addressed by investigating two different cognitive phenomena: involuntary autobiographical memories and everyday memory failures.

Involuntary autobiographical memories were chosen because they are part of a new, and rapidly growing area of cognitive psychology, which until recently was almost entirely based on the diary method, certainly in the first decade of research from 1996 until 2006. The development of new methods of measurement of involuntary autobiographical memories in naturalistic settings, such as via smartphone and audio recording, can contribute to the field, and complement recently developed laboratory methods. Given that highly counterintuitive findings were obtained in the initial studies of involuntary autobiographical memories in this dissertation, it was necessary to demonstrate the generalisability of these findings. Therefore, everyday memory failures were used as a second area of transient phenomena that were comparable to involuntary autobiographical memories methodologically, but different phenomenologically.

The primary aim was to compare paper diaries with electronic diaries installed on participant-owned smartphones as a way of significantly advancing our data gathering techniques. The second aim was to investigate the effect of varying the diary-keeping period on the number and characteristics of events recorded in diaries, with a view to finding optimal recording periods. The third aim was to explore different ways of measuring memory events, in particular, by developing an audio recording technique and testing it in environments where writing in a diary was not practicable. Finally, the feasibility of conducting paper diary studies, and associated laboratory and questionnaire measurements, over the phone and by post was also examined.

Although the primary focus was on methodological research, by studying involuntary autobiographical memories and everyday memory failures, the additional aim of this research was to advance existing knowledge of these phenomena by addressing several interesting empirical and theoretical questions, for example, the frequency of involuntary memories and memory failures in everyday life, the effects of age on everyday memory failures, and the concepts of cueing and priming in involuntary autobiographical memories.

1.14.1 Summary of Studies

In summary, research presented in this dissertation addresses the following unanswered questions: Is using a smartphone, in particular the participant's own phone, as compelling as it seems for studying transient psychological phenomena? Given the availability of low-cost electronic devices, is the paper diary still an acceptable research tool? Are we making life harder for participants and ourselves by unnecessarily prolonging the data gathering period?

Chapter 2 provides a brief overview of research on involuntary autobiographical memory. Then Chapters 3 to 8 describe the six empirical studies that were conducted to address the aims outlined above.

In Study 1 (Chapter 3), I tested the smartphone software I developed for a 7-day diary study of involuntary autobiographical memories, comparing an app on participant-owned smartphones with paper diaries. Study 2 (Chapter 4) sought to replicate the unexpected findings of Study 1, and also changed the diary-keeping period, reducing it to one day, which revealed important effects of the diary-keeping period. To test the generalisability of these novel findings, Study 3 (Chapter 5) evaluated paper and smartphone diaries in the study of everyday memory failures over seven days, and compared findings with those of Study 1 on involuntary autobiographical memories. To further examine the generalisability of findings in relation to the length of diary-keeping period, Study 4 compared the number and types of recorded everyday memory failures in 28-day and 7-day long recording periods, using the paper diary format.

The last two empirical chapters again focus on involuntary autobiographical memories and assess novel ways of measuring them in everyday life. In Study 5 (Chapter 7), I investigated my own involuntary autobiographical memories in a highly reproducible car journey. Here a new audio-recording technique was developed, which led to further insights into the involuntary autobiographical memory phenomenon and its underlying mechanisms. Bringing the audio and paper methods together, and mitigating the limitations of the researcher measuring himself, Study 6 (Chapter 8) compared the collection of IAMs via audio recording in a 30-minute walk by students around their familiar campus, with IAMs recorded in a paper diary (identical to the method used in Study 2) on the following day. The aim was to compare the number and qualities of involuntary autobiographical memories collected in an ecological study in controlled conditions, using the newly developed audio recording method, with involuntary autobiographical memories collected in a paper diary, within-subject.

Finally, Chapter 9 provides an integrated summary of key findings obtained in the six studies. Guidance is given in the use of smartphone diaries in the study of transient cognitive psychological phenomena, as well as suggesting enhancements to the paper diary method, and directions for further research are articulated. While the emphasis of the research was on methodological developments, the studies also resulted in new empirical findings that have theoretical implications for research on everyday memory phenomena. Thus, interesting new insights about the nature of involuntary autobiographical memories were gained, along with important new contributions to research on everyday memory failures.

CHAPTER 2: Involuntary Autobiographical Memories in the Laboratory and in Real Life

2.1 Introduction

This chapter describes the phenomenon of Involuntary Autobiographical Memory (IAM), and its similarities and differences with voluntary autobiographical memory. It reviews methods used to study the phenomenon, and raises important research questions, and theoretical ideas about underlying mechanisms. As such, the chapter provides essential background information for the empirical chapters that address questions about the diary method.

Autobiographical memories are memories of one's personal past (Conway, 1990). These can be retrieved voluntarily in order to complete an action, or when responding to a request for information (Berntsen, 2010). However, autobiographical memories often come to mind spontaneously, or involuntarily, without a conscious or deliberate attempt to retrieve them. The novelist Esther Salaman, in her book "A Collection of Moments, a study of involuntary memories" described the appearance of such memories as "unbidden" (Salaman, 1970). Involuntary memory was documented as early as 1883 when Francis Galton strolled in Pall Mall in London, and observed objects in the environment, which he then allowed to cue memories of his past (Galton, 1883). Ebbinghaus (1885) distinguished between involuntary and voluntary memories, observing that involuntary memories came to mind without an act of will. Involuntary memory was famously illustrated in literature by the story of the memory evoked by the madeleine cookie dipped in tea by Marcel Proust in the novel "In Search of Lost Time", published in 1913.

Voluntary autobiographical memories (VAMs) and IAMs appear to serve different functions and have different retrieval mechanisms. Mace (2007) noted that "A complete understanding of the differences between involuntary and voluntary retrieval processes is perhaps the most challenging question facing involuntary memory research" (p. 7), and several studies have sought to compare and contrast VAMs and IAMs (Berntsen, 1998;

Berntsen & Hall, 2004; Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009; Schlagman & Kvavilashvili, 2008). While comparisons show VAMs and IAMs share similar features, there are major differences, primarily in retrieval times, and whether memories are of specific or general events (Schlagman & Kvavilashvili, 2008), suggesting different underlying retrieval mechanisms (e.g. Berntsen, 2010).

2.2 Autobiographical Memory Retrieval

Research on deliberate, or voluntary retrieval of autobiographical memories started much earlier than the study of IAMs in the late 1990s, and has primarily been based on laboratory methods, where participants retrieve autobiographical memories in response to cue words and phrases (Conway & Bekerian, 1987; Haque & Conway, 2001; Rubin, 2005). For example, participants are given 60 seconds to retrieve a particular memory from their past in response to a cue like “teacher”. When the participants recall a memory, they press a button or speak to the researcher, which allows for the retrieval time to be measured. Typically, when people are exposed to these cues, they often start by recalling generic lifetime periods (e.g. when I was at college) and then move on to more general events (e.g. maths classes) before eventually retrieving a particular memory in response to the cue (e.g. a particular interaction with a maths teacher). Based on such cue word experiments, Conway and colleagues developed an influential theory of voluntary autobiographical memory (Conway & Bekerian, 1987). According to this theory, autobiographical memory is not based on a single trace but rather distributed across a hierarchical system that represents various time periods or types of information. Consequently, memory retrieval is slow and effortful, and suggests that people struggle to retrieve specific memories. Retrieval times are on average 10-15 seconds (Brewer, 1995), which also implies that effort is needed to find the way to the bottom of such a hierarchy.

However, it was also noticed that sometimes memories were retrieved very quickly, or just "popped up", and these were called directly retrieved memories. The theory does not specify how this occurs, but Conway suggested these are somehow accessed directly from the bottom layer of the hierarchy (Conway & Pleydell-Pearce, 2000). Subsequently, Conway (2005) postulated that they are recalled from a separate pool of memories that have not yet been consolidated into the main autobiographical memory system. However, if this theory was correct, directly retrieved memories should be very recent memories, but this has not been supported by the results of several empirical studies (Ball & Little, 2006; Schlagman & Kvavilashvili, 2008). In Conway's model, directly retrieved memories were considered rare. It was supposed there is a suppression mechanism, which if not present would allow people to be flooded with memories.

The latest developments in the field are interesting because they start to challenge the earlier view that autobiographical memory is primarily effortful (Uzer, Lee, & Brown, 2012). In their study participants were allowed up to 90 seconds to retrieve memories in response to word cues. Three approaches were used in measuring direct retrieval versus strategic (generative) retrieval. In the first study, participants were asked to think aloud and describe their retrieval process. In the second study, participants worked silently without researcher present and responded via computer to eliminate any demand characteristics. In the third study participants were asked to indicate if they had accessed additional information during the retrieval process, which would indicate effort. Sometimes effortful generation processes were needed to retrieve autobiographical memories, but when participants in these experimental situations saw words to retrieve memories, around 60% of memories were directly retrieved and participants did not need to try. The reaction time was minimal, rather than the expected 10-15 seconds, and as soon as they saw the cue they had a memory. This is over seven times the frequency reported by Haque and Conway (2001), who had argued that generation is the default strategy, and direct retrieval is rare in memory tasks using a word-cue technique. In contrast, the results of Uzer et al. (2012) suggest direct spontaneous retrieval is the default mode of operation in response to the cue, and only if that fails then the person works on the cue to retrieve something from memory. In this new model, memory generation is thus a backup strategy if direct retrieval fails (*cf.* Schlagman & Kvavilashvili, 2008). Moreover, direct retrieval is independent of retrieval intentions, that is, it occurs even when one is intending to retrieve. Uzer et al. (2012) raise the possibility that perhaps the process of generation is about creating cues which can then cause direct retrieval. In their model, involuntary memories come to mind at least as frequently as voluntary memories and, in their view, this narrows the distance between IAM and VAM.

Uzer et al. (2012) argued that direct retrieval implies the existence of pre-stored event representations. This contradicts the reconstructive model of Conway and colleagues (Conway & Pleydell-Pearce, 2000; Haque & Conway, 2001). Research in involuntary memory shows that direct retrieval is frequent in natural settings. This raises the question of the relationship between directly retrieved memories in the laboratory and involuntary spontaneously retrieved memories in everyday life. Are they the same, or different? Research on this is only just starting but there seems to be a clear similarity between direct retrieval in the laboratory and the concept of involuntary autobiographical memory in general, because both are assumed to arise from associative, non-deliberate retrieval processes, but direct retrieval happens while in retrieval mode when trying to recall, whereas with IAM there is no intent to retrieve.

The terms involuntary and directly retrieved memories have often been used interchangeably, for effortless, non-strategic retrieval. However, the recent study by Barzykowski and Staugaard (2015) demonstrated differences between directly retrieved voluntary memories and involuntary memories. According to this study, directly retrieved memories, while the person was in retrieval mode, had different characteristics compared with memories that were spontaneously recalled while not in retrieval mode, for example the valence of the memory, valence of the event, relevance to life situation and frequency of rehearsal differed significantly. The authors argued that this could be due to encoding and consolidation differences.

2.3 Can We Study Involuntary Memory?

George Miller (1962) argued that it was not possible to study involuntary memories. In his opinion, the major problem facing a psychologist wishing to study IAMs "would be that he has no way to capture the thing he wishes to study. He can only sit and wait, hoping for the improbable" (Miller, 1962, p. 180). Similar concerns were expressed by Cohen (1996), who believed that involuntary memories "cannot, by definition, be elicited in the laboratory" (p. 6). Nevertheless, the term *involuntary autobiographical memory* was coined by Berntsen (1996), who perhaps was the first to attempt to study IAMs in modern cognitive psychological research. Research evolved rapidly since then. This rapid increase in research might also be associated with the rapid growth of interest in other spontaneous phenomena, such as mind-wandering, involuntary musical imagery (INMI), certain aspects of prospective memory, and intrusive memories that are based on spontaneous retrieval.

2.4 The Function of IAMs

Mace and Atkinson (2009) discussed the function of IAMs, asking whether they are an accidental production of a restless autobiographical memory system, or whether they serve a purpose. From an evolutionary perspective, they would appear to help with survival. For example, negative cues remind us of negative events and thereby help us to avoid dangerous situations (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Schank, 1999). Alternatively, they could be facilitating self-orientation and the sense of identity. These are not mutually exclusive of course.

Berntsen (2010) asserted that IAMs are functional. Although they can have disturbing side-effects in the form of repetitive intrusive memories, as seen in some clinical conditions such as PTSD, they are usually an adaptive expression of memory and facilitate learning how to survive. In particular, “the involuntary mode enables us to rehearse lessons from the past (and envision possible future events)” (p. 141). Berntsen (2010) also suggested that the function of IAMs is generally to optimise the current life situation, via the relation of memories to current concerns, expectations, and future plans, and goals. Alternatively, one might speculate that IAMs have no function at all, and they are merely accidental or coincidental.

2.5 Methods of Studying IAMs and Approaches to Data Gathering

The first 10 years of research on IAMs since it started in 1996, was almost entirely based on diary methods (Berntsen, 1996; Kvavilashvili & Mandler, 2004, Study 4; Mace, 2005). Although, laboratory methods for studying IAMs under more controlled conditions have been developed in the past decade (Ball, 2007; Mace, 2006; Mazzoni, Vannucci, & Batool, 2014; Schlagman & Kvavilashvili, 2008; Vannucci, Batool, Pelagatti, & Mazzoni, 2014), diary methods still continue to be used in many studies of IAMs (e.g. Barzykowski, 2012; Watson et al., 2012). Only very few studies have used surveys (Berntsen & Rubin, 2002) and retrospective questionnaires (Berntsen, Rubin, & Salgado, 2015).

2.5.1 **Diary Methods**

Different diary methods have been used to study IAMs. When Berntsen (1996) first started using a diary method, she was concerned about the burden on participants if trying to record every IAM, even though at the time IAMs were considered to be relatively infrequent, compared with more recent estimates. Therefore, Berntsen (1996) firstly ensured her participants were committed to the task by briefing them and giving them time to consider their engagement. She then recruited motivated participants to record up to two IAMs per day until they reached a target of 50. All participants had reached the target in six weeks (42 days). A two-phase approach was used in recording. Initially, at the time the participants experienced an IAM, they recorded a keyword or phrase and answered a fixed set of questions in a small notebook. Later, at a self-chosen time, they completed a more extensive questionnaire. While this potentially reduced the burden of recording, it necessarily introduced some retrospective bias into the detailed data collected later.

Ball and Little (2006) and Mace and Atkinson (2009) used a method that asked participants to record just one memory. On noticing a memory, participants opened a sealed envelope, completed the enclosed questionnaire, and returned it to the experimenters. Most were returned within a few days. As participants only completed data for one IAM, this was more convenient and less effort for them, but limited the data to one IAM recorded per participant. Although participants were instructed to send the first IAM they noticed, it is quite likely that they might have selected their IAM, perhaps choosing a more vivid or significant memory. As only one IAM per participant was collected, there was no means of detecting any relationships or trends within-subject, between different IAMs.

To get a fuller understanding of the nature and frequency of IAMs, other researchers have asked participants to record each IAM they notice, as soon as possible, for example, over seven days (Kvavilashvili & Mandler, 2004; Schlagman & Kvavilashvili, 2008) or two weeks (Mace, 2004, 2005). Recognising the burden, and the difficulty of recording all IAMs, and associated details, close to their occurrence, Schlagman and Kvavilashvili (2008) introduced a novel option of simply making a tick to acknowledge an IAM in situations, or circumstances, where it was not possible for participants to fully record an IAM, for example, while driving or in a meeting, particularly if there was a delay before it could be recorded.

2.5.2 IAMs and Questionnaires

Compared with other areas of cognitive psychology, the use of questionnaires in studying IAMs has been very limited. However, given the transient nature of IAMs, this is unsurprising. As IAMs are forgotten very quickly, if not immediately recorded, survey methods are open to retrospective bias. Retrospectively, the more distinctive memories may be the ones that come to mind, and retrospective estimates of frequency are therefore unreliable.

Using a survey method, 1241 respondents were asked to nominate their happiest, saddest, most traumatic, most important memory (all voluntary, by definition), but also their most recent involuntary memory (Berntsen & Rubin, 2002). Older participants indicated a clear bump in their 20s for happiest and important memories. Happy involuntary memories were more than twice as common as unhappy ones for all ages.

More recently, Berntsen, Rubin, and Salgado (2015) developed a new scale, the Involuntary Autobiographical Memory Inventory (IAMI), to assess the frequency of IAMs (and of involuntary future thoughts), and the relationship with several demographic variables (e.g. age) and other psychometric tests (e.g. measuring daydreaming, mind-wandering, PTSD). Based on this questionnaire, they found the frequency of IAMs did not decline with age while, for example, daydreaming did.

2.5.3 Laboratory Method

Several laboratory methods of studying IAMs have been developed, which facilitate greater control over extraneous variables and allow for manipulation of theoretically interesting variables (e.g. types of cues, levels of concentration, etc.), which could not be achieved with diary studies. Perhaps the most popular method is the one is the one that is based on the method developed by Schlagman and Kvavilashvili (2008). This method tried to mimic the conditions in which IAMs had been reported in diary studies, namely the presence of incidental cues and being engaged in undemanding activities at the time when an IAM comes to mind. Therefore, participants were engaged in an easy and monotonous vigilance task in which they had to detect rare targets (vertical lines) in the stream of trials with non-target stimuli (horizontal lines) and were also exposed to some irrelevant cue phrases on each trial, some of which could potentially trigger IAMs. If, during the vigilance task, participants suddenly recalled a memory from their past they had to press a button to stop the task and record their IAM.

A potential problem with this method is that people know they must record IAMs, and this may affect the number and types of memories recorded (Vannucci et al., 2014). To address this issue two alternative methods have been reported in the literature. One method is to have participants report anything task-unrelated that pops into their mind while carrying out a task (Barzykowski, 2012; Mazzoni et al., 2014) with the expectation that some of these thoughts would be IAMs. However, this may also be problematic because the ongoing task is so easy and undemanding that participants may experience many more spontaneous thoughts than they would be willing to report. Participants cannot realistically stop for everything because they would be stopping all the time.

The second method is to use the probe-caught method, where participants do not know what is being studied. They are told the study is about concentration, and they just report what is going through their mind, when stopped and asked, which is thus the most reliable source of unbiased memories (Plimpton, Patel, & Kvavilashvili, 2015; Vannucci et al., 2014). Further, with a fixed schedule of interruptions, participants reported significantly more IAMs (Vannucci et al., 2014), and when participants were aware of the types of memories being sought (i.e. IAMs), participants reported more specific memories. These memories had also been rehearsed more frequently than the IAMs reported in the condition where participants reported all task-unrelated mental content. Vannucci et al. (2014)

suggested these findings indicate that what is currently known about involuntary memories might be far from the final picture and that important components of the process of retrieval are probably still not fully understood. When participants must interrupt themselves, this limits the memories to those that are necessarily over an awareness threshold. This becomes important when comparing characteristics of IAMs. While it is tempting to ask participants to focus on IAMs, this research suggests that in the laboratory it may be better to ask them to observe general mental activity, with either participant- or experimenter-interruption.

2.6 Conditions for IAMs

2.6.1 **Undemanding Tasks**

There is strong evidence from IAM research, and research in related fields such as mind-wandering and involuntary musical imagery, that spontaneous thoughts and memories tend to occur when people are engaged in undemanding, easy, habitual activities, for example making a hot drink, brushing teeth, or driving, and this is corroborated by diary and laboratory studies (Berntsen, 1996; Giambra, 1995; Kvavilashvili & Mandler, 2004; Schlagman & Kvavilashvili, 2008). Conversely, IAMs are less likely to occur when undertaking cognitively demanding tasks. Vannucci, Pelagatti, Hanczakowski, Mazzoni, and Paccani (2015) demonstrated this powerfully, by manipulating cognitive load in a vigilance task via the frequency of irrelevant verbal cues, or by adding an arithmetic task to the slides in the vigilance task. In the frequent word cue condition, 300 cue-phrases were presented in 450 trials (i.e. a ratio of 2 in 3), while in the infrequent cue condition 90 word-cues were presented in 450 trials (1 in 5). In the arithmetic condition, a set of 210 arithmetic operations in the form of easy additions and subtractions (e.g. 3 + 8 = 11) was used in addition to the 90 slides presenting word cues. In both conditions with increased load (increased word cue frequency, or word plus arithmetic operations), the number of IAMs reported was reduced in comparison to the infrequent condition with cue words presented on only 90 slides. While there were fewer cues, there were more IAMs, but when there were many word cues, or the cognitive load was increased by the arithmetic task, the number of memories was suppressed. A similar effect of cognitive load was obtained in a study of involuntary musical imagery (INMI) (Floridou et al., 2016) where participants listened to two songs and then either sat for five minutes with eyes closed, or performed a simple dot task (counting blue dots, but not red dots, which alternated), or more elaborate tasks on dots (counting blue but not red dots, when randomly displayed). In the “eyes closed” condition, 65% of participants reported having replayed the music in their mind. However, even with the simplest dot task, there was a dramatic drop to 32.5%. As the task got more demanding, there was a trend to drop further but it was not statistically significant. As such, even very low level of activity seems to markedly reduce the chances of something popping into mind.

2.6.2 **Cues and Triggers**

Another important feature of IAMs is that they often occur in response to triggers in one’s environment or thoughts (Mace, 2004; Mazzoni et al., 2014). For example, seeing friends in the street may elicit a memory of spending time with them, hearing some music may elicit a situation when the music was playing, or thinking about booking a plane ticket may elicit an experience from a previous trip. Most IAMs can be traced to easily identifiable cues, or triggers. In most diary studies cues have been reported in a large percentage of cases, for example, in 93% of 700 memories in a study by Berntsen (1996) and in 91% of 238 involuntary memories in a study by Schlagman and Kvavilashvili (2008). However, a cue cannot always be identified by the individual reporting the IAM. Further, research to date has found that cues form part of the remembered event (Berntsen, 1998; Mace et al., 2015; Schlagman et al., 2007). The majority of cues are external (environmental) rather than internal (e.g. from thoughts while planning, or retrieval of other information), with very few cases where there is no identifiable trigger (Berntsen, 1998; Berntsen & Hall, 2004;

Schlagman & Kvavilashvili, 2008; Schlagman et al., 2007). Berntsen and Jacobsen (2008) showed that 84% of IAMs were reported as being triggered by cues, with 52% of those being external cues. A number of studies have shown that verbal cues are more likely to elicit IAMs than sensory or perceptual cues (Mace, 2004; Mazzoni et al., 2014; Schlagman & Kvavilashvili, 2008; Schlagman et al., 2007). Contrary to the popular view that Proustian type of cues of smell and sensory cues trigger autobiographical memories, taste and smell account for very few memories in real life (Mace, 2004), and sensory cues are rarely noted in diary studies.

In laboratory studies it is possible to manipulate cue valence, and results from such studies have shown that IAMs are more likely to be elicited by negative than by neutral or positive cues (Kvavilashvili & Schlagman, 2011; Schlagman & Kvavilashvili, 2008). This supports the evolutionary model of the function of autobiographical recall, which offers protection in danger.

2.7 Chaining

The term *chaining* was coined by Mace (2006) and refers to a phenomenon where an initial memory (which may have been recalled deliberately or spontaneously) triggers a subsequent IAM, which may in turn trigger the next IAM. Berntsen (2009) has referred to this as *successive recollections*. A chained memory, cued by an immediately prior memory, is by definition internally cued because a triggering memory is an internal mental event. This internal memory trigger could be voluntarily recalled (Mace, 2005), but there is no reason why the chained memory cannot come from a preceding IAM as well. In self-reporting methods, such as diaries, or even surveys, participants may not report the chained memories as they are not usually briefed to monitor for them. If participants do observe them, they may choose to report only the first memory, or aggregate the multiple memories into a composite memory description. Mace, Clevinger, and Martin (2010) argued that different retrieval mechanisms may underlie involuntary recall of memories in response to external or internal cues, and memories that are caused by other memories. Mace (2010) argued that these different memory retrieval processes are due to different types of spreading activation processes. External or internal cues initiate a spreading from other memory systems, whereas memories cued by other memories are contained within the autobiographical memory system.

2.8 Priming

The classic understanding of priming comes from semantic and episodic memory research where, for example, seeing one word affects how a subsequent word is processed in terms of reaction time. In implicit memory studies, in a word-fragment completion task a word may come to mind spontaneously if primed with earlier sight of the word.

In a study of the organisation of autobiographical memory, Conway and Bekerian (1987) found that voluntary autobiographical memories were retrieved faster if participants were primed by lifetime period cues, for example, attending school or living in a particular place. These life period primes therefore appeared to show that it is possible to activate autobiographical memories, but there is very little further research on this in VAM, or indeed IAM.

Beyond the immediate effect of chaining, where there is only minimal delay between the subsequent memories, there is evidence that IAMs can be primed from some time earlier, i.e. earlier recollections or cues influence later spontaneous recollections (Mace, 2010). The earlier recollection can be voluntary recollection. For example, in a two-week diary study of IAMs (Mace, 2005), participants returned to the laboratory at the mid-point and voluntarily recalled high school memories for 30 minutes. The participants then reported more IAMs in the second week related to their high school days, than they had in the first week. Interestingly, the involuntary memories were not simply repeated involuntary recollections of the previously laboratory-based voluntary recalls, but included the recollection of new memories from this time period. This demonstrated evidence of the spreading activation concept as a potential underlying mechanism of IAMs.

Kvavilashvili and Mandler (2004) proposed that the activations could be long-lasting, resulting in memories coming to mind some time after the priming event occurred. The priming event may then have been forgotten, or be difficult to trace. This then raises interesting methodological questions about whether there is a way of detecting earlier cues, or primes, and measuring the effect of them. While Mace (2005) demonstrated the priming of IAMs with earlier recall of voluntary memories, it is reasonable to believe that earlier IAMs could also be responsible for priming later IAMS. Such mechanisms are absent from the literature, but this possibility is examined empirically in this dissertation.

2.9 Characteristics of IAMs

2.9.1 **Specificity**

Autobiographical memories can be of specific events that occurred at a particular time and place, or they can be of general events occurring repeatedly or over a protracted period of time. Examples of specific memories are the day of moving into a new house, when a family member was born or a short definable period such as watching a particular TV programme. Other memories may refer to more general events that occurred repeatedly over an extended period (e.g. commuting to work every morning, attending school, or taking holidays in the same place annually).

In VAM studies, participants tend to recall general memories, even when specific memories are requested. In studies that have compared VAMs and IAMs in the same participants (Ball, 2007; Berntsen & Hall, 2004; Mace, 2006; Schlagman & Kvavilashvili, 2008) the percentage of *specific* IAMs was reliably higher than *specific* VAMs. Berntsen (1998) found a similar effect in a between-subjects study design.

2.9.2 Other Characteristics of IAMs

Other aspects of IAMs have been less consistently observed. Berntsen (1998) found IAMs more positive and more recent, but less rehearsed, than voluntary memories. However, this was not replicated by Berntsen and Hall (2004) where no differences in the age of memories or prior rehearsal was found, but involuntary memories were less positive and more unusual.

The findings of Schlagman and Kvavilashvili (2008) showed that IAMs were more likely to be triggered by negative cues, whereas cue valence did not have any effect on the number of voluntary memories. Furthermore, laboratory measured involuntary memories did not differ from naturalistic involuntary memories recorded in a diary by the same participants (Study 2).

2.10 Issues with Current Methods

Although diary methods have produced largely consistent results, recent interest in the frequency of IAMs, and the nature of retrieval of IAMs, and their overlap with voluntary memories, suggests that the time is right for a re-examination of the methods used. The validity issues that come up in relation to the diary method in IAM research, while perhaps initially disconcerting, is a healthy development and is a sign of a maturing field of research. Previously, validity of findings was not questioned, partly because people were finding consistent replications, but recent findings are starting to cast some doubts, raise questions, and highlight limitations of the diary method. If there are problems with the method, they should be addressed.

Of recent interest is the extent to which participants are made aware of what they are being asked to record. Vannucci et al. (2014) found that the proportion of specific IAMs was lower when the IAMs were caught in the laboratory by the experimenter asking the participants (59.5%), compared with self-caught IAMs recorded by the participants (74.5%).

The 74.5% is comparable with previous diary studies (Berntsen, 1998; Berntsen & Hall, 2004; Schlagman et al., 2009). Plimpton et al. (2015) reported a similar low percentage of specific IAMs with experimenter-imposed probes (57.7%), when the participants were recording all task-unrelated thoughts in response to random thought probes. Similarly, when participants recorded their thoughts during a vigilance task in response to prompts, and only retrospectively classified them (as a memory or future thought), the specificity of involuntary memories was much lower than when they were monitoring for IAMs in a diary or in a laboratory vigilance task (Schlagman & Kvavilashvili, 2008). This points to a possibility that participants have more IAMs than they are aware of, and warrants further evaluation. In diaries, and in the laboratory, participants may only be recording a subset, and/or sub-class of IAMs and perhaps there are issues of identification and classification. However, when stopped by the experimenter, it may be that participants are creating memories in response to demand characteristics, or conversely it could be argued that interrupting could prevent fabrication of IAMs. It seems that IAMs that get entered in the diaries of participants may be more distinctive, specific IAMs because they are the ones that get noticed. This raises the question of whether laboratory studies and diaries are measuring the same thing.

2.11 Potential Research Questions / Unanswered Questions:

Cues, triggers and priming are not fully understood. This is partly a problem of terminology. For instance, are triggers immediate, and does priming refer to more delayed responses? Are these delays minutes, hours, days or longer? Is it possible to identify primes, and to detect or measure these delays? Should the distinction be made on time differences or whether different mechanisms are at play? Recent laboratory research has raised questions about retrieval mechanisms, and challenged earlier models. Can these mechanisms be examined using diary methods, or other ecological approaches?

While there are large individual differences in the experience of IAMS, the frequency of IAMs seems to be considerably greater than originally appreciated at the beginning of IAM research. The true frequency remains unknown, and perhaps cannot be fully known, but warrants further research and is thus first investigated in Study 2 (Chapter 4), where the relevant literature is presented. The frequency of IAMs is further addressed in Studies 5 and 6. IAMs measured in a variety of ways have common characteristics, but as shown above, other characteristics change depending on various factors. For example, characteristics can be affected by changing how the participants are briefed, how they are asked to record the IAMs, and for how long they are required to monitor themselves.

CHAPTER 3: Comparing Paper and Smartphone Diaries of Involuntary Autobiographical Memory: A 7-Day Study (Study 1)

3.1 Introduction

The review of the diary method in Chapter 1 showed that it has evolved and has kept pace with technological advances. With the increasing ownership of smartphones worldwide, the opportunity exists now to use these participant-owned devices for cognitive psychological research. However, while some researchers have started to do this (Killingsworth & Gilbert, 2010; MacKerron & Mourato, 2013; Monk et al., 2015), no systematic comparisons have been made between participant-owned smartphones and traditional paper diary methods to establish how participants use them and whether the data are equivalent, as was the case with earlier generations of electronic devices versus paper (Dale & Hagen, 2007; Lam et al., 2010).

The overall conclusion from the Dale and Hagen (2007) review of PDAs and paper diaries, and the general debate about “paper or plastic” was that the paper diary method should not be replaced universally by electronic diaries (Bolger et al., 2006; Broderick, 2008; Dale & Hagen, 2007; Tennen et al., 2006). Rather, the method used should be influenced by the nature of data collected, the characteristics of the populations tested and research questions asked in a study. This aspect of methodology has become of interest again because, for the first time, participants can almost universally use devices that they own. This changing landscape could substantially modify the way participants interact with ecological studies.

The possibility of using participant-owned smartphone diaries raises several important questions about the diary method. Participant-owned smartphones may provide the opportunity to reduce costs, increase compliance and improve data quality. Further, their use can increase the geographic reach of studies, and ease recruitment. However, the nature of how participants might use their own phones, compared with paper, is unknown and should be evaluated formally. Study 1 addresses the gap in research by conducting the first systematic comparison of an electronic diary app installed on the participants' own smartphones versus paper diaries.

The general aim of this study was to build a simple smartphone app, comparable with paper diaries previously used, and conduct this systematic comparison to study the unique effect of participants using their own devices. Of particular interest was the self-initiated event-contingent diary method, which was not properly represented in a review conducted by Dale and Hagen (2007), as they concentrated primarily on probe-contingent experience sampling and time-based diary methods. However, as observed in Chapter 2, the event-contingent recording method has dominated in research on IAMs, and other types of transient phenomena. It is also used increasingly in clinical and medical research and merits further investigation.

An app was installed on participants' own smartphones for self-initiated recording of event-contingent memory phenomena using 7-day recording of involuntary autobiographical memories (IAMs). This study builds on previous paper diary methods to study IAMs (Mace, 2004; Schlagman & Kvavilashvili, 2008), adding a participant-owned smartphone condition.

There seems to be just one published paper describing smartphone diaries for IAM research (Rasmussen, Ramsgaard, & Berntsen, 2015, Study 2 and 3), but these were standard Android smartphone models lent to the participants, and there was no evaluation of the smartphone method versus the standard paper diary method.

3.1.1 **The Smartphone Diary and App Design Philosophy**

The smartphone app was made as similar as possible to the paper diary, both in terms of simplicity of completing a diary entry and the questionnaire format/interface. It was installed on the participants' phones by the researcher, and available to the participant as an icon on the home screen of the phone. All questions were the same as in the paper diary, except that participants did not need to enter the date and time that the memory was recorded in the app because the diary entries were date and time-stamped automatically using the phone's internal clock. In addition, in the smartphone app, the time participants took to complete their diary entries was computed.

The design philosophy was to keep the app as simple as possible: it was to work on participants' own phones, had to launch quickly, and there was no logon screen. Unlike many phone apps, it had a very clean and simple interface that mimicked as closely as possible the paper diary with which it was being compared. Every effort was made to avoid it being more attractive to use than a paper diary. There were no pre-filled (default) answers. As with the paper diary, any field could be left unanswered. If a participant omitted a field, at the point of submitting they were not alerted to the omission.

Data were kept locally on the phone for the seven days so there was no requirement for an Internet connection, and no use of the participant's phone data plan, so there was no financial deterrent to making entries. This was important as it meant entries could be made at any time, even when the phone was out of mobile or Wi-Fi signal (e.g. on the London Underground, or if the phone was in "flight mode"). As such there would be no excuse that it was not possible to record an IAM because of a lack of Internet connection. Participants could not edit completed entries, and there was no prompting to make entries.

3.1.2 **Study Design**

Participants were randomly assigned to either a paper- or smartphone-diary condition and had to fill in a set of questions and rating scales every time they experienced an IAM. They were also allowed to simply acknowledge the memory if they were unable to fill in a diary entry at the time of its occurrence (see Schlagman & Kvavilashvili, 2008). The smartphone app was designed to be as near-equivalent to the paper-diary as possible, and was installed on the participant's own smartphone (iPhone or Android)[3]. In addition, all participants completed questionnaires about their smartphone ownership and usage patterns (before keeping a diary), and a diary compliance questionnaire (after seven days of recording).

Paper- and smartphone-diaries were compared in terms of self-assessed compliance and the actual number of IAMs recorded. Compliance was measured by several indices, such as the number of days that participants reported keeping the diary with them, the percentage of IAMs that they had been able to record, the delay between the IAM occurrence and its recording, and the length of memory descriptions. The additional aim was to compare the phenomenological characteristics of the IAMs recorded by the two methods (e.g. ratings of vividness, pleasantness, previous rehearsal).

The main prediction was that participants would show greater compliance in carrying their own smartphones than paper diaries over the 7-day period. Therefore, participants in the smartphone-diary condition would record more IAMs and possibly sooner after having a memory than those in a paper-diary condition. On the other hand, if writing on paper was preferred over typing into smartphones by most participants, then one would expect memory descriptions to be shorter in the smartphone- than paper-diaries, or the number of acknowledged memories would be higher in the smartphone than in the paper diaries. However, no differences between the two methods were expected to occur in terms of ratings of memory characteristics.

[3] The term "smartphone" has been used for several years and the meaning has evolved. Here smartphone is defined as an Apple iPhone, Google Android-based or Windows 8/8.1/10 based phone capable of running apps written by third-parties, and having Internet access and high resolution touch-screens.

3.2 Method

3.2.1 **Participants**

Sixty participants, who owned an Apple iPhone or a smartphone with the Google Android operating system, were recruited from university students and staff. They were randomly allocated to smartphone-diary (N = 29, 3 male, 26 female), and paper-diary (N = 31, 3 male, 28 female) conditions.[4] The mean age of the smartphone group was 24.14 years (*SD* = 8.16, range 18-51), and did not differ from the mean age of 24.71 years (*SD* = 9.28, range 18-51) in the paper-diary group ($F < 1$). Psychology students (20 in the smartphone-, and 22 in the paper-diary condition) received course credit for their participation.

The iPhone was more common than Android in both groups, but the proportion of iPhone and Android ownership did not differ by condition, $\chi^2(1, N = 60) = 2.55, p = .11$. There were no group differences in the length of ownership of a smartphone with a mean of 2.01 years (*SD* = 1.09) in the smartphone group, and 2.07 years (*SD* = 1.72), in the paper diary group ($F < 1$), or the frequency with which the groups reported upgrading their phone on a 5-point scale ("*Once a year or as soon as a new version comes out*", "*About every 2 years*", "*About every 3 years*", "*About every 4 years*" or "*About every 5 years or less often*"), $\chi^2(4, N = 60) = 3.80, p = .43$.

3.2.2 **Materials**

3.2.2.1 ***Smartphone Usage Questionnaire***

Before completing the diary study, participants answered several questions about their use of smartphones. Questions were divided into two sections. The first nine questions were

[4] One additional female smartphone participant did not return for two weeks, and the data on her phone indicated that she had not complied (most of her recordings were in the 14 days beyond the agreed 7-day period). Hence, her data were not included in the final sample of 60 participants reported here. This, however, illustrates a key benefit of the smartphone diary.

answered on 3-point scale with response options of "*Yes, regularly*", "*Yes, sometimes*" and "*No*" and assessed use of the smartphone for voice calls, texting (SMS), making notes, social networking, managing a calendar, contacts and address book, web access, reading email, and playing games. Participants were then asked to rate their typing speed on a phone keyboard ("*very slow*", "*slow*", "*average*", "*fast*" or "*very fast*"), how often they made errors when typing ("*never*", "*once or twice*", "*a few times*", "*several times*" or "*many times*"), and their ability to adapt to new technology ("*very slow*", "*slow*" "*average*", "*fast*" or "*very fast*"). See Appendix A.

3.2.2.2 ***Diary Compliance Questionnaire***

A diary compliance and feedback questionnaire was completed after the diary-keeping phase. Participants had to indicate whether they carried the diary with them every day of the study (*yes/no*). If the 'no' option was chosen, they indicated how many days they forgot. Participants also had to estimate what percentage of all the IAMs that they had in the 7-day period they were able to record (fully and in the form of acknowledged or 'ticked' memories). Finally, they had to rate how easy they found (i) keeping the diary with them at all times and (ii) recording their memories in the diary (*Very easy, Somewhat easy, Somewhat difficult, Very difficult*). See Appendix B.

3.2.2.3 ***Paper Diary***

In the paper diary condition, participants received an A5 paper diary booklet containing 32 identical pages, one page to be completed for each IAM experienced.

The following items were collected in the diaries: 1. When did you have a memory (*Date and time*); 2. When did you record it? (*Date and time*); 3. Describe your memory, what was it about? (*free text entry*); 4. How vivid is your memory (a 7-point scale: 1 = *very vague*, to 7 = *extremely vivid*); 5. Was the memory triggered by something? (a) *In your thoughts*, (b) *In your environment*, (c) *There was no trigger*; 6. If there was a trigger, what was it? (*free text* *entry* to describe the trigger, if known). 7. Please estimate the time between the trigger and the memory (*free text entry for participants to indicate any perceived delay between the trigger and occurrence of the IAM*). 8. What were you doing? (*free text entry* to describe their activity); 9. How much were you concentrating on this activity? (1 = *not at all*; 5 = *fully concentrating*); 10. How pleasant or unpleasant is the memory now (1 = *very unpleasant*, 2 = *quite unpleasant*, 3 = *neutral*, 4 = *quite pleasant*, 5 = *very pleasant*); 11. How pleasant was the original event? (1 = *very unpleasant*, 2 = *quite unpleasant*, 3 = *neutral*, 4 = *quite pleasant*, 5 = *very pleasant*); 12. Is the memory of a general or specific event? (1 = *General*; 2 = *Specific*); 13. When did the original event occur? (*free text area* to provide a description of the time); 14. Have you ever had this memory before? (1 = *never*, 2 = *once or twice*, 3 = *a few times*, 4 = *several times*, 5 = *many times*). The diary page is shown in Appendix C, and the Diary cover page, including the memory acknowledgment grid, and instructions is shown in Appendix D.

3.2.2.4 ***Smartphone Diary App***

The smartphone diary app contained the same questions and used the same ratings as the paper diary, except that participants were not asked when they recorded the memory as this could be determined from the smartphone's internal clock. See Appendix E for screenshots of the app.

3.2.3 **Procedure**

The study was advertised through the psychology department course credit system, on the university intranet, and via university mailing lists. Participants were told that it was a 7-day diary study of IAMs. They had to own a smartphone and be willing to use it to take part in the study, but they were told they may be asked to carry a paper diary. They were not told that the purpose was to compare the two modes of data collection.

Following consent, participants supplied demographic information, and completed the Smartphone Usage Questionnaire. Participants in the paper-diary condition were given an A5 paper diary booklet containing 32 identical pages. For those in the smartphone-diary condition, the researcher installed the app on their smartphone while they were completing questionnaires.

Each participant was individually briefed thoroughly for 20-30 minutes, taking them through each item on the diary page, or on the smartphone screen. The concept of IAMs was carefully explained, with relevant examples. A clear distinction between voluntary and involuntary memories was made. For example, participants were told that if someone asked them about what they did on their last birthday that was voluntary, not an involuntary memory, and should not be recorded, but if they were buying a birthday card for someone and, thus, thought about their own most recent birthday, or another birthday party they had attended, that would be an involuntary memory and should be recorded. The concept of general and specific memories was also illustrated. For example, if they found themselves thinking about the school they had attended for several years before university, that would be a general memory, but if they thought about a particular incident in a lesson, perhaps when the teacher had told them off, that would be a memory of a specific event.

Participants were asked to record any IAMs that occurred over the next seven days, starting from waking the day after the briefing (day 2), so that only full days were recorded. In addition to verbal briefing, they were given written instructions on how to complete their paper or smartphone diary. See Appendix F.

Participants were urged to keep the diary with them at all times and record their IAMs immediately, or as soon as possible after occurrence. However, they were informed that it would not always be possible, or appropriate, to record memories, because of activities such as driving, meetings or social or work situations. If that was the case, and to minimise the back filling, they were advised if they could not complete immediately and later felt that they could not record key characteristics, they could record them as a tick (implemented as grid, with rows for the appropriate day, in the inside front cover of the paper diary) or by pressing an *acknowledge memory* button in the app. Acknowledge button presses in the app were time-stamped. No expectations were set regarding the number of memories participants were expected to record. Participants were also told that if the memory was too personal, or embarrassing, they should record as much as they were willing, and enter the description as "too personal".

Finally, an appointment was made with each participant for them to return one, or two days after the 7-day diary-keeping period (day 9 or day 10), to hand in the paper diary or have the electronic diary data uploaded to a data-server, at which time they completed the Diary Compliance Questionnaire and were debriefed.

3.3 Results and Discussion

Both parametric and non-parametric methods of analysis were used depending on the type of the dependent variable used. Unless otherwise specified, the rejection level was set at .05, and the effect size, measured by partial eta-squared (η_p^2), was defined as .01, .06, and .16 for small, medium and large respectively (Cohen, 1988). No corrections have been made for multiple comparisons throughout, because the measures were exploratory, and were often simply trying to rule out gross differences between, for example, subject groups or memory characteristics.

3.3.1 **Equivalence of Groups – Smartphone Usage**

Before starting any analysis, it was essential to establish the group equivalence in terms of participants' use of their phones for a variety of purposes, their technical ability with phones, and their attitude towards new technology. Participants were asked to what extent they used their smartphone for various tasks ('*Yes, regularly*', '*Yes, sometimes*', and '*No*'), such as phone calls, texting, playing games. No significant differences between the groups were found. Similarly, there were no significant differences between the groups in their self-rated typing ability, error rates on a smartphone keyboard, or their adaptability to technology (see Table 3-1 for a summary).

Table 3-1.Comparing Groups on their Use of Smartphones and Technical Ability

Smartphone Usage	χ^2 (2, N = 60)	p
1. Phone Use		
Voice calls	1.39	.50
Texting (SMS)	0.30	.59
Making Notes	1.14	.57
Social networking	0.66	.72
Managing calendar	4.25	.12
Contacts/Address book	4.45	.11
Web access[a]	3.21	.20
Reading email	4.27	.12
Playing games	1.64	.44
2. Self-rated Phone Ability		
Rate typing on phone	1.81[b]	.61
Keyboard errors	2.12[c]	.71
Self-rated technical adaptability	4.02[b]	.26

Note: [a] N=37; [b] degrees of freedom = 3; [c] degrees of freedom = 4;

3.3.2 Measures of Compliance in Paper- and Smartphone-diary Conditions

Next, to address the hypothesis that compliance rates would be significantly higher in the smartphone- than paper-diary condition, analyses were conducted on several different measures of compliance provided in diaries and in the post-diary questionnaire. The length of memory descriptions was also compared.

3.3.2.1 ***Self-rated Retrospective Compliance***

At the end of the study, all participants completed the Diary Compliance Questionnaire. There was no significant difference between the groups in terms of the percentage of IAMs that they reported to have been able to record (69% in the smartphone-diary, 68% in paper-diary condition, $F < 1$). However, groups differed significantly on the remaining questions. For example, while 79% of the smartphone group reported that carrying the diary with them at all times was ‘very easy’, only 21% of participants in the paper-diary condition chose this option on a 4-point rating scale (*very easy, somewhat easy, somewhat difficult, very difficult*), χ^2 (3, $N = 60$) = 21.94, $p < .0001$. Similarly, 68% of participants in the smartphone-diary condition reported that recording memories in the diary was ‘Very easy’ in comparison to only 32% of participants in the paper-diary condition, χ^2 (3, $N = 60$) = 8.54, $p = .036$.

Consistent with this, and perhaps most importantly, all smartphone-diary participants reported carrying their smartphone with them on each of the seven days of the study, whereas in the paper diary condition, 35% reported forgetting to carry the diary for one, two or even three days (see Table 3-2).

This difference between the conditions was significant when comparing the number of participants who carried diary with them on all seven days with those who reported forgetting on one to three days, χ^2 (1, $N = 60$) = 12.60, $p < .0001$. In addition, in a one-sample *t*-test, the number of forgotten days in the paper-diary condition was significantly different from zero, $t(30) = 3.50$, $p = .001$.

Table 3-2. Number of Participants, in Each Diary Condition, who Reported Forgetting to Keep a Diary on a Given Number of Days (Paper- vs Smartphone Diary) in Study 1

	Number of Days Diary Forgotten				
	0	1	2	3	Total
Smartphone	29 (100%)	0 (0%)	0 (0%)	0 (0%)	29
Paper diary	20 (65%)	6 (19%)	3 (10%)	2 (6%)	31

3.3.2.2 *Delay between Reported Occurrence of Memory and its Recording*

Participants in the paper-diary condition recorded the time they experienced the memory, and the time they recorded it in the diary. In the smartphone-diary condition, participants only recorded the time they experienced the memory as the diary entry was automatically time-stamped. Table 3-3 shows the compliance times of recording memories in the diary, by condition.

Table 3-3. Number of Memories Recorded in Each Time Window by Condition (Paper- vs. Smartphone-Diary) in Study 1

	Diary Entry Compliance Time			
	Up to 10 minutes	10 minutes to 1 hour	Over 1 Hour	Total
Smartphone app	193 (71%)	44 (16%)	36 (13%)	273 (100%)[a]
Paper diary	296 (54%)	121 (22%)	192 (24%)	546 (100%)[b]
Total	489 (60%)	165 (20%)	165 (20%)	819 (100.0%)

Missing cases: [a] 3; [b] 13

Nearly 71% of memories were recorded in the smartphone diary within 10 minutes of occurrence, whereas 54% were said to have been recorded in the paper diary within 10 minutes. Nearly a quarter of all IAMs in the paper-diary condition were recorded over an hour after they were said to have occurred compared to only 13% of IAMs recorded in the smartphone diary condition. The differences between the conditions were significant, χ^2 (2, N = 819) = 21.43, $p < .0001$.

3.3.2.3 *Additional Measures of Compliance*

The mean number of words in memory descriptions in the smartphone-diary condition (M = 14.81, SD = 10.01) was not significantly different from the mean number of words in the paper-diary condition (M = 13.69, SD = 5.60), $F < 1$.

For IAMs recorded on smartphones, the time from opening the app's IAM page to pressing "save" was logged. The median completion time was 2 minutes 46 seconds, with the quickest entry being 1 minute and 4 seconds. The longest entry times were 13, 19 and 24 minutes, suggesting that participants were distracted but came back to complete their entries. This information was not available for the paper-diary condition as participants were not asked to record the amount of time it took them to complete an entry.

In summary, results presented in this section provide strong support for the original prediction that participants in the smartphone-diary condition would exhibit significantly better compliance than those in the paper-diary condition. The superior compliance displayed in the smartphone-diary participants, especially in terms of carrying the diary with them on every day of the study, provides preliminary support for the second prediction that more memories would be recorded in smartphone- than paper-diaries.

3.3.3 **The Number of Recorded Memories**

All participants kept a diary and made at least two entries during the 7-day period. A total of 835 memories were fully recorded by completing a diary page questionnaire (559 in the paper-diary and 276 in the smartphone-diary condition), and 442 memories were acknowledged by putting ticks in the special grid on inner cover page of the paper-diary (304 in the paper-diary) or pressing a button in the app (138 in the smartphone-diary condition). Just five of the 835 fully recorded memories were marked as "personal", one for each of two participants in the smartphone group, and one participant marking three as personal in a paper diary. Other items on the diary page for these "personal" memories were completed (e.g. ratings of concentration, vividness etc.) and these entries were therefore included in the analyses. Two independent coders checked memory descriptions and all were deemed to be autobiographical memories, which was probably due to very careful instructions and briefing, so participants knew what they were supposed to record.

In line with previous research on IAMs, there was a large variability in the number of recorded and ticked IAMs in both conditions (see Table 3-4). To normalise the data, the analyses of variance were carried out on square root transformed means. In contrast to predictions, results showed that participants in the paper-diary condition recorded almost twice as many entries than those in the smartphone-diary condition, $F(1, 58) = 16.74$, $p = .0001$, $\eta_p^2 = .22$ (see Table 3-4). Similar results were obtained for the number of acknowledged memories $F(1, 58) = 4.15$, $p = .046$, $\eta_p^2 = .067$.

Table 3-4. Mean numbers (Standard Deviations) of Recorded and Acknowledged Involuntary Autobiographical Memories (IAM) in Study 1 in Paper- and Smartphone-Diary Conditions

		Condition	
		Paper-diary	Smartphone-Diary
Fully Recorded			
	Mean	18.03	9.52
	SD	10.68	8.43
	Range	4-56	2-46
Acknowledged			
	Mean	9.81	4.76
	SD	9.86	4.84
	Range	0-34	0-20

To understand possible reasons behind this counterintuitive finding, the number of fully recorded IAMs across the seven days of diary-keeping were examined to see if different patterns emerged in two conditions. The results of a 2 (condition) x 7 (days) mixed ANOVA on the mean number of IAMs (square root transformed) showed that, in addition to the main effect of condition, there was a main effect of days, $F(6, 348) = 6.48$, $p <.0001$, $\eta_p^2 = .10$. Importantly, the interaction between the condition and days was approaching significance, $F(6, 348) = 1.91$, $p = .078$, $\eta_p^2 = .03$. Because the means presented in Figure 3-1 show very different patterns, a follow up analysis was carried out to tease apart this interaction.

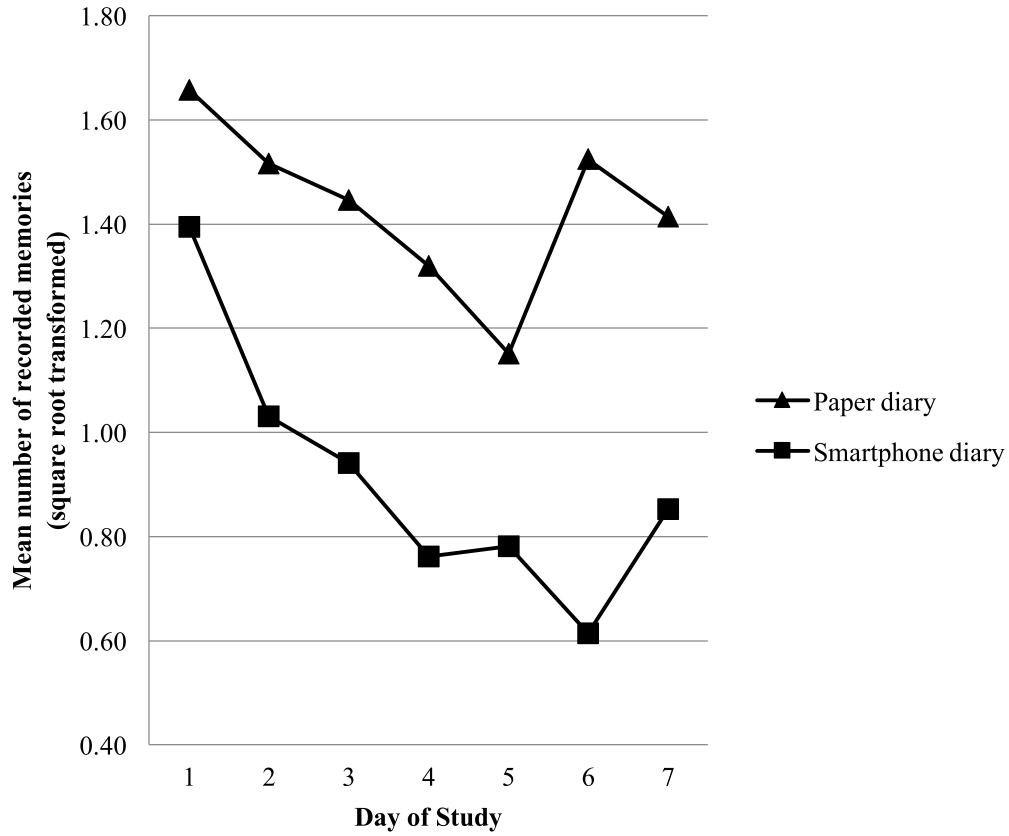

Figure 3-1 Mean Number of Fully Recorded Memories (square-root transformed) Each Day in Paper- and Smartphone-Diary Conditions in Study 1

Tests of simple main effects showed that the main effect of days was significant in both conditions (for paper-diary: $F(6, 53) = 2.56$, $p = .03$, $\eta_p^2 = .23$, and for smartphone-diary $F(6, 53) = 5.58$, $p = .0001$, $\eta_p^2 = .39$), but *post hoc* tests comparing the mean number of memories in Day 1 to each of the subsequent days showed a very different pattern. Specifically, participants in the smartphone-diary condition recorded significantly more memories on Day 1 than any of the subsequent days (all p values $\leq .001$), which indicates that there was a sharp drop in the number of recorded memories from the second day of the diary keeping period. In contrast, in the paper-diary condition, the number of recorded memories remained stable in the first three days (with p-values ranging from .16 to .67). The significant drop in the number of recorded memories occurred only on Day 4 and Day 5 in comparison to Day 1 ($p = .008$, and $p = .002$, respectively), and the number of recorded memories increased thereafter so that the number of recorded memories on Day 6 and Day 7 were not significantly different from that recorded on Day 1 ($p = .35$ and $p = .097$, respectively) (see Figure 3-1). It is also important that the difference between the paper- and smartphone-diary was significant on each day of the study except on Day 1 where the difference failed to reach the statistical significance, $F(1, 58) = 2.19$, $p = .145$, $\eta_p^2 = .036$ (Day 2: $F(1, 58) = 6.40$, $p = .01$, $\eta_p^2 = .099$; Day 3: $F(1, 58) = 8.35$, $p = .005$, $\eta_p^2 = .13$; Day 4: $F(1, 58) = 7.48$, $p = .008$, $\eta_p^2 = .11$; Day5: $F(1, 58) = 4.39$, $p =.04$, $\eta_p^2 = .07$; Day 6: $F(1, 58) = 28.67$, $p < .00001$; $\eta_p^2 = .33$; Day 7: $F(1, 58) = 8.87$, $p =.004$, $\eta_p^2 = .13$).

A similar 2 (condition) x 7 (days) mixed ANOVA on the number of acknowledged memories resulted in a significant main effect of condition ($F(1, 58) = 4.47$, $p =.039$, $\eta_p^2 = .07$), but no significant effect of days ($F < 1$). However, as with fully recorded memories, the condition by days interaction was approaching significance ($F(6, 348)=1.99$, $p =.067$, $\eta_p^2 = .03$) showing rather different patterns for paper- and smartphone-diary conditions across the seven days (see Figure 3-2). Tests of simple main effects showed that there was no main effect of condition on Day 1, Day 6 and Day 7 (all F values < 1.02). However, participants in the paper-diary condition acknowledged significantly more IAMs than those in the smartphone-diary condition on Days 2 to 5 (Day 2: $F(1, 58) = 4.53$, $p = .038$, $\eta_p^2 = .07$; Day 3: $F(1, 58) = 5.11$, $p = .028$, $\eta_p^2 = .08$; Day 4: $F(1, 58) = 6.70$, $p =.012$, $\eta_p^2 = .10$: Day 5: $F(1, 58) = 5.03$, $p = .029$, $\eta_p^2 = .08$). In addition, while the number of acknowledged memories in the smartphone-diary condition did not differ significantly between any of the days (all p values >.09), in the paper diary condition, the number of acknowledged memories displayed an inverted U-shaped pattern with significantly more memories on Days 4 and Day 5 in comparison to Day 1, and Day 6 and 7 (all p values < .05).

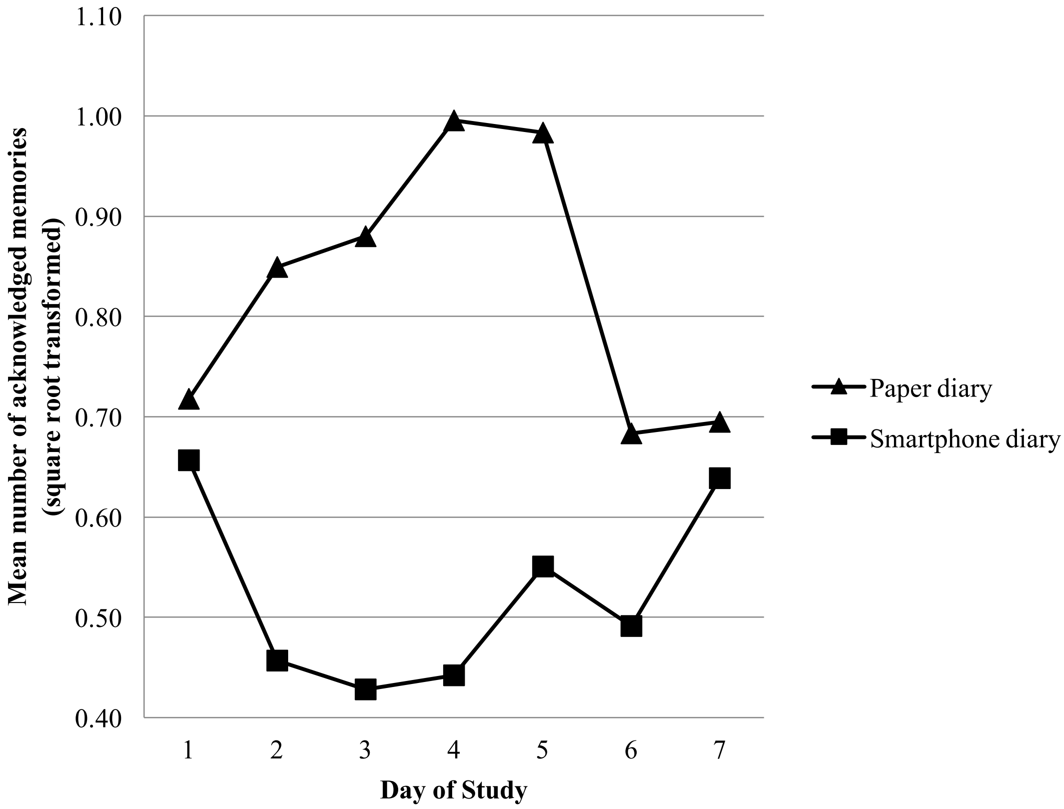

Figure 3-2. Mean Number of Acknowledged Memories (square-root transformed) Each Day in Paper- and Smartphone-Diary Conditions in Study 1

3.3.4 **Conditions in which Memories were Experienced**

3.3.4.1 ***Concentration***

Participants reported being predominantly engaged in fairly mundane activities, such as getting ready to go out, washing-up and tidying up, lying in bed, preparing or eating a meal, and walking in the street. These are easy, attentionally undemanding activities that do not require high levels of concentration. In line with this, mean levels of concentration on a five-point scale were 3.21 (SD = 0.75) in the smartphone-diary condition and 3.05 (SD = 0.58) in the paper-diary condition, which were not significantly different ($F < 1$).

3.3.4.2 ***Triggers of IAMs***

For each recorded memory, participants indicated whether anything in the environment or their thoughts triggered it, or whether there was no apparent trigger. As indicated in Table 3-5, the majority of the triggers in both conditions were external, although participants in the paper diary condition were more likely to indicate the triggers as external (75%) than those in the smartphone-diary condition (67%), χ^2 (2, N = 835) = 7.33, p = .026.

Table 3-5. Frequencies (Percentages) of Trigger Types by Condition (Paper- vs. Smartphone-Diary)

	Trigger Type			
	Internal	External	No Trigger	Total
Smartphone-diary	52 (18.8%)	184 (66.7%)	40 (14.5%)	276 (100%)
Paper-diary	88 (15.7%)	419 (75.0%)	52 (9.3%)	559 (100%)

3.3.5 **Characteristics of Recorded Memories**

For each participant, the mean proportion of specific IAMs recalled as well as the mean ratings of vividness (on a 7-point rating scale), pleasantness and rehearsal (on 5-point rating scales) were calculated. These means were entered into several one-way between-subjects ANOVAs (see Table 3-6). There were no significant differences between the paper- and smartphone-diary conditions in terms of memory characteristics.

In summary, in line with the predictions, participants in the smartphone-diary condition reported significantly higher compliance rates by remembering to carry a diary with them on every day of the study, and recording IAMs in the diary sooner than participants in the paper-diary condition. In addition, smartphone-diary users rated both carrying and completing the diary as easier than paper-diary users. Despite these major differences, and contrary to expectations, the number of fully recorded IAMs and acknowledged (ticked)

IAMs was almost twice as high in the paper-diary than smartphone-diary condition**.** The superiority of the paper-diary condition was present on a majority of days during the 7-day recording period: on six days for fully recorded IAMs (Days 2 to 7) and on four days for acknowledged IAMs (Days 2 to 5). However, the two diary recording conditions did not differ in terms of memory characteristics. In both conditions, IAMs referred to specific events, which were more neutral and positive than negative and were not thought about frequently in the past. IAMs were also reported to occur predominantly during undemanding activities and in response to external triggers. These findings concerning specificity and undemanding activities fully replicate the results reported in previous diary studies (Berntsen, 1996, 1998; Berntsen & Hall, 2004; Schlagman & Kvavilashvili, 2008).

Table 3-6. Mean Ratings (Standard Deviations) of Memory Characteristics as a Function of Condition (Paper- vs. Smartphone-Diary) in Study 1

	Condition		
	Smartphone-diary (n = 29)	Paper-diary (n = 31)	$F(1, 58)$
Specificity	0.78 (0.23)	0.68 (0.26)	2.56^{ns}
Vividness	5.29 (0.93)	5.42 (0.59)	.47
Pleasantness now	3.37 (0.78)	3.46 (0.43)	.27
Pleasantness then	3.31 (0.83)	3.42 (0.50)	.43
Rehearsal	2.65 (0.71)	2.41 (0.59)	2.10^{ns}

3.4 Discussion

Study 1 was conducted to establish the feasibility of using a smartphone app for cognitive research, and to compare recording of spontaneous everyday memory phenomena (IAMs) in either a paper-diary or with a diary app running on participants' own smartphones. It was predicted that participants in the smartphone diary condition would display significantly higher compliance than those in the paper-diary condition by carrying their phones, and therefore the diary, on every day of the study and that this would result in higher numbers of diary entries. A secondary objective was to compare the qualities and characteristics of recorded phenomena across two modes of recording.

Several novel findings emerged from this study. Firstly, participants in the smartphone-diary condition displayed significantly better self-rated compliance rates than those in the paper-diary condition by keeping the diary with them always and making diary entries significantly sooner than those in the paper-diary condition. In addition, smartphone participants considered carrying the diary, and making entries in it, easier than did the paper-diary participants.

The second major finding was that irrespective of compliance rates, and contrary to predictions, significantly fewer IAMs were recorded fully by participants on their own smartphones, compared with paper diaries. The consistent qualities and characteristics of IAMs recorded across the two conditions, implies that smartphone-diary participants were recording events diligently if they recorded them, but they were not recording them so often.

The higher rates of compliance in terms of carrying the smartphone diary is not at all surprising given that typically people carry their smartphones everywhere and consult them in every spare moment. Participants estimated the number of events they recorded, stated the number of days they forgot to carry their diaries, and rated the ease of carrying the diary at all times. While it should be cautioned that these compliance measures were self-reported, paper-diary users appeared honest in admitting that they forgot the paper diary some days, while smartphone users were confident they had not. It is obviously difficult to record actual compliance using paper diaries, without elaborate technology such as used by Stone et al. (2003), but these self-report measures gave a relatively accurate view of compliance since participants were free to record, or not record, in their diaries without consequences. This freedom was further enhanced in this method by allowing participants the briefer acknowledge option, if needed.

Compliance in this study was also measured by the time between the event and its recording. This seven-day study suggests that the smartphone app was to hand and convenient, with 71% of IAMs recorded in the app within 10 minutes of occurrence, whereas in the paper diaries just 54% of IAMs were recorded within 10 minutes. Conversely, in the smartphone condition, if IAMs were not recorded soon after occurrence it seems less likely that they would be recorded. In contrast, the paper diary, although rated less convenient, picked up more entries later.

3.4.1 Number of diary entries in paper- versus smartphone-diaries

The most important finding emerging from this study was the higher number of entries recorded in the paper- versus participant-owned smartphone-diaries. This was highly counterintuitive given the original prediction. The analysis of day-to-day data further supports the idea that smartphone users forget about the study. The number of recorded IAMs in the smartphone-diary condition dropped sharply after the first day and never picked up.

Reviewing the recordings day-by-day, in both conditions, there was a decline in recording over subsequent days. This was significant from Day 2 with the smartphone diary, but not until Day 4 in the paper diary (and recovered on Day 6 and 7). The difference between paper and smartphone was significant on every day except the first. From these observations, it might be inferred that there is an initial enthusiasm, or at least effort, to record IAMs but this falls over time. In the case of paper diary this lasted three days. However, after three days, even when participants appeared less willing to record in full they compensated by increasing their ticks. None of this was seen with the smartphone diary.

In conclusion, although the smartphone diary was carried consistently, and liked by the participants, the numbers of memories logged in the app was disappointing. Meanwhile, the paper diary has received an unexpected boost to its reputation in this study. This finding will be revisited in several later studies.

CHAPTER 4: Comparing Paper and Smartphone Diaries of Involuntary Autobiographical Memory: A 1-Day Study (Study 2)

4.1 Introduction

The main finding of Study 1 was that markedly fewer IAMs were recorded in smartphone- than paper-diaries, despite the significantly better compliance measures in the smartphone-diary condition. This finding was highly surprising and contrary to initial predictions. Consequently, the aim of Study 2 was to replicate, and extend these findings on IAMs using a 1-day diary recording period instead of 7-day recording period used in several previous studies. As in Study 1, Study 2 compared paper and smartphone diaries in terms of the number of recorded IAMs and their characteristics, and compliance measures.

The one-day diary period was chosen for two reasons. Firstly, in Study 1, the only day on which no reliable differences in the number of logged IAMs were found between the smartphone- and paper-diary conditions, was Day 1. It was therefore of interest to see if reducing the length of recording period from seven days to one day would replicate the general superiority of the paper-diary condition observed in Study 1, or repeat the non-significant differences between the conditions obtained on Day 1 of the 7-day recording period of Study 1. Secondly, recent research has shown that reducing the diary-keeping period does not proportionally reduce the number of recorded memories (see below). This raises an important methodological question of whether the extended periods of recording used in diary studies up to now are needed and cost-effective.

Despite growing research on IAMs over the past 20 years, there is almost no research that has investigated the effects of the length of the diary recording period on the observed frequency of IAMs in everyday life. However, results of several diary and laboratory studies that have used different recording periods paint a rather inconsistent picture, indicating that the actual frequency of IAMs is currently unknown.

Berntsen's (1996) initial approach was to ask participants to record up to two IAMs per day until a total of 50 was reached. Although the fastest to finish was not reported (which at best would have been in 25 days), among the 14 participants all had recorded 50 IAMs in six weeks (42 days). In the post-recording interview, most participants claimed to have had more than two IAMs per day, and indicated surprise at the frequency of their IAMs. They estimated between 3-20 IAMs per day, with 5-6 being the modal estimate. Participants also indicated that they had probably experienced IAMs they had not really paid attention to, and therefore not recorded. As the number was capped it was not possible to obtain an actual measure of frequency, or indeed a potential frequency of reporting in a diary.

Other diary studies have observed 17 IAMs per week (< 3 per day) or similar (Berntsen, 1998; Kvavilashvili & Mandler, 2004; Mace et al., 2011; Schlagman & Kvavilashvili, 2008; Schlagman et al., 2007). Schlagman et al. (2007) reported between 1-3 IAMs per day in young and old participants, in a method that also allowed participants to make ticks in lieu of full memory descriptions, a method previously described and used in Study 1 (Chapter 3). In a 14-day diary study, Mace (2004) found a mean of 2.9 IAMs per day, while in a second study he found 2.5 per day (Mace, 2005).

However, in shorter periods of recording, people record similar absolute numbers compared with longer periods, for example, in two studies, which sought to reduce the recording burden, where participants had to acknowledge the occurrence of their IAMs by mechanical clickers throughout one day only, participants logged on average 19 to 22 memories (Rasmussen & Berntsen, 2011; Rasmussen et al., 2015, Study 1). This number dropped to 12 memories when the recording effort was increased by adding just three rating questions that participants had to answer every time they logged a memory in a loaned smartphone (Rasmussen et al., 2015, Study 3), although no comparison was made with paper. Similarly, Finnbogadóttir and Berntsen (2013) observed a mean of 22 in one day when participants recorded IAMs on a tick sheet. These are hard to audit though as by the nature of the method, any detail is non-existent compared with the rich descriptions provided in diaries, albeit with the time commitment required from participants.

In a study that reduced the burden on participants by a method of controlled field interviewing (Kamiya, 2013), participants provided a mean of 12.3 IAMs while walking round a prescribed route of a university campus for an average of 60 minutes (range 30 to 90 minutes) and reporting them to the researcher who was following a few paces behind. However, in this study participants were not engaged in any activity other than walking around the campus, and were followed by the researcher, potentially creating demand characteristics.

Additional evidence in support of the idea that there are more memories than apparent from self-monitoring diary studies comes from laboratory studies of IAMs (Plimpton et al., 2015; Vannucci et al., 2014). In Plimpton et al. (2015) participants experienced over three IAMs in a vigilance task that lasted just 15 minutes. Similarly, participants in the Vannucci et al. (2014) study experienced on average up to 11 IAMs in a 20 minute vigilance task. The number of reported IAMs differed depending on whether the participants were probed by the experimenter, or whether they had to report spontaneous thoughts themselves and whether the participants were focussed on reporting IAMs or any task-unrelated thoughts. For example, on average 6.9 IAMS were observed in a condition where participants had to report any spontaneous task-unrelated thought they noticed during the vigilance task.

Gardner and Ascoli (2015) compared the frequencies of prospective memories (addressed later in this dissertation), and autobiographical memories, using an experience sampling method. In their study, participants were sampled randomly by automated telephone calls, on average 11.5 calls per participant per day, with a mean of 219 calls over 19 days, and asked whether they were experiencing thoughts about the past (i.e. an autobiographical memory), or thoughts about the future (i.e. a prospective memory), at the moment of the call.

While Gardner and Ascoli (2015) were interested in the relative numbers in different age groups, and did not distinguish between voluntary and involuntary autobiographical memories, they reported that individuals indicated having autobiographical memories in about 10% of the probes, at a rate of 13.70 per hour (one every 4-5 minutes) with a mean duration of 32.03 seconds.

In summary, the estimates of the number of IAMs experienced by people in their daily life have changed over time from initially low figures, to higher frequencies reported in recent studies, and this seems to be highly sensitive to the method of recording (e.g. paper diary, simple counter, or via interviewer), the time period of recording (from minutes to several weeks), sampling method (fixed number per day, ESM, or event-contingent), and the burden to the participant (e.g. see Rasmussen, Ramsgaard, & Berntsen, 2015). These parameters may also affect participants' subjective estimates of the frequency of their IAMs. This raises the important question of whether we yet know the true frequency of IAMs.

Study 2 had two principal aims. The first aim was to replicate the findings of Study 1, to see if more IAMs were recorded in paper than smartphone diaries. The second aim was to investigate the frequency of IAMs in everyday life by asking participants to record their IAMs for one day only. If participants are more aware of being in a study and more willing to monitor their memories for the study in one day than for seven days, then the number of IAMs recorded in a 1-day diary would be greater than on Day 1 of the 7-day diary. Clearly, if reducing the diary-keeping period can be justified, it would be beneficial to both participants and researchers.

4.2 Method

4.2.1 Participants

Forty-nine participants, who owned a smartphone, were recruited from the university student body. They were randomly allocated to two conditions: smartphone electronic diary

(N=23, 4 male, 19 female), and paper diary (N=26, 5 male, 21 female). Some received course credit (11 in paper condition, 10 in smartphone condition). All but one were psychology students.

The mean age of the smartphone group was 21.74 years (*SD* = 4.64, range 18-36), and did not differ significantly from the mean age of 23.19 years (*SD* = 7.61, range 18-51) in the paper-diary group ($F < 1$).

4.2.2 **Materials and Procedure**

Instructions and the paper diary were modified, as necessary, for a one-day study. The smartphone app did not require modification. Some additional questionnaires were used but were not relevant to the aims of the present study, so are not reported here. The procedure was the same as the Study 1, 7-day diary-keeping period, except that participants were briefed on Day 1, kept the diary only on Day 2 and returned on Day 3.

4.3 Results and Discussion

4.3.1 **Equivalence of Groups**

The groups were assessed for their smartphone usage and self-rated technical ability, using the same measures as in Study 1 (Chapter 3). There were no significant differences between the conditions on any of the measures listed in Table 3-1 (all $p_s > .10$).

4.3.2 **Measures of Compliance in Paper- and Smartphone-diary conditions**

4.3.2.1 ***Self-rated Retrospective Compliance***

The groups did not differ significantly in terms of the percentage of IAMs that they reported they had been able to record (62% in the smartphone-diary, 66% in paper-diary condition). However, as in Study 1, 70% of the smartphone-diary participants said that keeping the diary with them was ‘very easy’, in comparison to just 16% in the paper-diary condition, χ^2 (3, N = 49) = 14.48, p = .002. Similarly, 70% of participants in the smartphone-diary condition said that recording memories was ‘very easy’, compared with 42% in the paper-diary condition, but this difference was not significant, χ^2 (3, N = 49) = 5.31, p = .15. As participants kept the diary for one day only, there were no instances of forgetting to carry it.

4.3.2.2 ***Delay between Reported Occurrence of Memory and its Recording***

Unlike in Study 1, there were no significant differences between the two conditions in the reported delay from the time of having an IAM until recording it (see Table 4-1). In both conditions, a large majority of IAMs (78%) were logged within 10 minutes of their reported occurrence. This may provide extra weight to shortening the diary-keeping period, as evidence that participants appear more "on-task" when keeping a diary for just one day.

Table 4-1. Number of Memories Recorded in Each Time Window by Condition (Paper- vs. Smartphone-Diary) in Study 2

Diary Entry Compliance Time				
	Up to 10 minutes	10 minutes to 1 hour	Over 1 Hour	Total
Smartphone app	69 (78%)	11 (12%)	9 (10%)	89 (100%)
Paper diary	139 (78%)	28 (15%)	12 (7%)	179 (100%)[a]
Total	208 (78%)	39 (14%)	21 (8%)	268 (100.0%)

Missing cases: [a]17

4.3.2.3 ***Number of Words in Memory Descriptions***

The mean number of words used for memory descriptions in the smartphone-diary condition (M = 10.70, SD = 6.67) was nominally lower than the mean number of words in the paper-diary condition (M = 14.77, SD = 7.59), but the difference was not statistically significant, F(1, 47) = 3.93, p = .053.

4.3.3 **The Number of Recorded Memories**

All participants recorded at least one IAM. A total of 285 memories were fully recorded (196 in the paper-diary, and 89 in the smartphone-diary condition), and 75 were acknowledged (30 in the paper diary and 45 in the smartphone). Seven were marked as personal but other items on the diary page were completed. The mean numbers of recorded and acknowledged IAMs in both conditions are presented in Table 4-2.

The analysis of variance, carried out on square root transformed means, showed that participants in the paper-diary condition fully recorded almost twice as many memories as those in the smartphone-diary condition, $F(1, 47) = 10.21$, $p = .002$, $\eta_p^2 = .18$. However, there was no significant difference for the number of acknowledged memories, $F(1, 47) = 2.82$, $p = .10$, $\eta_p^2 = .057$.

Table 4-2. Mean numbers and Standard Deviations of Recorded and Acknowledged Involuntary Autobiographical Memories (IAM) in Study 2 in Paper- and Smartphone-Diary Conditions

		Condition	
		Paper-diary	Smartphone-Diary
Fully Recorded			
	Mean	7.54	3.87
	SD	5.42	2.43
	Range	1-22	1-12
Acknowledged			
	Mean	1.15	1.96
	SD	1.89	2.06
	Range	0-7	0-6

4.3.4 Conditions in which Memories were Experienced

4.3.4.1 *Concentration*

Participants reported being predominantly engaged in fairly mundane activities. Mean concentration levels were low, and similar to those found in Study 1, and other studies. Although concentration levels were nominally higher in the smartphone-diary ($M = 3.13$, $SD = 0.66$) than in the paper-diary condition ($M = 2.74$, $SD = 0.73$), the difference was not statistically significant, $F(1, 47) = 3.90$, $p = .054$.

4.3.4.2 ***Triggers of IAMs***

As in Study 1, the majority of reported triggers were external (see Table 4-3). There was no significant difference between conditions in the percentage of reported external triggers, χ^2 (2, N = 279) = 1.65, p = .44.

Table 4-3. Frequencies (Percentages) of Trigger Types by Condition (Paper- vs. Smartphone-Diary)

	Trigger Type			
	Internal	External	No Trigger	Total
Smartphone-diary	10 (11%)	72 (82%)	6 (7%)	88 (100%)
Paper-diary	30 (16%)	143 (75%)	18 (9%)	191 (100%)

4.3.5 **Characteristics of Recorded Memories**

There were no significant differences between the two conditions in terms of mean proportion of specific IAMs recorded, and in terms of mean ratings of vividness and rehearsal (see Table 4-4). However, mean ratings of memory pleasantness ("then" and "now") were higher in the paper- than smartphone-diary condition.

Table 4-4. Mean Ratings (Standard Deviations) of Memory Characteristics as a Function of Condition (Paper- vs. Smartphone-Diary) in Study 2

	Condition		
	Smartphone, n = 23	Paper, n = 26	F(1, 47)
Specificity	0.73 (0.18)	0.80 (0.14)	2.27^{ns}
Vividness	4.64 (1.49)	4.91 (0.97)	.60
Pleasantness Now	3.10 (0.99)	3.71 (0.59)	7.22**
Pleasantness Then	3.16 (0.88)	3.64 (0.71)	4.45*
Rehearsal	2.41 (0.81)	2.78 (0.83)	2.44^{ns}

* p = 0.04; ** p = 0.01

4.3.6 **Number of Recorded Memories in Day 1 (Study 1 versus Study 2)**

Finally, the fully recorded and acknowledged memories in this 1-day study were compared with the number of memories recorded in Day 1 of the 7-day study (Study 1). A 2 diary period (1-day vs. 7-day) x 2 diary type (paper vs. smartphone) between subjects ANOVA on the mean number of fully recorded memories (square root transformed) resulted in a significant main effect of diary period, $F(1, 105) = 26.88$, p =.000001, $\eta_p^2 = .20$. Overall, significantly more IAMs were fully recorded in the 1-day diary in Study 2 ($M = 5.82$, $SD = 4.71$) than on Day 1 of a 7-day diary in Study 1 ($M = 2.82$, $SD = 2.55$). This main effect did not interact with diary type ($F(1\ 105) = 2.42$, $p = .12$, $\eta_p^2 = .02$. As expected, the main effect of diary type was also significant ($F(1,105) = 11.87$, $p = .001$, $\eta_p^2 = .10$) with more IAMs recorded in the paper-diary ($M = 5.23$, $SD = 4.71$) than smartphone-diary condition ($M = 3.00$, $SD = 2.28$). A similar 2 (diary period) by 2 (diary type) ANOVA on the mean number of acknowledged memories did not result in any significant main or interaction effects (all Fs < 2.38).

4.4 Discussion

Study 2 made a second systematic comparison of paper diaries versus an app installed on participants' own smartphones for self-initiated recording of IAMs, using a one day recording period. Three main findings emerged. Firstly, compliance rates in the paper diary condition improved, and were comparable to those in the smartphone diary condition. Secondly, results of Study 1 were replicated by showing that a significantly higher number of IAMs were recorded in the paper diary than in the smartphone diary. Finally, results also showed that the number of entries made in the 1-day diary in this study was significantly higher than entries made on Day 1 of the 7 day in Study 1, in both the paper- and smartphone-diary conditions.

4.4.1 **Compliance**

Unlike the results of Study 1, paper- and smartphone-diary conditions did not differ in several measures of compliance. No participants in the paper diary condition reported forgetting to keep the diary with them, which is perhaps unsurprising given that it had to be kept for one day only. Most importantly, the two conditions did not differ in terms of reported time elapsing between having an IAM and recording it in the diary. The finding in the 1-day paper-diary condition of this study, that the delay in recording memories was markedly reduced in comparison to the 7-day paper-diary condition of Study 1, and matched the smartphone condition (in both diary types 78% recorded within 10 minutes, in comparison to 54% in the paper diary condition of Study 1) is particularly interesting. It speaks in favour of reducing the diary-keeping period to one day, especially for studies using paper diaries. It appears that the paper diary is reasonably convenient for the shorter period, and participants are willing to carry it, keep it close to hand and make prompt entries when IAMs are experienced and noticed.

4.4.2 **Paper Versus Smartphone**

The second major finding was that irrespective of compliance rates in this study, and contrary to initial predictions, significantly more entries were recorded in the paper diary than in the electronic diary on participant-owned smartphones in one day, replicating the findings in the 7-day diary in Study 1. There are several possible explanations for this unexpected finding, such as the possible cueing effect of the paper diary, the distraction of other apps on the smartphone, or the inconvenience of making smartphone entries. These are relevant to several studies, and are evaluated in the closing Chapter 9. However, the pattern with acknowledged entries (rather than completing a full diary page) was less clear, with no reliable differences between conditions in this study, whereas there were more ticks in the paper-diary group in Study 1.

In Study 2, the qualities, and characteristics of IAMs, recorded across the two conditions remained largely consistent, as in Study 1, except ratings of pleasantness, which were higher in the paper-diary condition. This suggests that smartphone-diary participants were recording events properly, if they recorded them, but they were not recording them so often.

4.4.3 The Effect of Varying the Length of recording period (1 day versus 7 days)

The third important finding was that reducing the diary-keeping period to one day, in Study 2, did not proportionally decrease the number of memory events recorded in either the paper or smartphone diaries. The IAMs that were fully recorded in paper diaries in just one day in Study 2 equated to 42% of the total number of IAMs recorded in paper diaries of Study 1 over 7 days. An almost identical 41% was obtained in the smartphone conditions of Study 1 versus Study 2. Furthermore, the cross-study comparisons in the two respective diary conditions showed that the number of fully recorded IAMs in the 1-day diary of Study 2 was significantly higher than the number recorded on Day 1 of the 7-day diary in Study 1. This is the first direct evidence of this reduced rate of entries with longer recording periods, the *diary entry rate reduction effect*. This finding is consistent with previous diary and laboratory studies of IAMs where participants recorded more memories during shorter time periods, or where they had fewer questions to answer (Kamiya, 2013; Rasmussen et al., 2015; Schlagman & Kvavilashvili, 2008).

It appears that participants may find it easier to follow instructions to keep the diary for one day than over a longer diary recording period, or adjust their approach and are more engaged with the study. This was further supported by the improved compliance measures in the paper-diary condition in Study 2. Further, the results suggest that diary-keeping periods of one or two weeks, typically used by IAM researchers, could safely be reduced (e.g. to one, or just a few days only). Put simply, if the engagement required is only one day then commitment is easier. This, together with the finding that more IAMs are recorded in paper diaries rather than in participant-owned smartphones, has important implications for conducting diary studies of IAMs.

CHAPTER 5: Comparing Paper and Smartphone Diaries of Everyday Memory Failures: A 7-Day Study (Study 3)

5.1 Introduction

The important question that arises in relation to the key findings of Studies 1 and 2 is whether they are specific to IAMs, or generalisable to other cognitive phenomena. It is indeed methodologically very important to establish whether differences obtained between paper diaries and electronic diaries on participant-owned smartphones point to a more general effect, because if they do, this sounds a note of caution to researchers planning to ask participants to use their own smartphones with an app provided to them by the researchers.

Therefore, the primary goal of Study 3 was to address this issue by comparing the number of recorded everyday memory failures (EMFs) in paper diaries and in participant-owned smartphones. EMFs were chosen as they are cognitively very different from IAMs, but share common characteristics of spontaneous manifestation, and transient nature. After a short period, many memory errors are quickly forgotten, and like IAMs, they are not amenable to recording via experience sampling methods. Also, like IAMs, EMFs are experienced in the healthy population, but have relevance to clinical populations, making their study of practical value, with the growing interest in cognitive impairment (subjective and mild), and dementia.

There were a few diary studies of cognitive failures in the 1980s (Crovitz & Daniel, 1984; Reason & Lucas, 1984; Terry, 1984, 1988), but research in this area has been very sporadic since then despite its obvious practical and theoretical importance. The vast majority of research on memory and cognition to date has been conducted in the laboratory using experiments testing participants' memory for digits, words, pictures and other simplified material. The assumption, or hope, has been that findings from these laboratory studies would generalise automatically to how memory operates in everyday life.

The most obvious way to study everyday memory is to conduct naturalistic experiments, by giving memory tasks (staged or real-life) to be completed in everyday life, and then observe how participants perform them. Such tasks include remembering to make phone calls, or recalling incidental details while, for example, navigating to a particular place (e.g. Maylor, 1990; Qin et al., 2014). Other examples include research on flashbulb memories, staged emotional events, and eyewitness testimony where participants are asked to recall what happened in an observed event.

Field experiments can be completely naturalistic where people do not know they are participants. However, more commonly participants are aware they are in an experiment. The main issue with using field experiments to study EMFs is that it is too time-consuming and resource-demanding to stage these naturalistic events, so such studies are rare. Furthermore, it is hard to study some naturally occurring events, for example, learning a person's name on introduction.

It has been suggested in the literature that the easiest way to research cognitive change and memory failures would be to ask people to rate them (Rabbitt, 2006). Accordingly, much research has been conducted with self-assessment questionnaires (Herrmann, 1982; Smith, Del Sala, Logie, & Maylor, 2000). There are different types of memory questionnaires. Some test memory itself, for example checking memory of news events, or recognition of famous people. However, most research has been conducted with metamemory questionnaires, which ask individuals about how they see their memory working in everyday life. There are many questionnaires to choose from, but the majority describe scenarios or situations and ask about forgetfulness, or performance in those situations. Participants can also be asked questions about memory changes (e.g. over time) (Broadbent, Cooper, FitzGerald, & Parkes, 1982; Smith et al., 2000; Sunderland, Harris, & Baddeley, 1983; Zelinski, Gilewski, & Anthony-Bergstone, 1990).

Given the transient nature of EMFs, it is possible that people's ability to assess the frequency and the nature of their EMFs retrospectively is quite poor, which raises the importance of using a diary method to study EMFs. Recently, the self-initiated diary method has been revived to study a variety of cognitive failures in everyday life (e.g. Unsworth, Brewer, et al., 2012). However, all these studies have still used a traditional paper diary format. As was the case with IAMs, no study of EMFs has been conducted comparing paper and participant-owned smartphone diaries. In fact, there is little evidence of electronic diaries being used in research on EMFs, although PDAs were used in an experience sampling study of mind-wandering by Kane et al. (2007). The study described in this chapter may thus be the first study to use electronic diaries in the evaluation of EMFs, and the first to use participant-owned smartphones.

In the two diary studies of IAMs (Studies 1 and 2), participants recorded significantly fewer entries in their own smartphones than in paper diaries. While this is an interesting and important finding, it is possible that this was entirely due to the nature of the phenomenon being investigated. Indeed, IAMs are highly transient internal events that are difficult to notice in one's flow of consciousness (e.g. Mace, Bernas, & Clevinger, 2015). It is therefore possible that if participants were asked to record some other phenomena that were easier to notice, the superiority of paper over participant-owned smartphone diaries, in terms of the number of fully recorded diary entries, would disappear or be even reversed. Consequently, this study was conducted to test the generalisability of results of Studies 1 and 2 (Chapters 3 and 4) by asking participants to keep a diary of their everyday memory failures for a 7-day period, and compare several critical dimensions such as feasibility, compliance, and data equivalence.

Like IAMs, EMFs occur intermittently throughout the day, and they are transient, in that people may soon forget about having them. Although these errors may take a variety of forms, they can be classed into three broad categories (e.g. see Kvavilashvili, Kornbrot, Mash, Cockburn, & Milne, 2009; Unsworth et al., 2012). Specifically, the errors can consist of retrospective memory errors (e.g. forgetting information from the past such as someone's name or a route), prospective memory errors (e.g. forgetting to carry out intended actions such as making a phone call or posting a letter), or attention based absent-minded errors (e.g. going into a room and forgetting why, or throwing away an item instead of putting it in a cupboard).

While IAMs may go unnoticed, everyday memory failures often disrupt day-to-day activities, and may cause annoyance and embarrassment or even have significant negative consequences (McDaniel & Einstein, 2007; Reason & Mycielska, 1982). Therefore, participants may be more likely to notice memory failures than IAMs. If a failure is embarrassing or has negative consequences (e.g. forgetting an appointment) it may even act as a trigger, reminding the participant that they are in a diary study.

If the above reasoning is correct, then it is possible that participants will record equal numbers of errors irrespective of diary type. However, if the findings from Studies 1 and 2 on IAMs are generalizable to other transient phenomena, then the number of memory errors recorded in a paper diary would be greater than the number recorded in a participant-owned smartphone despite the superior compliance rates in the smartphone e-diary condition. Finally, in line with the results of Studies 1 and 2, no significant differences were expected to occur between paper- and smartphone-diary conditions in terms of characteristics of recorded everyday memory failures.

5.2 Method

5.2.1 Participants

Thirty-seven participants were recruited from university students and staff. Psychology students received course credits for their participation. They were randomly allocated to smartphone-diary (N = 19, 3 male, 16 female), and paper-diary (N = 18, 9 male, 9 female) conditions. The mean age of participants in the smartphone-diary condition was

21.79 (*SD* =7.03, range 18-46), and did not differ significantly from the mean age of participants in the paper-diary condition (M = 26.28, SD = 9.87, range 18-49), $F(1,35) = 2.56$, $p = .12$.

5.2.2 Materials

5.2.2.1 ***Paper Diary***

In the paper-diary condition, participants received an A5 paper diary booklet, similar to the IAM diary, containing 32 identical pages, one page to be completed for each everyday memory failure noticed. The following items were collected in the diaries: 1. When did you have a memory error? Or when did you realise you made an error? (*Date and time*); 2. When did you record it here? (*Date and time*); 3. Describe your memory error (*free text entry*); 4. What was your mood immediately before the error (a 5-point scale: 1 = *very unhappy* to 5 = *very happy*); 5. How relaxed or stressed were you immediately before the error (a 5-point scale: 1 = *very relaxed* to 5 = *very stressed*); 6. How serious was the memory lapse (1 = *Insignificant,* 2 = *Minor,* 3 = *Somewhat significant,* 4 = *Significant*, 5 = *Very significant/potentially dangerous*); 7. Were there or could there have been any consequences? (*free text*); 8. How upset are you by the memory lapse? (1 = *Not at all upset,* 2 = *A little,* 3 = *Somewhat,* 4 = *Quite*; 5 = *Very upset*); 9. Describe the emotions you felt in response to your lapse, if any (*free text*); 10. If you later recovered from this error, describe when and how (*free text*) (see Appendix G).

5.2.2.2 ***Smartphone Diary***

The smartphone diary was modified to use the questions about everyday memory failures, but was otherwise identical to the IAM app used in Studies 1 and 2. As before, it time-stamped the entries so the participants did not need to enter the time of recording (see Appendix H for screenshot).

5.2.2.3 ***Post-diary questionnaires***

In a Diary Compliance Questionnaire, completed after the diary-keeping phase, in addition to the questions about ease of carrying and using the diary, participants were asked if they felt a daily text message (SMS), reminding them that they were in the diary study, would have been useful (*Yes*/*No*). Two additional questions were asked and participants also filled in questionnaires that were not relevant to the present study, and hence will not be reported here (see Appendix I).

5.2.3 **Procedure**

The procedure and instructions were identical to those used in Study 1 and 2 except that participants were individually briefed for 20-30 minutes face-to-face about everyday memory failures instead of IAMs. They were told that everyday memory failures vary and take different forms, with examples of retrospective, prospective, and absent-minded errors provided. Each item on the diary page, or on the smartphone screen, was explained. Participants were asked to record any EMFs that occurred over the next seven days, starting from waking the day after the briefing, so that only full days were recorded. As with IAMs, participants were urged to keep the diary with them at all times and record their memory failures immediately, or as soon as possible after occurrence, or if this was not possible, to acknowledge the memory failure. After the 7-day diary period, participants returned the diary to the researcher and completed the post-diary questionnaire.

5.3 Results and Discussion

5.3.1 **Measures of Compliance in Paper- and Smartphone-diary conditions**

Participants' responses to the Diary Compliance Questionnaire resulted in the following findings. The two groups did not differ reliably in terms of the percentage of everyday memory failures they reported they were able to record (83% in the smartphone-diary, 82% in paper-diary condition, $F < 1$). However, 95% of the smartphone-diary participants (all but one) said keeping the diary with them was 'very easy', in comparison to just 33% in the paper-diary condition, χ^2 (4, N = 37) = 15.99, p = .003. Similarly, 79% of participants in the smartphone-diary condition said recording errors in the diary was 'very easy', compared to 62% in the paper-diary condition, but this difference was not significant, χ^2 (3, N = 37) = 1.46, p = .69. Most importantly, and in line with the results of Study 1 and 2, no smartphone-diary participants forgot to carry their device, but 33% of the paper-diary participants admitted to forgetting to carry their diary on at least one day of the seven (five participants forgot on one day, one participant forgot on two days, see Table 5-1). In a one-sample t-test, the number of forgotten days in the paper diary condition was significantly different from zero, $t(17) = 2.72$, p = .008.

Table 5-1. Number of Participants, in each Diary Condition, who Reported Forgetting to Keep a Diary on a Given Number of Days (Paper- vs. Smartphone-Diary) in Study 3

	Number of Days Diary Forgotten				
	0	1	2	3+	Total
Smartphone	19 (100%)	0 (0%)	0 (0%)	0 (0%)	19
Paper	12 (67%)	5 (28%)	1 (5%)	0 (0%)	18

Furthermore, as in Study 1, there was a large difference between the two conditions in terms of reported delay from the time of having a memory failure until recording it (see Table 5-2). In the smartphone-diary condition, a large majority of memory errors (64%) were logged within 10 minutes of their reported occurrence, whereas in the paper diary condition only 35% were reported within 10 minutes, χ^2 (2, N = 259) = 21.19, p < .0001. Again, the smartphone facilitated prompt recording.

In this study, participants were also asked whether they would have found it helpful to have a text (SMS) message each day reminding them they were in the diary study. While 63% of participants in the smartphone-diary condition said that it would have been helpful, only 39% in the paper-diary condition thought that it would have been helpful. However, this difference was not significant, probably due to relatively small participant numbers in each condition χ^2 (1, N = 37) = 2.18, p = .14.

Table 5-2. Number of Memory Failures Recorded in Each Time Window by Condition (Paper- vs. Smartphone-Diary) in Study 3

	Diary Entry Compliance Time			
	Up to 10 minutes	10 minutes to 1 hour	Over 1 Hour	Total
Smartphone app	68 (64%)	18 (16%)	21 (20%)	107 (100%)
Paper diary	53 (35%)	37 (24%)	62 (41%)	152 (100%)[a]
Total	121 (47%)	55 (21%)	83 (32%)	259 (100%)

Missing cases: [a] 29

5.3.2 The Number of Recorded Everyday Memory Errors

All participants recorded at least two memory errors. A total of 290 memory errors were recorded (107 in the smartphone- and 183 in the paper-diary condition), and 71 were acknowledged (27 in the smartphone- and 44 in the paper-diary condition). The mean numbers of fully recorded and acknowledged memory failures are presented in Table 5-3.

The analysis of variance, carried out on square root transformed means, showed that participants in the paper-diary condition fully recorded almost twice as many memory errors (M = 10.60, SD = 7.94) than those in the smartphone-diary condition (M = 5.63, SD = 2.59), F(1, 35) = 4.57, p = .04, η_p^2 = .116.

Overall, there were very few acknowledged memory failures, in comparison with acknowledged IAMs in Studies 1 and 2. There was one outlier with 33 ticks in the paper condition and one with eight ticks in the smartphone diary condition. When these were excluded the mean numbers of ticks in the two conditions were not significantly different, F(1, 33) = 1.31, p = .261.

Table 5-3. Mean numbers and Standard Deviations of Recorded and Acknowledged Everyday Memory Failures (EMF) in Study 3, in Paper- and Smartphone-Diary Conditions

		Condition	
		Paper-diary	Smartphone-Diary
Fully Recorded			
	Mean	10.60	5.63
	SD	7.94	2.59
	Range	2-27	2-12
Acknowledged			
	Mean	0.65[a]	1.06[b]
	SD	1.17	0.94
	Range	0-17 (outlier: 33)	0-3 (outlier: 8)

[a, b] One outlier removed

5.3.3 Characteristics of Recorded Everyday Memory Errors

Analysing EMF characteristics, there was no significant difference between paper- and smartphone-diary conditions for any of the four rating scales used (i.e. mood before, relaxed or stress level before, seriousness of the lapse, and how upset the participants were by the lapse), all *F*s < 1.

5.4 Discussion

Based on the results of Studies 1 and 2, it was predicted that smartphone diary-keepers would display significantly higher compliance than those in the paper-diary condition by carrying their phones, and therefore the diary, at all times. However, in the light of the counterintuitive findings of Studies 1 and 2 about the frequencies of recorded IAMs, it was of great interest to see whether this increased compliance would result in a higher number of diary entries in the smartphone diary condition. A second objective was to compare the qualities and characteristics of recorded memory failures across two modes of recording.

Overall, the results of the present study on EMFs fully replicated and extended the main findings of Studies 1 (Chapter 3) and 2 (Chapter 4) on IAMs. As in Study 1, participants in the smartphone-diary condition displayed significantly better self-rated compliance than those in the paper-diary condition by keeping the diary with them at all times and making diary entries significantly sooner than those in the paper-diary condition. In addition, smartphone participants considered carrying the diary and making entries in it, easier than did the paper-diary participants. As in the 7-day IAM study, this 7-day EMF study suggests that the smartphone app was to hand and convenient, with 64% of memory failures recorded in the app within 10 minutes of occurrence, whereas in the paper diaries just 35% of memory failures were recorded within 10 minutes. Conversely, in the smartphone condition, if they were not recorded soon after occurrence it seems less likely that they would be recorded. In contrast, the paper diary, although rated less convenient, picked up more entries later. A possible explanation for this is that the paper diaries were not to hand, or were less convenient to complete at the time. However, later sight of the paper diary may have cued retrieval of earlier memory errors, allowing them to be recorded. Some tentative support for this comes from the question about the usefulness of text message reminders, where participants in the smartphone diary condition indicated a greater, although non-significant, preference for such reminders.

The main finding that significantly fewer EMFs were recorded in smartphone rather than paper diaries demonstrated that this effect is not unique to IAMs. This suggests that the same pattern may occur whenever measuring a phenomenon where self-monitoring and self-initiated recording is necessary, although this would have to be tested for each phenomenon. This was highly counterintuitive given the original predictions, but less surprising in the light of finding with IAMs.

The pattern with acknowledged entries (rather than completing a full diary page) was less clear for EMFs, with no reliable differences between conditions, while there were more ticks in the paper-diary condition in Study 1 on IAMs. This difference could be due to fairly low numbers of these acknowledge entries, with the majority of participants recording none, or very few acknowledged memory errors, and may reflect the different nature of memory failures which, while random and spontaneous like IAMs, are less transient in that the irritation, inconvenience or embarrassment of these failures means that they can be recalled and fully described later whereas IAMs are more quickly forgotten.

While the smartphone diary was carried consistently, and liked by the participants, as with the IAM studies, the number of memory errors logged in the app was disappointing. As with IAM studies, the caution therefore remains that the anticipated benefits of using participant-owned smartphones might need to be supported with some means of raising participants' awareness to ensure they are monitoring their errors. Taken together, these findings have important implications for different research areas in psychology and clinical studies that use diary methods for data collection.

CHAPTER 6: Investigation of Diary Entry Rate Reduction Effect: Comparing 7- and 28-Day Paper Diaries of Everyday Memory Failures (Study 4)

6.1 Introduction

6.1.1 Aims

The main finding in Studies 1 to 3 (Chapters 3-5) was the superiority of the paper diary over the smartphone diary in terms of the higher number of recorded entries in paper diaries, despite the better compliance rates in smartphone diaries. Another interesting and somewhat unexpected finding that emerged when comparing results of Study 1 and Study 2 on IAMs concerned the diary recording periods. Reducing the recording period did not *proportionally* reduce the number of IAMs recorded. This raises the important question of what the optimal diary recording period might be, which we currently know little about. Clearly, for IAMs, it looks like seven days is not necessary and it seems 1-3 days may be sufficient. However, the optimal period might vary for different phenomena. It might also be that this disproportionate reduction in the number of recorded entries with longer recording periods is specific to IAMs and therefore research is warranted to validate this effect with other phenomena. As everyday memory failures (EMFs) were used in Study 3 (Chapter 5) to test the generalisability of findings on IAMs when comparing paper and smartphone methods, it made sense to use the same phenomenon to examine this *diary entry rate reduction effect* with longer recording periods (e.g. seven days versus 28 days).

There are several justifications for addressing this research question with EMFs as a phenomenon in Studies 4a and 4b reported in this chapter. (The studies are called 4a and 4b because they were conducted at different times.) Firstly, in comparison to research on IAMs, there is very little diary research on EMFs. There were some early studies in the 1980s (Cavanaugh, Grady, & Perlmutter, 1983; Crovitz & Daniel, 1984; Reason, 1979; Reason & Mycielska, 1982; Terry, 1984, 1988), but then interest in the method waned until a few studies appeared more recently (McAlister & Schmitter-Edgecombe, 2016; Unsworth, McMillan, Brewer, & Spillers, 2012, 2013). Given the limited diary research, we know very little about the frequency of EMFs in everyday life.

Secondly, it has been suggested in the literature that the easiest way to research cognitive change and memory failures might be to ask people (Rabbitt, 2006). Perhaps the reason there are so few diary studies is that in the 1980s many metamemory questionnaires were developed, which were thought to measure EMFs by tapping into participants' own self-knowledge. There has been almost no research addressing the reliability of these questionnaires, although Herrmann (1982) conducted a comprehensive review of these metamemory questionnaires to study memory. Herrmann (1982) argued that questionnaires were reliable, but they showed only moderate correspondence with laboratory performance. If memory questionnaires corresponded with memory performance, that would conveniently reduce research time, but if not, Herrmann (1982) argued they were insufficient. Other researchers have observed that comparisons of questionnaires with diary measures are absent in the literature given the rarity of diary studies (Unsworth et al., 2013). So, another aim of the studies described here was to check the validity of these questionnaires against the number of EMFs recorded in the diary.

A further reason to study EMFs is that they do not appear to occur as frequently as IAMS. In Study 1 with the 7-day paper diary method, the mean number of recorded IAMs was 18.03 (SD = 10.68), whereas in Study 3 on EMFs, using the same recording period of seven days the mean number was 10.60 (SD = 7.94), which were significantly different, $t(47) = 2.41$, $p = .02$. As EMFs seem to occur less frequently, the assumption made in published studies has been that it is necessary to use longer diary recording periods. In the few studies that have used diaries for EMFs, 28-day diaries were used (Reason, 1984; Reason & Lucas, 1984). Similarly, a 28-day diary method was used in two studies of the tip of the tongue (TOT) phenomenon (Burke et al., 1991; Heine et al., 1999).

Keeping a diary for 28 days requires a big commitment from participants, and given there were issues with compliance in the 7-day IAM study, these are likely to be amplified over 28 days. Therefore, to investigate whether the diary entry rate reduction effect is replicable in EMF, a 28-day versus 7-day protocol was used, rather than using the 7-day versus 1-day diary as in the IAM studies reported in Chapters 3 and 4. If similar findings were obtained in this comparison, that would be helpful in demonstrating that EMFs are also more frequent than previously thought and that 28-day diary-keeping periods may be unnecessarily long.

In addition to the main question of the diary entry rate reduction effect, several other methodological questions were addressed. One of the biggest issues with diary studies is the difficulty of recruitment, particularly if participants must sign up for long periods of time and make visits to the laboratory. Research would be much easier if the entire study could be conducted by telephone, or perhaps by web video (e.g. Skype), rather than face-to-face. Therefore, Studies 4a and 4b used 28- and 7-day recording periods to test the feasibility of this approach, and were conducted entirely over the phone, and by post. If successful, this approach could demonstrate the equivalence with the face-to-face briefing of the paper diary part of Study 3.

Another feature of these two studies was that participants were not just young undergraduates but members of the public with various backgrounds and a broad age range. This allowed more general conclusions to be drawn. Very often diary studies have been conducted mainly on young adults, but here age varied from 18 to 87 years, which was deliberate decision in order to investigate the relationships between chronological age and participants' responses to the metamemory questionnaires and everyday memory failures recorded in the diaries. This is important because previous research in cognitive ageing has resulted in an interesting paradox where very substantial negative age effects have been found in almost all laboratory tasks of memory, cognition, attention and executive function (Grady & Craik, 2000), while in contrast, research examining the effects of age on self-reported metamemory questionnaires has shown mostly an absence of age effects (e.g., de Winter, Dodou, & Hancock, 2015; Smith et al., 2000). This absence of age effects has often been explained as older adults' inability to assess their everyday memory function because they forget about their problems (Rabbitt & Abson, 1990). The design of the present studies therefore facilitated the additional aim of examining relationships between chronological age and number of EMFs recorded in the diaries, and participants' scores on metamemory questionnaires. There is increasing evidence to show that older adults' memory in everyday life, at least prospective memory, is not as impaired as implied by the results of laboratory studies on prospective memory (Aberle, Rendell, Rose, McDaniel, & Kliegel, 2010; Henry, MacLeod, Phillips, & Crawford, 2004; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011). Therefore, if these initial findings are correct, we would expect no correlations of age with number of recorded failures in diaries, while we would expect to obtain significant negative correlations of age with most laboratory measures of memory and cognition.

Studies 4a and 4b were identical except for the diary-keeping period. The first study used a 28-day diary-keeping period, while the second employed the shorter 7-day diary period. The laboratory assessments (of prospective memory, verbal short-term and long-term memory, working memory, verbal fluency and inductive reasoning), and participant briefings, were conducted by telephone. Materials were sent out and returned by post. This allowed recruitment of more participants, who were geographically dispersed. Participants were recruited from a panel of volunteers, via web advertising, and emails to university alumni and local community groups. These studies were unique in that participants were measured using three methods: laboratory assessment, questionnaires, and keeping a diary. This allowed the comparison of memory failures assessed by the diary method with both laboratory and questionnaire measures of memory and cognition, addressing some methodological questions of key importance for which we currently have no answers.

Prior to the diary-keeping period, participants were screened by telephone, asked about any medical conditions that could affect their memory performance, and were assessed for general health and ability to complete the tasks. In a subsequent call, they first completed the Telephone Interview for Cognitive Status, TICS-M scale (de Jager, Budge, & Clarke, 2003) to ensure they did not have pre-existing memory problems. They then underwent a 30-minute telephone based laboratory assessment, The Cognitive Telephone Screening Instrument – COGTEL (Kliegel, Martin, & Jäger, 2007). After the call, they completed a series of metamemory questionnaires posted to them at home. The questionnaires used are summarised in Table 6-1.

Table 6-1. Summary of Metamemory Questionnaires used before and after Diaries

Metamemory Questionnaire	Types of Information Collected
Cognitive Failures Questionnaire – CFQ (Broadbent et al., 1982)	Self-rated frequencies of proneness to memory errors, slips of actions and attention failures.
Everyday Memory Questionnaire – EMQ, (Sunderland et al., 1983)	Self-rated frequencies of memory errors relating to speech, reading and writing, faces and places, actions, learning new things.
Memory Functioning Questionnaire – MFQ (Zelinski et al., 1990)	Self-rated seriousness of forgetting in various situations, relative remembering over time, and frequency of use of mnemonics and techniques assist memory.
Prospective & Retrospective Memory Questionnaire - PRMQ (Smith et al., 2000)	Frequencies of prospective and retrospective memory errors. Produces scores for PM and RM, and a total performance score.

Once the questionnaires were returned, participants were briefed on the diary method over the phone and kept the diary for 28 or 7-days (Studies 4a and 4b respectively). At the end of the diary-keeping period, participants completed a second set of the same questionnaires, returning these and the diaries in a pre-paid envelope. Finally, the participants were telephoned to debrief them about their experience, and to establish their compliance with the diary-keeping and any potential effect that they thought keeping the diary had had.

If the findings obtained for IAMs in Chapter 4 on the diary entry rate reduction effect using longer recording periods (7-days versus 1-day) are generalisable, then similar effects should be observed with EMFs using different diary-keeping periods (28-day versus 7-day). Therefore, it was predicted that significantly more memory errors would be recorded in the shorter diary-keeping period *pro rata* in comparison to the longer diary-keeping period. In addition, it was expected that the number of EMFs recorded in the first week of the 28-day diary would be significantly lower than in the 7-day diary. However, it was predicted that the relative occurrence of absent-minded, prospective and retrospective memory errors in the diaries would be independent of the diary keeping period.

In line with the ageing paradox reported for prospective memory (e.g. Henry et al., 2004), it was predicted that there would be negative correlations between age and laboratory measures, but that there would be no correlation between the number of memory errors recorded in the diaries and the chronological age and the laboratory scores.

6.2 Method

Two studies were conducted, Studies 4a and 4b. The recruitment approach was the same, and participants followed the same protocol, except for the diary-keeping period, which was either 28 days (Study 4a) or 7 days (Study 4b).

6.2.1 **Participants**

In Study 4a, there were 38 participants with a mean age of 55.21 years (SD = 22.99; range 18-87). There were 31 females (82%) and 7 males. In Study 4b, there were 26 participants with mean a age of 61.46 years (*SD* = 17.78; range = 25-78). There were 21 females (81%) and 5 males. Table 6-2 shows means for participants' age, years of education, ratings of current health (1=*poor*, 2=*below average*, 3=*average*, 4=*good*, 5=*excellent*), and health in comparison to peers (1=*worse*, 2=*slightly worse*, 3=*same*, 4=*better*, 5=*significantly better*) as a function of study (7-day versus 28-day). Occupations were mostly "skilled" (11%) or "professional" (88%), with only one participant in unskilled work. Participants in the two diary studies did not differ from each other on any of the variables (see Table 6-2).

Table 6-2. Means (standard deviations) for age and background variables in Studies 4a (28-day diary) and 4b (7-day diary) and results of one-way ANOVAs on means

	28-day (N=38)	7-day (N=26)	F	p	η_p^2
Age	55.21 (22.99)	61.46 (17.78)	1.362	.248	.021
Years of Education	14.84 (2.64)	15.62 (3.13)	1.077	.303	.017
Health rating[a]	4.29 (.732)	4.08 (.796)	.801	.374	.019
Health versus peers[b]	3.68 (.739)	3.61 (.847)	.726	.397	.012
TICS-M[c]	29.45 (3.88)	28.81 (2.83)	0.517	.475	.008
COGTEL Scores:[d]					
COGTEL total	39.65 (9.18)	43.53 (11.38)	2.271	.137	.035
Verbal Short-term	5.66 (2.03)	5.04 (1.71)	1.628	.207	.026
Working Memory	8.16 (2.34)	7.96 (2.16)	.115	.735	.002
Verbal Fluency Total	34.00 (8.78)	35.58 (9.80)	.453	.503	.007
Letter Fluency	15.58 (5.53)	16.08 (6.76)	.104	.748	.002
Category Fluency	18.68 (4.84)	19.50 (4.30)	.479	.492	.008
Inductive Reasoning	5.66 (1.98)	5.27 (1.73)	.658	.420	.011
Verbal Long-term	5.66 (1.78)	5.08 (1.85)	1.596	.211	.025

[a] Self-report health rating (1=poor, 2=below average, 3=average, 4=good, 5=excellent)

[b]Health versus peers (1=worse, 2=slightly worse, 3=same, 4=better, 5=significantly better)

[c]Telephone Interview for Cognitive Status. (de Jager et al., 2003)

[d]The Cognitive Telephone Screening Instrument

Given the wide age range used, it was essential to establish that older participants (in particular over 60) were well functioning. Therefore, the Telephone Interview For Cognitive Status (TICS-M) (de Jager et al., 2003) was administered to all participants. A TICS-M score of 21 or above reflects normal cognitive functioning and corresponds to a score of 25 and above on the Mini–Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). All participants scored at least 21 on the TICS-M scale. There were also no differences between participants in the two studies in terms of cognitive performance in initial telephone interview as measured by total score and sub-scores on the Cognitive Telephone Screening Instrument (COGTEL) (Table 6-2). Participants also did not differ in terms of summary scores and sub-scores on metamemory questionnaires conducted before the diary-keeping period, except for the RM subscale of the PRMQ, and the EMQ Learning New Things scale (see Table 6-3).

In the screening call, participants were also asked "Do you feel your memory is becoming worse?". In the 28-day diary condition 74% said "yes", while 73% said "yes" in the 7-day diary condition. Participants who thought their memory was becoming worse were asked how worried they were about it, on a scale 1=*not worried*, 2=*slightly*, 3=*somewhat*, 4=*quite worried* and 5=*very worried*. There was no significant difference between the conditions, χ^2 (4, N = 47) = 1.385, p = .847. Across the conditions, 81% were either *not worried*, or *slightly worried*, and just 11% were *quite worried* or *very worried*. There was no correlation between age and worry about memory (r = -.085, n = 64, p = .570).

Table 6-3. Means (standard deviation) for Metamemory Questionnaires Scores in Studies 4a (28-day diary) and 4b (7-day diary)

	28-day (N=38)	7-day (N=26)	F	p	η_p^2
CFQ	37.74 (12.32)	42.31 (11.42)	2.253	.138	.035
PRMQ Total	37.37 (7.71)	41.31 (9.23)	3.431	.069	.052
PRMQ PM	20.34 (4.52)	21.65 (5.69)	1.053	.309	.017
PRMQ RM	17.03 (4.21)	19.65 (4.02)	6.229	.015*	.091
MFQ Remembering	17.11 (4.45)	17.88 (3.87)	0.525	.472	.008
MFQ Seriousness of Forgetting	71.74 (18.49)	75.00 (17.79)	.496	.484	.008
MFQ Use of Mnemonics	23.47 (7.54)	23.81 (9.14)	.025	.874	.000
EMQ Speech	19.97 (10.255)	21.00 (9.27)	.167	.684	.003
EMQ Reading and Writing	5.95 (3.38)	7.15 (3.82)	1.770	.188	.028
EMQ Faces and Places	5.11 (3.15)	7.15 (3.82)	1.270	.264	.020
EMQ Actions	6.08 (4.53)	7.92 (5.89)	2.001	.162	.031
EMQ Learning New Things	7.74 (2.99)	9.58 (3.24)	5.458	.023*	.081

Notes: CFQ - Cognitive Failures Questionnaire; PRMQ - Prospective & Retrospective Memory Questionnaire; PRMQ PM - PRMQ prospective subscale; PRMQ RM - PRMQ retrospective memory subscale; MFQ - Memory Functioning Questionnaire; EMQ - Everyday Memory Questionnaire

6.2.2 **Materials**

The Telephone Interview For Cognitive Status (TICS-M) (de Jager et al., 2003) was used to screen participants for cognitive function (Appendix J). TICS-M assesses orientation, free recall, attention and calculation, comprehension, semantic and recent memory, language, and delayed recall. It has a minimum score of zero and a maximum of 39. A score of $\geqslant$ 21 reflects normal cognitive function.

The Cognitive Telephone Screening Instrument, COGTEL (Kliegel et al., 2007), consists of several standard cognitive tests that are conducted over the telephone (prospective memory, verbal short-term and long-term memory, working memory, verbal fluency and inductive reasoning) (Appendix K).

The metamemory questionnaires used in the questionnaire packs completed before and after the diary-keeping period are shown in Table 6-1. The questionnaires are reproduced in Appendices L, M, N and O.

6.2.2.1 ***Cognitive Failures Questionnaire (CFQ)***

The Cognitive Failures Questionnaire (Broadbent et al., 1982) asks participants to reflect on minor mistakes that they have made in the past six months. It consists of 25 questions, such as "Do you forget why you went from one part of the house to another?", and "Do you find you forget appointments?". Questions are answered on a scale of 4=*very often*, 3=*quite often*, 2=*occasionally*, 1=*very rarely*, 0=*never*. Scores range from 0 to 100.

6.2.2.2 ***Memory Functioning Questionnaire (MFQ)***

The full MFQ (Zelinski et al., 1990) consists of 64 items rated on 7-point scales covering a number of areas of memory function. However, to reduce participant burden, and avoid duplication with other questionnaires in the pack, only the following were used:

1. How well you remember things that occurred in four time periods: *last month*, *between 6 months and 1 year ago*, *between 1 and 5 years ago*, and *between 6 years and 10 years ago,* (7-point scale 1=*very bad* to 7=*very good*).
2. Seriousness of Forgetting, ratings of memory failures from 18 different situations, for example, names, faces, appointments, where things were put, (7-point scale 1=*very serious* to 7=*not serious*). Scores range from 18 to 126.
3. Mnemonics Usage. How often do you use these techniques to remind yourself about things? For example, writing notes, making lists, mental repetition. Eight specific mnemonics (7-point scale 1=*Always* to 7=*Never*). Score range 8-56.

In this questionnaire, higher scores mean higher levels of perceived memory function, i.e. fewer or less serious incidents, improvements in memory relative to when younger, and reduced use of, or need for, memory aids.

6.2.2.3 ***Everyday Memory Questionnaire (EMQ)***

The Everyday Memory Questionnaire (EMQ, Sunderland et al., 1983), was initially developed to evaluate patients with head-injury, but is also used in the normal population. It consists of 35 questions. The questions are grouped under four headings presenting scenarios asking participants to rate frequency on a six-point scale (5=*several times a day*, 4=*about once each day*, 3=*once or twice a week*, 2=*once or twice a month*, 1=*once or twice a year*, 0=*never*): “Speech” (17 questions, score range 0-85), “Reading and Writing” (4 questions, score range 0-20, “Faces and Places” (6 questions, score range 0-30), “Actions” (6 questions, score range 0-30).

A final category “Learning New Things”, consists of items such as being unable “to remember the name of someone met for the first time recently”, and “to pick up a new skill such as a game or working some new gadget after you have practised once or twice”, and responses are made on a 4-point scale with 4=*on every occasion*, 3=*on every other occasion*, 2=*only sometimes*, 1=*rarely*, 0=*never*, (6 questions, score ranges from 0 to 24).

6.2.2.4 ***Prospective and Retrospective Memory Questionnaire (PRMQ)***

The Prospective and Retrospective Memory Questionnaire (PRMQ) (Smith et al., 2000) asks participants to indicate the types of mistakes they make in normal everyday life. There are 16 scenarios reflecting short- and long-term prospective and retrospective memory failures, which are scored on a scale of 5 = *often*, 4 = *quite often*, 3 = *sometimes*, 2 = *rarely*, 1 = *never*. Examples include: “Do you decide to do something in a few minutes’ time and then forget to do it?”, and “Do you mislay something that you have just put down, like a magazine or glasses?”. (Total PRMQ score range: 16-80, PM and RM scores range 8-40.)

6.2.2.5 ***Diary Booklet***

The diary booklet was the same as the paper diary used in Study 3, described in Chapter 5 (see Appendix G). It was an A5 booklet, containing 32 identical pages, one page to be completed for each everyday memory failure noticed. The following items were collected in the diaries: 1. When did you have a memory error? Or when did you realise you made an error? (*Date and time*); 2. When did you record it here? (*Date and time*); 3. Describe your memory error (*free text entry*); 4. What was your mood immediately before the error (a 5-point scale: 1 = *very unhappy* to 5 = *very happy*); 5. How relaxed or stressed were you immediately before the error (a 5-point scale: 1 = *very relaxed* to 5 = *very stressed*); 6. How serious was the memory lapse (1 = *Insignificant,* 2 = *Minor,* 3 = *Somewhat significant,* 4 = *Significant*, 5 = *Very significant/potentially dangerous*); 7. Were there or could there have been any consequences? (*free text*); 8. How upset are you by the memory lapse? (1 = *Not at all upset,* 2 = *A little,* 3 = *Somewhat,* 4 = *Quite*; 5 = *Very upset*); 9. Describe the emotions you felt in response to your lapse, if any (*free text*); 10. If you later recovered from this error, describe when and how (*free text*).

6.2.2.6 ***Post Diary Questionnaire***

The post-diary questionnaire was administered by telephone during the debriefing call. Participants answered the following questions, which were recorded by the researcher:

1. Did you keep your diary with you every day of the study? (Yes/No). If no, on how many days did you not have the diary?
2. If you did not keep your diary with you all the time, were there reasons for this and if so please tell me what the reason was/were?[5]
3. What percentage of everyday memory errors do you think you recorded and acknowledged (on the days when you had the diary with you all the time)?
4. How difficult did you find keeping your diary with you at all times? (1=*Not difficult*, 2=*A little*, 3=*Medium*, 4=*Quite*, 5=*Very Difficult*).
5. How difficult did you find recording your everyday memory errors using the diary? (1=*Not difficult*, 2=*A little*, 3=*Medium*, 4=*Quite*, 5=*Very Difficult*).

6.2.3 **Procedure**

The procedure was the same in both studies, except that in Study 4a participants kept a 28-day diary, while in Study 4b participants kept a 7-day diary. Potential participants were screened by telephone. In addition to gathering demographic details, they were asked if there was any reason they might have memory problems (e.g. previous head injury, stroke, or mental health issues). They were asked if they thought their memory was getting worse, and if so how worried they were about this. The protocol was then explained.

Participants who passed this initial screening procedure were administered two tests over the telephone, the TICS-M screen, followed by the COGTEL instrument. At the end of these tests, which took 30-40 minutes, participants were told they would receive the

[5] When participants had not carried the diary, they were probed with appropriate questions: Did you forget? Was it not convenient? Did you choose not to for a reason? e.g. Social event, or it was inappropriate (funeral, working, felt awkward).

questionnaire pack in the post in the following days. They were requested to complete and return these questionnaires as soon as possible, using a pre-paid envelope.

Once the questionnaires had been returned, participants in the 28-day diary study were sent three diary booklets (each containing 32 pages), while participants in the 7-day diary study were sent two diary booklets. When participants had received these, they were briefed by telephone on how to complete the diary, with examples of different types of memory failures. They were asked to start using the diary from the next day for either 28 or seven consecutive days. Participants were instructed: "Each time you experience a memory failure, please fill in a brief questionnaire on the next diary page." The tick option was also explained to participants, giving them the option to place a tick in the grid if they were unable to record a memory failure near to the event, and could not recall all the details later.

To coincide with the end of the diary-keeping period, participants were sent a pre-paid return envelope along with a second set of the questionnaires, the same as the first, to be completed and returned with the diaries. When the diaries and the second set of questionnaires had been returned, the participants were telephoned for a debriefing interview, to determine their compliance (had they kept the diary with them every day, and if not how many days had they forgotten, what percentage of memory failures they think they recorded and acknowledged) and to gather the other information as described in Materials.

6.3 Results

6.3.1 **Diary Compliance**

In the post-diary interview, participants were asked how easy it was to carry the diary, and how easy it was to complete it. Participants keeping the diary for seven days reported that it was significantly easier to carry the diary at all times compared with the 28 day diary, $F(1, 62) = 4.13$, $p = .046$, $\eta_p^2 = .062$. However, there was no difference between the studies in the rating of difficulty of recording memory errors in the diary, $F(1, 62) = 1.53$, $p = .220$, $\eta_p^2 = .024$.

In both studies, 76% of participants claimed to have carried the diary with them at all times. In the 7-day diary study, four participants forgot the diary on one day, and two on two days. In the 28-day diary study, three participants reported forgetting on four days, two participants on five days and one participant on seven days (see Table 6-4).

Table 6-4. Number of Participants, in Each Diary Condition, who Reported Forgetting to Keep a Diary on a Given Number of Days (28-day vs 7-day)

	Number of Days Diary Forgotten				
	0	1	2	> 2	Total
28-day diary	29 (76%)	1 (2.6%)	2 (5.3%)	6 (15.8%)	38
7-day diary	20 (77%)	4 (15.4%)	2 (7.7%)	0 (0.0%)	26

Since the diary-keeping periods were different in Studies 4a and 4b, the number of days that the diary was forgotten was expressed as a proportion of the total number days it should have been carried in order to make a valid comparison. There was no significant difference between the two diary studies for the proportion of days the diary was forgotten (3% for 28-day diary and 4% for 7-day diary, $p = .535$). Similarly, using the raw numbers of forgotten days without this correction, did not result in a statistically significant difference, $\chi^2 = 4.98$, $p = .083$. Hence, even though the longer 28-day diary study gave more opportunity to forget the diary, there was no significant difference between the studies in the days forgotten.

The studies also did not differ in the mean percentage of EMFs that participants thought they had been able to record (86% in 28-day diary and 91% in 7-day diary, $p = .153$). For comparison, these percentages are very similar to the mean percentage of 83% reported by participants in the 7-day paper diary condition in Study 3 (Chapter 5), where participants were briefed face-to-face. This finding is important because if all participants considered they had recorded the same percentage of errors, and carried the diary for the same percentage of time, then we would expect the number of memory errors recorded in the diaries to be proportional to the diary-keeping period.

6.3.2 **Results for Diary Entries**

6.3.2.1 ***Coding of Memory Descriptions***

Prior to analysis of memory errors, it was necessary to code them. Memory error descriptions broadly fall into three categories: absent-minded (AM) errors, prospective memory (PM) errors and retrospective memory (RM) errors (Kvavilashvili et al., 2009). Table 6-5 provides examples from diaries in these two studies of each type of memory error. The fully recorded memory errors were analysed and classified into these categories by two raters. Inter-rater agreement was high (95%), and disagreements were resolved by discussion. Ticks, of course, could not be allocated to types of memory error.

Table 6-5. Examples from diaries of memory errors by type (AM, PM, RM)

Memory Error Type	Examples
AM	"Got out telephone book instead of address book"
	"Forgot what I went upstairs for"
	"Put keys in bag instead of phone", "went to put bread in fridge"
PM	"Forgot to charge mobile phone overnight"
	"Forgot to take my 3:15pm tablet"
	"Forgot to tell brother something – rang later"
	"Forgot to ring hairdresser"
RM	"Forgot the name of a shop I regularly visit"
	"Forgot part of a dance I have done many times"
	"I was not able to find papers I had stored safely"
	"Forgot what I was going to say"

6.3.2.2 ***Number of Fully Recorded and Acknowledged EMFs as a Function of the Recording Period***

In line with the data analysis in previous chapters, due to large individual variability in counts of memory errors, to normalise data, the counts were squared-root transformed for analysis in this, and subsequent sections. However, in the tables, actual values of counts are presented.

The average number of fully recorded failures, ticks, and the breakdown by AM, PM and RM errors for both 28-day and 7-day diary recording periods are shown in Table 6-6, Panels A and B.

Table 6-6. Means, SDs and ranges of memory failures, ticks, and breakdowns for 28 and 7-day diaries. Percentages recorded in seven days versus 28 Days

Diary Type	Fully Recorded	Ticks	AM	PM	RM
Panel A					
28-day diary (N=38)					
Mean	17.82	8.89	3.53	7.16	7.13
SD	16.42	18.75	5.77	6.52	7.84
Range	1-71	0-78	0-32	0-29	0-33
Panel B					
7-day diary (N=26)					
Mean	9.50	1.04	2.12	3.12	4.27
SD	5.97	2.47	1.24	3.68	4.12
Range	3-25	0-11	0-5	0-16	0-17
Panel C					
Number of EMFs in 7 days as % of number in 28 days	53%	11.70%	60%	44%	60%

Unsurprisingly, there were more fully recorded memory errors and ticks in the 28-day diary than in the 7-day diary. This was confirmed by a 2 diary length (28-day vs. 7-day) x 2 type of EMF (fully recorded vs. tick) mixed ANOVA with the repeated measures on the second factor. There was a significant main effect of memory type (fully recorded vs. tick),

$F(1, 62) = 79.82$, $p < .001$, $\eta_p^2 = .56$, and a significant main effect of diary length (28-day versus 7-day), $F(1, 62) = 42.68$, $p < .001$, $\eta_p^2 = .41$, but no interaction ($F = .71$, $p = .40$).

Next, this superiority of 28-day diary over 7-day was also examined with fully recorded memory errors broken down into AM, PM and RM errors. When using different diary periods, an important question concerns whether the same pattern of absent-minded, prospective and retrospective memory errors is observed. This is important methodologically, to understand whether people record more of one type of error over other types, and whether it depends on the length of diary-keeping period. Mean number of memory errors, over the period, were entered into a 2 diary length (28-day vs. 7-day diary) x 3 error-type (AM vs. PM vs. RM) mixed ANOVA, with repeated measures on the error type. There was a significant main effect of error type, $F(2, 124) = 9.81$, $p = .0001$, $\eta_p^2 = .14$. Follow-up tests showed participants recorded significantly more PM than AM errors ($p = .002$) and significantly more RM than AM errors ($p = .00004$). However, the difference between PM and RM was not significant ($p = .35$).

The main effect of diary length (28- vs. 7-day) was not significant, $F(1, 62) = 3.80$, $p = .06$, $\eta_p^2 = .06$. However, there was a significant diary length by memory error type interaction, $F(2, 124) = 4.08$, $p = .02$, $\eta_p^2 = .06$. Tests of simple main effects showed there was no significant difference between the 7-day and 28-day diary studies for absent-minded errors ($F < 1$), and for retrospective memory errors ($F = 1.98$), but more PM errors were recorded in 28- than 7-day diary, ($F(1, 62) = 9.22$, $p = .004$, $\eta_p^2 = .13$).

6.3.2.3 *Number of EMFs in 7-Day Diary as a Proportion of EMFs in 28-Day Diary*

In order to assess the diary entry rate reduction effect, firstly the mean number of EMFs recorded in the 7-day diary was expressed as a percentage of the mean number recorded in 28-day diary. Percentages for memory errors by type, and ticks were calculated.

These percentages are shown in Panel C in Table 6-6. If recording in the diary was *pro rata* to the number of days of recording, we would expect the ratios of 7-day diary entries to 28-day diary entries to be 25%, assuming a uniform rate of recording. Clearly the percentages for "fully recorded errors" and errors broken down by type (AM, PM and RM) were well in excess of 25%. Interestingly, the ticks were not, but the use of the tick option varied widely, and many participants did not use this option at all.

This finding confirms that there was a similar diary entry rate reduction effect compared with the 1-day to 7-day effect in Studies 1 and 2 on IAMs, although the ratios of the periods were different (1:4 rather than 1:7). The effect appears less dramatic with EMFs than with IAMs, but it is clearly there.

Having found this effect, the next step was to address the question of whether the participants recorded more memory errors in the 7-day diary than in the first week of the 28-day diary.

6.3.2.4 *Comparing the Number of EMFs in 7-Day Diary versus Week 1 of 28-Day Diary*

Table 6-7 shows the mean number of total memory errors, as well as means broken down by error type for the 7-day diary and week 1 of the 28-day diary. One-way between-subjects ANOVAs on these means showed that the number of fully recorded, absent-minded and retrospective errors were significantly higher in the 7-day diary than week 1 of 28-day diary, but the difference for PM errors was not significant. Additionally, there was no difference between studies for the number of ticks made. The diary period entry reduction effect appears to hold for the entire number of recorded errors, and RM and AM errors, but not PM errors.

Table 6-7. Comparing means of recorded memory errors in Week 1 of 28-day diary and in 7-day diary.

	Week 1 of 28-day	**7-day**	F	p	η_p^2
Fully recorded	5.95 (4.91)	9.50 (5.97)	9.067	.004	.128
AM	1.39 (2.28)	2.12 (1.24)	9.303	.003	.130
PM	2.37 (2.31)	3.12 (3.68)	0.207	.651	.003
RM	2.16 (2.66)	4.27 (4.12)	8.397	.005	.119
Ticks	1.61 (3.36)	1.04 (2.47)	1.058	.308	.017

Note that the means and standard deviations are for the actual counts, but the F, p, and η_p^2 values are calculated on the square root transformed values.

6.3.2.5 *Analysis of 28-day Entries by Week*

Finally, the 28-day diary data were considered in terms of the breakdown of error counts by week. These are of interest to see if the rate changes over the four consecutive weeks of the 28-day diary, as this gives insight as to whether there might be an effect of keeping a diary over time.

The means of square root transformed fully recorded EMFs and acknowledged EMFs (ticks) are shown in Figure 6-1.

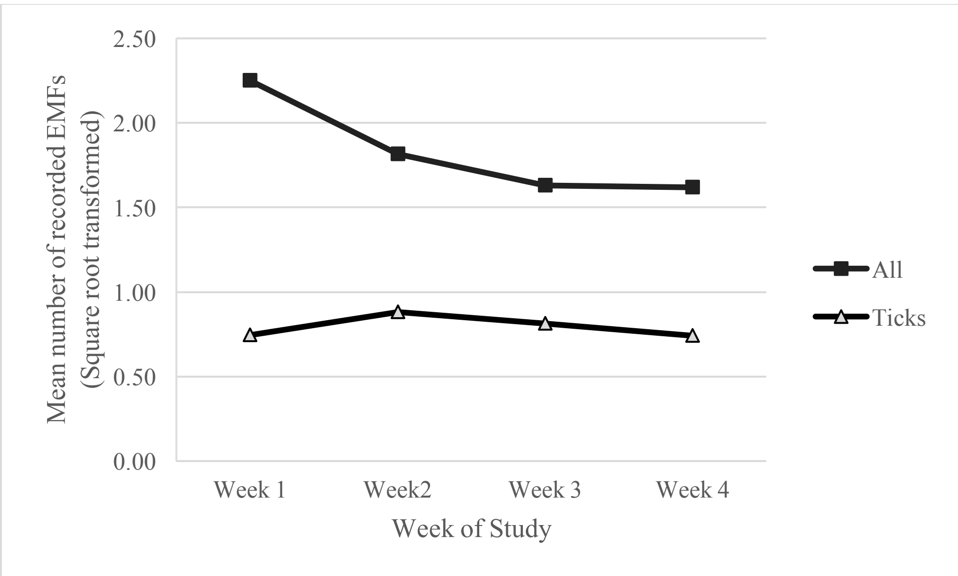

Figure 6-1.Mean number of fully recorded EMFs, and ticks, by week of 28-day diary

In a 2 type of recorded EMF (fully recorded vs. ticks) x 4 weeks (week 1, 2, 3 and 4) mixed ANOVA with repeated measures on the second factor, there was a significant main effect of weeks $F(3, 111) = 4.34$, $p = .006$, $\eta_p^2 = .11$, and a significant main effect of EMF recording type, $F(1, 37) = 30.57$, $p = .000003$, $\eta_p^2 = .45$. However, these main effects were qualified by a significant interaction between these variables, $F(3, 111) = 8.33$, $p = .00005$, $\eta_p^2 = .18$.

Tests of simple main effects showed that the main effect of weeks was significant for fully recorded memories ($F(3, 111) = 8.225$, $p = .0003$, $\eta_p^2 = .413$), but not for ticks ($F = .668$). *Post hoc* comparisons for fully recorded memory errors showed that the number of recorded errors in week 1 was significantly higher than any of the subsequent weeks (all $p_s < .002$), but there were no significant differences between weeks 2, 3 and 4 (all $p_s > .056$). This makes a further case for reducing the diary-keeping period to one week.

6.3.3 **Correlations between Age and Memory Errors, Laboratory Measures of Cognition, and Metamemory Questionnaires**

Given that performance on COGTEL and metamemory questionnaires was equivalent across Studies 4a and 4b, the data from these two studies were pooled when calculating correlations with chronological age. In line with most findings in cognitive ageing literature, there were reliable negative correlations between age and total COGTEL scores as well as several subscales of COGTEL (see Table 6-8). In addition, there were negative correlations of age with TICS-M total score ($r = -.364$, n = 64, $p = .003$), TICS-M free recall ($r = -.318$, n = 64, $p = .010$), and TICS-M delayed recall ($r = -.370$, n = 64, $p = .003$).

In sharp contrast, none of the correlations between age and total metamemory questionnaire scores, or their subscale scores were significant (all $p_s > .06$). Importantly, similar non-significant correlations were obtained between age and number of fully recorded EMFs and any of the three types of recorded failures in Study 4a with the 28-day diary (all $p_s > .56$).

In the 7-day diary study, there was one negative correlation of age with fully recorded memory errors (r = -.412, p = .037), indicating that younger participants recorded more memory errors. However, this correlation disappeared when two young participants (both 27 years old) who recorded particularly large numbers of memory errors (23 and 25 memory errors respectively) were excluded from the sample.

Taken together these findings appear to suggest that diaries and questionnaires are measuring something different from what the laboratory tests are measuring.

Table 6-8. Correlations of Age with COGTEL Totals and Sub-scores

COGTEL		Total Score	Verbal Short-term Memory	Working Memory (reverse digit span)	Verbal Fluency	Letter Fluency	Category Fluency	Inductive Reasoning	Verbal Long-term Memory
Age	r	-.488**	-.435**	.086	-.189	-.088	-.284*	-.308*	-.461**
	Sig	.000	.000	.497	.135	.491	.023	.013	.000
	N	64	64	64	64	64	64	64	64

*$p < .05$; **$p < .01$

6.3.4 **Correlations between Memory Failures and Scores on Laboratory Measures and Questionnaires**

To examine the possible relationship between participants' scores on laboratory tests, their self-reports on metamemory questionnaires, and the number of recorded EMFs, partial correlations were calculated between these variables, controlling for participants' age. Correlations between the number of EMFs and scores on COGTEL and TICS-M were all non-significant, except for a correlation for the COGTEL backward digit span task (r = .49, p = .01), and between the number of recorded PM errors and COGTEL backward digit span score (r = .45, p = .02), and letter fluency (r = .40, p = .046) in the 7-day diary study, suggesting that better performance in laboratory tests was associated with higher number of recorded EMFs (for similar results see Wilkins & Baddeley, 1978).

In contrast, the pattern for metamemory questionnaires was more varied and difficult to interpret, and given they were not the primary focus of the present investigation, are not presented in detail here. However, a few observations were made that suggest avenues for further research.

With the PRMQ, before the 28-day diary there was no correlation between fully recorded memory errors and the PRMQ score, but after the 28-day diary there was significant correlation of fully recorded memory errors with PRMQ PM total (r = .390, p = .015), and PM errors and PRMQ PM (r = .434, p = .006). No correlations were seen in the 7-day diary. This potentially suggests that keeping a diary for a longer period leads to an improved self-understanding of prospective memory errors, which could be investigated further.

Similarly, testing the correlation of number of recorded memory errors with the EMQ scales, there were no correlations with any of the EMQ scores before the diary, whereas after the 28-day diary the following correlations were found: EMQ speech (r = .380, p = .019), EMQ Reading and Writing (r = .328, p = .044), EMQ Actions (r = .422, p = .008) and EMQ Learning New Things (r = .420, p = .009). Again, perhaps the diary made participants more aware of these classes of errors, as the correlations suggests those with more memory errors in the diary rated their memory problems higher in the EMQ having kept the diary for four weeks.

6.4 Conclusions

The main aim of Studies 4a and 4b was to test whether the diary entry rate reduction effect generalised from IAM diaries to EMF diaries. Further, the effect was examined with longer diary periods typically used in EMF diary studies. The second aim was to examine possible correlations between the number of recorded EMFs and age, with laboratory measurements of memory, and metamemory questionnaire scores.

Finally, the studies also allowed testing of the feasibility of a telephone and postal-based method of recruiting, screening, and testing participants, to ease the process for researchers and reduce the burden on participants. This approach facilitated participation by members of the public, rather than just university students and staff, over a wide age range, allowing observation of any age effects.

The main finding was that the rate of recording of all memory errors in seven days was significantly higher than the rate in 28 days. Further, the number of all fully recorded errors entered in the 7-day diary was significantly higher than the number entered in the first week of the 28-day diary. This reproduced the diary entry rate reduction effect seen in the IAM diary studies.

Breaking down the errors by type, the diary entry rate reduction effect was present for AM and RM, but not for PM errors. This finding was somewhat unexpected, but it suggests that it might be worth keeping the diary for longer if there is specific interest in PM errors, although there are diminishing returns, when asking participants to keep a diary for longer periods and it may not be worth keeping a diary for four weeks instead of one week only to double the PM count.

Another methodologically important finding was that using the telephone to conduct laboratory measurements, and to brief participants about the diary task, together with postal distribution of diary booklets and questionnaires, is feasible and produces findings which do not differ from results obtained in diary studies conducted face to face. Indeed, the mean number of recorded EMFs in Study 4b over the 7-day period was 9.50 (SD = 5.97) which did not differ from the mean number of EMFs (M = 10.60, SD = 7.94) recorded in the 7-day paper diary condition of Study 3. These results indicate that, in future, this type of remote testing might be able to be extended to web-based video format, e.g. Skype, webcast, or YouTube video briefing.

Important findings also emerged from the correlational analysis. Firstly, results demonstrated that participant age did not positively correlate with the total number of recorded EMFs, or the scores on metamemory questionnaires. While findings concerning metamemory questionnaires is in line with previous research, the absence of age effects in the number of recorded EMFs is a completely novel finding that sharply contradicts current theories of ageing and numerous findings from laboratory studies showing negative age effects. Interestingly, strong age effects in the laboratory measures of memory and cognition were obtained in both studies on the same participants making the discrepancy of findings between laboratory and diary methods particularly noteworthy. These contrasting age effects suggest that EMFs captured in the diary measure something different from what is measured in the laboratory. This idea was further supported by absence of correlations between the number of recorded EMFs and the laboratory measures of COGTEL and TICS-M.

The findings with the metamemory questionnaires were less conclusive. However, there seemed to be some effects on the self-perception of memory functioning, as recorded in some of the questionnaires completed after the diary, when keeping the diary for the longer 28-day period. This may be a justification for a longer diary-keeping periods, and warrants further research. Clear age effects were seen with the laboratory measures, as predicted. However, there were no age effects for diaries or metamemory questionnaires.

In summary, Studies 4a and 4b confirm the diary entry rate reduction effect for EMFs. They also show that the combined method of laboratory tests, questionnaires and diaries can be conducted by telephone and post. Finally, they confirm previous findings of age effect in laboratory measurements, but these were not found with metamemory questionnaires and diaries, suggesting that the latter two methods are not measuring the same thing. Further research on whether keeping a diary of memory failures affects the perception of memory performance, as measured by metamemory questionnaires should be considered.

CHAPTER 7: The Frequency and Cueing Mechanisms of Involuntary Memories while Driving: A Novel Audio Recording Method *in situ* (Study 5)

7.1 Introduction

The research described so far in this dissertation has shown that shorter recording periods can be better than longer in terms of the rate of data collection. This raises the question of whether the number of phenomena occurring is changing, or are people approaching the task differently depending how long they are given to keep a diary. Are participants more engaged or motivated, or more meta-aware, and able to notice, if monitoring for a shorter period? This issue is particularly important in current research on IAM, where we do not know the actual frequency of IAMs.

An interesting observation in Study 1 (Chapter 3), comparing 7-day paper and smartphone diaries of IAMs was that surprisingly few IAMs were recorded over the week. Study 2 (Chapter 4), which compared 1-day paper and smartphone diaries demonstrated an increase in the *rate* of recording memories (number per unit time) with this much shorter diary-keeping period, but there still seemed room for improvement in the rate of collection of IAMs. Although the frequency of IAMs recorded in those studies was in keeping with earlier studies (Berntsen, 1998; Kvavilashvili & Mandler, 2004; Mace et al., 2011; Schlagman et al., 2007), they did not seem consistent with my self-observation in daily life, having commenced research in this domain. In particular, I noticed when driving on a familiar route that I had many IAMs, relative to those in the diary studies, triggered by what I was seeing outside the car, hearing inside the car (on the radio or music playing), physical sensations (e.g. temperature, discomfort), and thought processes about events prior to my departure, or anticipated for the day at the end of my journey. This study was therefore primarily about examining the frequency of IAMs in everyday life. However, it also developed a method for capturing IAMs while driving, which can be extended to other aspects of everyday life.

7.1.1 **Frequency of IAMs**

A brief overview of research on IAMs was presented in Chapter 2. A discussion of the literature on the frequency of IAMs was presented in Chapter 4, where the issue of frequency was first raised. That study (Study 2) examined how frequency was affected when reducing the period of keeping a paper or smartphone diary.

Given my self-observation, this gave me the idea of using driving as a naturalistic on-going activity during which IAMs could be audio-recorded without too much disruption to the task. IAMs could then be transcribed later and analysed. An initial pilot of a couple of journeys showed a surprising range of memories (both numbers of them, and types) and that the method was feasible without disrupting, or negatively affecting driving.

7.1.1.1 ***How the Study was Conceived***

The method was adapted from an idea of using an audio recorder in the car to capture free-flowing thoughts. For example, ideas for sections of text for journal articles often came to mind, but frustratingly could not be recalled at the end of the journey. Furthermore, when briefing participants in the paper and smartphone diary studies described in previous chapters, I typically explained that I could not recall details of IAMs occurring while driving at the end of the car journey (hence the tick option).

7.1.1.2 ***Literature on Driving***

There is an extensive literature on the psychological aspects of driving, and research methods examining “naturalistic driving studies”, which will not be reviewed at length here. However, research on automaticity and inattention blindness while driving on familiar roads (Charlton & Starkey, 2013) is relevant. Most drivers will have experienced a loss of awareness and arriving at a point without any recollection of the previous few minutes. This phenomenon is known as driving without attention (Kerr, 1991) or without awareness (Brown, 1994), although in reality the experience is realising the gap at the end of the attention lapse (Chapman, Ismail, & Underwood, 1999). Distracted driving ("How did I get here?") suggests that the mind is somewhere else (Charlton & Starkey, 2011; Groeger, 2002; May & Gale, 1998). This is significant because many accidents are associated with failure during automatic, or procedural driving. The phenomenon of driving without awareness increases on familiar roads. Charlton and Starkey (2013) described a tandem model applied to their data, which includes implicit and explicit processes related to driving performance. As drivers become increasingly familiar with the environment, they will process fewer external elements in their driving environment.

Returning to IAM research, results from several diary studies suggest that more IAMs (67%) occur when people are not engaged in demanding tasks, but when they are in diffused or unfocussed states of mind (Berntsen, 1998; Kvavilashvili & Mandler, 2004). My perceived number of memories experienced while driving is consistent with these findings. While driving requires vigilance and attention, there is automaticity about the activity. In particular, an experienced driver on a familiar route may not be under great demand.

Driving might therefore be an ideal activity for cognitive research because of its semi-automatic nature, which is thus conducive to mind-wandering. People move in and out of mind-wandering as they approach hazards and need to concentrate. Therefore, on a standard journey, such as a commute, this is potentially a good way to study IAMs in a controlled, regular environment where the same things happen. There is a consistency with the same landmarks and road signs on each journey, as a well-controlled real life situation. There are however random elements, such as different weather conditions and different vehicles. Rather than a vigilance task in the laboratory (such as Schlagman & Kvavilashvili, 2008), this study uses a driving task in real life.

7.1.1.3 *Study of Self – Precedent in psychology*

Measurement of oneself has both advantages and disadvantages. There are many precedents of self-observation in psychology of memory (Berntsen, 2009; Kvavilashvili & Mandler, 2004; Linton, 1986; Wagenaar, 1986) as a precursor to novel research. Linton (1986), for example, recorded events from her everyday life for several years and then tested herself monthly by drawing events randomly from a pool to see if she recognised them, and attempted to date them.

This study follows a similar pattern of recording the experimenter's own memories. Such research, while limited to one participant who is aware of the hypothesis, gives insights into psychological phenomena and generates hypotheses that can then be developed into experiments on larger groups of participants (e.g. see Kvavilashvili & Mandler, 2004).

7.1.1.4 *Predictions*

My prediction, based on my informal observations, was that a larger number of IAMs would be noted in the relatively short journey time, compared with the rates seen in the longer studies and more formal diary recording discussed in previous chapters.

I was expecting that memories would be predominantly triggered than not, and by external cues more than internal, in line with previous findings (Berntsen, 1996; Berntsen & Hall, 2004; Kvavilashvili & Mandler, 2004; Schlagman et al., 2007). I also predicted that IAMs recorded while driving would be predominantly specific rather than general, as is found in diary studies (Ball & Little, 2006; Berntsen, 1998).

Driving a consistent route multiple times provides an interesting opportunity to compare static versus transient cues. For example, there are potential cues that will always be present: buildings, landmarks, road signs etc. While other cues will be dynamic, and perhaps unique to one journey, or at least point in the journey, for example, a lorry or van with a company logo, a certain model or colour of car, or piece of music playing in the car. No prediction was made as to which might predominate.

In terms of outcomes of this research, I also anticipated that the method could be refined in the experiment and applied more broadly, with insights into the value of the novel data collection method. It may also be useful to the driving research community as another approach to studying distracted driving. For example, to ascertain what are people thinking about when driving. Are their thoughts and attention localised inside the car rather than focussed outside? Are the cues (or distractions) external to the vehicle? Are the thoughts common or irregular? How does familiarity with the route affect the number and types of memories?

7.2 Method

7.2.1 Participant

The participant was male aged 54 years 3 months at first journey to 55 years 11 months at the final journey. The participant passed his driving test aged 17 years and had driven regularly since age 22.

7.2.2 Journeys

A total of 22 journeys were collected. However, one was abandoned because of an incoming phone call, and another because a highly absorbing radio programme (a recording of the politician Tony Benn reading from his diaries, following his death) prevented the participant from noticing and recording any IAMs[6]. The journeys were recorded from 4 July 2013 to 23 February 2015. See Figure 7-1 for an illustration of the distribution of the journeys over time.

[6] This was a very powerful demonstration to the participant that engagement in a task quickly reduces the number of IAMs experienced.

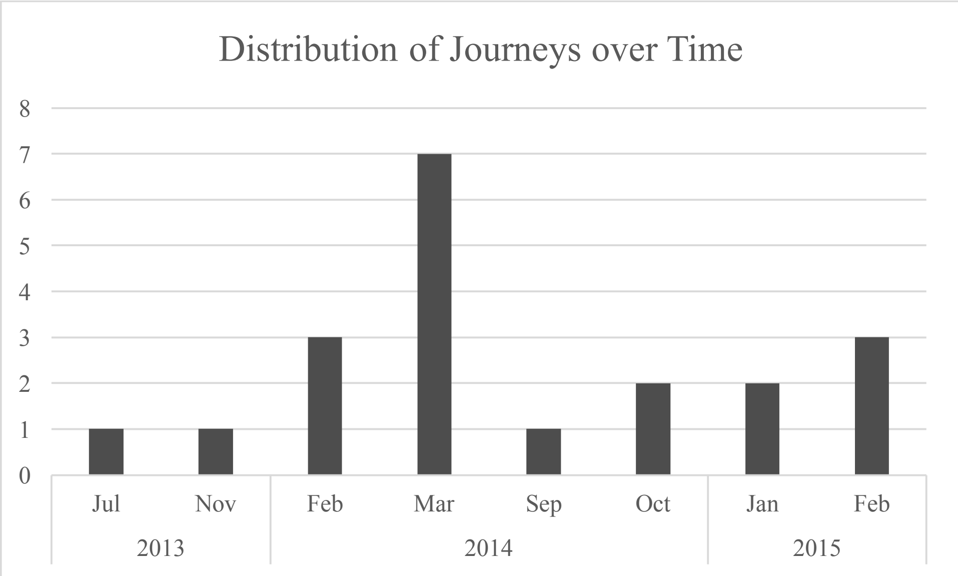

Figure 7-1 Number of Journeys over Time

The first two journeys (in 2013) were pilot recordings to test the feasibility of the method but as they went so well they were included. The majority of journeys were recorded in February and March 2014, a further three in September and October 2015, and then another five in January and February 2015. Data from the 10 journeys in the intensive period in 2014 were comparable with the other, earlier and later 10 journeys. The journeys recorded were chosen where it was expected they would follow the standard pattern of journey time, outside of peak periods. All journeys followed the same route in the same direction.

7.2.3 **Materials**

An Olympus WS-811 digital audio recorder, with "tie-clip" microphone was used. Audacity audio software was used to play back the MP3 audio file for transcription of memory events and noting time into journey (*Audacity*, 2016).

7.2.4 **Procedure**

A standard journey was used, namely between the participant's home and the University of Hertfordshire student car park. This was a very familiar journey driven by the participant many times before staring the experiment, and on other days when not recording the journeys, using a consistent route. The distance was 38.7 km, and typically took about 37 minutes to complete. Morning journeys outside the “rush hour” were used so the car was moving normally all the time apart from mandatory stops at traffic lights and junctions, avoiding prolonged periods in stationary traffic. The recording was started immediately before pulling away, and continued until pulling into a parking space and turning the engine off.

While driving, the participant would comment from time to time on what he was observing, not only recording memories. This enabled him to keep track of what was going on and also to keep himself reminded that he was doing the experiment[7]. Expressing inner thoughts out loud helped to keep the mind active in terms of metacognition. Each time the participant was aware of an IAM, he would describe it and, where possible, identify the trigger. No other information was gathered at this point to ensure safe driving, but the memory descriptions and other comments were subsequently used to assess various memory characteristics, for example specificity and emotional valence (*cf.* Berntsen, 2009). Given the frequency of IAMs and the overall need to drive safely, descriptions were occasionally curtailed.

7.2.5 **Scoring**

After all the journeys were gathered, the audio files were played back and transcribed in a notebook in sufficient detail to identify characteristics of the memories, and to record other salient comments about the journey. The journeys were reviewed in reverse chronological order such that the most recent journey was transcribed first.[8] On transcription, each IAM was classified as specific or general (following the pattern in Chapters 3 and 4), and rated as a positive (+1), negative (-1) or neutral memory (0)[9]. In keeping with the

[7] This turned out to be very useful in discovering otherwise unidentifiable links between the environment and subsequently recorded involuntary memories.
[8] This approach was serendipitous but revealed some interesting insights, for example, it was easier to notice memories that repeated, or were similar, across journeys.
[9] A full 5-point Likert scale spoken at the time would have been disruptive and was not realistic given the need to drive safely.

previous diary studies, the trigger was evaluated as external, internal or that there was no apparent trigger (see Chapter 2). For those identified as having an external trigger, the cue was further classified as a static or dynamic cue. Static cues were cues that were always present in the journey (such as a landmark or road sign), while dynamic cues were random, transient items that were encountered on one occasion only (e.g. another vehicle, or particular music playing, or some change to the usual, such as a petrol station sign not working).

7.3 Results

7.3.1 Number of Recorded IAMs

The total number of IAMs recorded over 20 journeys was 674, with a mean of 33.70 (*SD* = 7.57) per journey (minimum 19, maximum 44).

The mean journey time was 37 minutes 42 seconds (*SD* = 3 minutes and 1 second). The mean rate of memories was 0.90 memories per minute, which equates to a mean time between consecutive IAMs of 71 seconds, with a minimum of 52 seconds, and a maximum of 117 seconds across all journeys. A full breakdown of journey durations, number of memories in each journey and rates of occurrence of memories is given in Table 7-1.

7.3.2 Triggers

A summary of the cue types and proportions for each journey is given in Table 7-2. The majority of memories (N = 332, 49%) were externally cued, with percentages varying from 20% to 76% per journey. Thirty-nine per cent were internally cued (N = 266) with percentages varying from 19% to 67% per journey. No cues were identified on only 11% of recorded memories (N = 76). Overall, across all journeys there was a clear picture of memories having an identifiable cue, whether internal or external (89%).

Although the number of externally cued memories (M = 16.60, *SD* = 5.85) was higher than internally cued memories (M = 13.30, *SD* = 5.93) this was not statistically significant, $t(19) = 1.74$, $p = .10$. Mace (2004) found a similar non-significant effect, but Berntsen (1998) found significantly more external cues than internal cues. This difference is further examined later in terms of chaining.

Table 7-1 Summary of number of memories per journey, journey duration, mean memories per minute and mean time between memory

Journey Number	Number of Memories	Journey Duration (mm:ss)	Memory Rate (memories per minute)	Mean time between memories (Seconds)
1	25	34:30	0.72	82.80
2	43	39:58	1.08	55.77
3	34	37:58	0.90	67.00
4	29	39:05	0.74	80.86
5	20	39:06	0.51	117.30
6	33	33:31	0.98	60.94
7	31	34:35	0.90	66.94
8	34	36:41	0.93	64.74
9	42	36:31	1.15	52.17
10	19	33:59	0.56	107.32
11	26	46:48	0.56	108.00
12	28	35:06	0.80	75.21
13	39	35:54	1.09	55.23
14	32	38:02	0.84	71.31
15	42	39:27	1.06	56.36
16	44	40:53	1.08	55.75
17	39	37:00	1.05	56.92
18	37	39:33	0.94	64.14
19	44	37:47	1.16	51.52
20	33	37:33	0.88	68.27

Table 7-2 Breakdown of cues by External, Internal or No Cue, actual and percentage

Journey Number	External Cue N (%)	Internal Cue N (%)	No Cue N (%)	Total (100 %)
1	19 (76%)	5 (20%)	1 (4%)	25
2	30 (70%)	8 (19%)	5 (11%)	43
3	17 (50%)	14 (41%)	3 (9%)	34
4	15 (52%)	10 (34%)	4 (14%)	29
5	4 (20%)	11 (55%)	5 (25%)	20
6	17 (52%)	7 (21%)	9 (27%)	33
7	15 (48%)	13 (42%)	3 (10%)	31
8	15 (44%)	15 (44%)	4 (12%)	34
9	18 (43%)	19 (45%)	5 (12%)	42
10	7 (36%)	6 (32%)	6 (32%)	19
11	17 (65%)	7 (27%)	2 (8%)	26
12	14 (50%)	6 (21%)	8 (29%)	28
13	22 (56%)	15 (39%)	2 (5%)	39
14	21 (66%)	10 (31%)	1 (3%)	32
15	20 (48%)	18 (43%)	4 (9%)	42
16	22 (50%)	17 (39%)	5 (11%)	44
17	9 (23%)	26 (67%)	4 (10%)	39
18	16 (43%)	20 (54%)	1 (3%)	37
19	22 (50%)	20 (45%)	2 (5%)	44
20	12 (36%)	19 (58%)	2 (6%)	33
Total	**332 (49%)**	**266 (39%)**	**76 (11%)**	**674**

7.3.3 Internal Triggers and Chaining

Many of the internally cued memories were in fact cued by the immediately preceding and recorded memory, rather than internal thoughts. For example, in the journey on 17th February 2015, the participant was aware of tyre/road noise (external cue), which led to thoughts of him driving in the USA where, in his experience, the roads are noisy (a general IAM), which led to him remembering driving in Seattle the previous year (specific IAM) trying to find the Air and Space museum and getting lost and a bit anxious (specific IAM). While on 25th March 2014, the participant was thinking about a computer he had ordered, which would have Windows 8 installed (specific IAM), which led to recollection of a Microsoft seminar he attended where they were giving away copies of Windows 8 (specific IAM).

This phenomenon is described by Mace (2005) as *chaining*, and has alternatively been described as *successive recollections* (Berntsen, 2009). It occurs where the initial memory (which may have an external, internal or no cue) triggers the next memory, which may in turn trigger a third memory, and so on.

A chained memory cued by an immediately prior memory is internally cued, and this is how they were represented in Table 7-2. However, as a high number of chained memories were detected they were re-coded as memory (IAM) cued, rather than cued by internal thoughts. Table 7-3 shows the chained memories separated out from the internally cued memories (memory cue versus thought cue). With the number of internally cued memories reduced, the difference from externally cued then became highly significant, $t(19) = 5.76$, $p < .0001$ (*cf.* Berntsen, 1998).

Table 7-3 Internally Cued Memories versus Chained Memories

Journey	External	Internal Memory Cue	Internal Thought Cue	Total
1	19 (79%)	4 (17%)	1 (4%)	24
2	30 (79%)	6 (16%)	2 (5%)	38
3	17 (55%)	6 (19%)	8 (26%)	31
4	15 (60%)	8 (32%)	2 (8%)	25
5	4 (27%)	4 (27%)	7 (47%)	15
6	17 (71%)	4 (17%)	3 (13%)	24
7	15 (54%)	4 (14%)	9 (32%)	28
8	15 (50%)	10 (33%)	5 (17%)	30
9	18 (49%)	16 (43%)	3 (8%)	37
10	7 (54%)	4 (31%)	2 (15%)	13
11	17 (71%)	2 (8%)	5 (21%)	24
12	14 (70%)	4 (20%)	2 (10%)	20
13	22 (59%)	11 (30%)	4 (11%)	37
14	21 (68%)	5 (16%)	5 (16%)	31
15	20 (53%)	7 (18%)	11 (29%)	38
16	22 (56%)	7 (18%)	10 (26%)	39
17	9 (26%)	16 (46%)	10 (29%)	35
18	16 (44%)	11 (31%)	9 (25%)	36
19	22 (52%)	5 (12%)	15 (36%)	42
20	12 (39%)	1 (3%)	18 (58%)	31
Totals	**332 (55%)**	**135 (23%)**	**131 (22%)**	**598**

It was therefore possible to count chain events in each journey, and determine chain lengths. There were 135 observations classified as chained memories in 674 memories. Chains were observed in all 20 journeys, the minimum number of chains per journey was one, and maximum was 11. The minimum chain length is, by definition, one link, which was the longest chain seen in five journeys. The longest chain length observed was six, i.e. an initial memory followed by a cascade of six chained memories. There were 91 identified chains (regardless of length). The frequency distribution of chain lengths is shown in Table 7-4. Quite clearly, the majority of chains were only one link long, so only one memory was prompted from the initial memory, but longer chains were observed, even to the extent of five or six memories following from the initial memory cue.

Table 7-4 Distribution of Memory Chain Lengths

Chain Length	Number of Chains of this Length
1	62
2	19
3	8
4	0
5	1
6	1
Total	**91**

The number of chains observed in each journey, and the maximum chain length for each journey are shown in Table 7-5.

The six-long chain, in journey 13, started with a memory for which there was no identifiable cue, concerning a friend for whom the participant had done some computer work, and whether he would invoice her. The subsequent memories related to another client he had invoiced but was slow to pay, and the events related to that job. The five-long chain, in journey 6, related to a conversation he had had with a schoolteacher about the school’s website and a tweet he had shown her, which led to recollections of a number of other tweets that he had made, or had amused him.

Table 7-5 Number of Chains in each Journey and the Maximum Chain Length in that Journey

Journey	N of chains	Maximum Chain Length
1	1	1
2	5	1
3	6	3
4	10	3
5	6	2
6	3	5
7	4	2
8	7	3
9	3	2
10	2	1
11	3	2
12	11	3
13	4	6
14	2	3
15	3	2
16	4	1
17	5	3
18	3	3
19	5	2
20	4	1

7.3.4 **External Triggers**

Externally cued memories (332 out of 674) were further analysed to determine whether they were triggered by static cues (e.g. buildings, landmarks, road signs that were always present in the journey) versus dynamic cues (i.e. triggers that were not consistently there, such as other vehicles, or music playing in the car, weather, or physical sensation such as discomfort). The breakdown of external cues into static and dynamic, by journey is shown in Table 7-6.

Across all 20 journeys, as many as 66% (218) of memories were triggered by dynamic cues, while 34% (114) were triggered by static cues. The percentage of memories with dynamic cues ranged from 14% to 84% per journey, while the percentage of memories with static cues ranged from 16% to 86% per journey. With few exceptions (5 out of 20 journeys), the dynamic cues outweighed the static cues and the mean percentage of dynamic cues was significantly higher than the mean percentage of static cues, $t(19) = 2.84$, $p = .01$.

Table 7-6 Breakdown of External Cues by Static or Dynamic Nature, actual and per cent

Journey Number	Static N (%)	Dynamic N (%)	Total N (%)
1	3 (16%)	16 (84%)	19 (100%)
2	12 (40%)	18 (60%)	30 (100%)
3	8 (47%)	9 (53%)	17 (100%)
4	4 (27%)	11 (73%)	15 (100%)
5	3 (75%)	1 (25%)	4 (100%)
6	3 (18%)	14 (82%)	17 (100%)
7	5 (33%)	10 (67%)	15 (100%)
8	8 (53%)	7 (47%)	15 (100%)
9	5 (28%)	13 (72%)	18 (100%)
10	6 (86%)	1 (14%)	7 (100%)
11	3 (18%)	14 (82%)	17 (100%)
12	8 (57%)	6 (43%)	14 (100%)
13	14 (64%)	8 (36%)	22 (100%)
14	5 (24%)	16 (76%)	21 (100%)
15	4 (20%)	16 (80%)	20 (100%)
16	6 (27%)	16 (73%)	22 (100%)
17	2 (22%)	7 (78%)	9 (100%)
18	6 (38%)	10 (62%)	16 (100%)
19	6 (27%)	16 (73%)	22 (100%)
20	3 (25%)	9 (75%)	12 (100%)
Total	**114 (34%)**	**218 (66%)**	**332 (100%)**

7.3.5 **Analysis of External Static Cues**

The data collected in this study facilitated addressing an unanswered question about whether the same static cue always elicits the same IAM, or whether different IAMs were elicited on different occasions. The 114 static triggers were therefore further analysed and 56 unique, or different, triggers in the journey were identified (e.g. road signs, petrol stations etc.). Of these, 30 triggered only one memory each across all 20 journeys, i.e. that these cues were always present but cued a memory only once in the 20 journeys that were monitored. The other 26 triggers cued a memory in more than one of the journeys.

The breakdown of static triggers, and the number of memories they cued is shown in Table 7-7.

Table 7-7. Breakdown of static triggers by number of memories they cued

Unique, Static Triggers Count	Memories Cued by Static Trigger
30	1
11	2
8	3
3	4
1	5
1	6
1	7
1	8
Total Static Triggers: 56	

Of interest were the 30 different cues that triggered only one memory, which means that the participant passed these 19 times out of 20 journeys without having any memory triggered. This raises questions about attention, and whether these cues were noticed, but did not activate a memory. On other occasions, the same or a different memory came up (from 2 to 8 times), but clearly not on all 20 occasions, and not every time in the many unrecorded journeys made over the past few years. Importantly, of the 26 static cues responsible for eliciting more than one memory (i.e. after subtracting the 30 that only cued one), they were not always of the same event. For example, there was a lay-by on the route where a mobile speed camera was sometimes parked. On some occasions, it cued a memory of the time when the participant had not realised there was a camera there and was concerned he had been going too fast, while on other occasions he recalled an impatient driver behind when he was driving cautiously in anticipation of the camera being there.

Two of the static cues were locations where the participant had, in the past, turned off the route for a different destination. In each case three different memories were evoked. These were potentially decision points in the journey, which may have changed the state of attention.

Some static cues related to points where the participant had to become more alert, such as whether there might be a mobile speed camera (7 IAMs), or where more care was needed changing lanes (5 IAMs), or at the end of journey (6 IAMs) where he had to make decisions (e.g. assess parking options, or starting to focus on next actions). While others related to strong emotional links, for example, where he witnessed an accident (3 IAMs), or relevant to significant personal matters, such as a care home that brought to mind eight memories of caring for, visiting, or discussing care of elderly relatives.

7.3.6 Delayed Triggers or Priming of IAMs?

In diary studies, participants can identify an external or internal trigger for most IAMs, but occasionally report that there was no trigger. Where there is no apparent trigger this could be that there was a trigger but the participant did not notice it, or there was genuinely no trigger and the IAM arose spontaneously. A third possibility is that there was some kind of priming event a while before, which the participant cannot recall, or cannot relate to the IAM. If this is the case, any such link is typically lost in diary studies. However, with this audio technique there was some opportunity to review such unattributed IAMs.

In the majority of cases in this study, a trigger was easily identifiable in the environment or in thoughts, and the memories were perceived to be near-instantaneous, as is observed in laboratory studies. However, on several occasions there was no immediately apparent trigger so the IAM was coded "no cue". However, on reviewing the audio a precursor was later identified in some cases. Of the 76 cases coded as no cue, 22% (17 IAMs) were identified as almost certainly related to memories or observations several (up to 20) minutes earlier in the journey, while another 8% (6 IAMs) could reasonably be explained by comments and memories earlier in the journey (again up to 22 minutes earlier), leaving 70% for which no cue could be identified.

Some examples illustrate the phenomenon. In journey 15, in memory 23 at 22 minutes and 39 seconds into the journey, the participant spontaneously recalled a conversation with a lecturer in the department about the relative workload of publishing a paper versus giving a conference presentation. This was traced back to memory 6 at 3 minutes 42 seconds, i.e. nearly 20 minutes earlier, where the participant had remembered his mother seeing the same lecturer on television but getting his name wrong.

In journey 15, memory 19, at 17 minutes 53 seconds into the journey, the participant apparently spontaneously recalled buying an in-car dashboard video camera. During play-back however, this could be traced to an incident at 15 minutes 1 second where he commented aloud (not a memory) on a dangerous manoeuvre made by a van, a reason why it is useful to have such a camera.

In journey 14, in memory number 10, at 5 minutes 58 seconds, the participant passed a junction he would have used to visit a business client. At 10 minutes 5 seconds into the journey (four minutes later), starting with no apparent cue at the time, a chain of memories about this client manifested.

A shorter delay appeared in journey 10, where at 4 minutes 28 seconds a bus drove up close behind the participant, and at 5 minutes 50 seconds (a minute and a half later) the participant remembered complaining to the bus company in the past about one of their buses departing early.

7.3.7 **Characteristics of Memories**

7.3.7.1 ***Specificity***

The mean percentage of specific memories varied with a minimum of 50% to a maximum of 95%, with a mean of 76% (*SD* = 13%), which is in keeping with specificity found in other diary and laboratory studies (as discussed in Chapter 2). A full breakdown of the number of specific and general memories by journey is given in Table 7-8.

7.3.7.2 ***Emotional Rating***

Out of 674 recorded IAMs, 134 were negative (20% of the total memories), and varied from a minimum of 4%, to a maximum of 39% per journey, 409 were neutral (61%)

and varied from minimum of 30% to maximum of 80% per journey, and 131 positive (19%) and varied from a minimum of 5% to a maximum of 36% per journey.

A total of 80% were therefore either neutral or positive. Schlagman et al. (2007) used a 5-point Likert scale, but combining the two negative points, and the two positive points found 16% negative, 34% neutral and 50% positive in a mix of 21 younger and older adults keeping a seven-day paper diary in everyday life. Although neutral and positive add to 84%, there was a much lower proportion of positive memories in this study than in Schlagman et al. (2007) (19% vs. 50%).

Table 7-8 Number of Memories, Specific and General (Percentage)

Journey Number	Number of Memories	Number Specific	Number General
1	25	20 (80%)	5 (20%)
2	43	24 (56%)	19 (44%)
3	34	29 (85%)	5 (15%)
4	29	22 (76%)	7 (24%)
5	20	19 (95%)	1 (5%)
6	33	30 (91%)	3 (9%)
7	31	25 (81%)	6 (19%)
8	34	28 (82%)	6 (18%)
9	42	35 (83%)	7 (17%)
10	19	16 (84%)	3 (16%)
11	26	24 (92%)	2 (8%)
12	28	23 (82%)	5 (18%)
13	39	28 (72%)	11 (28%)
14	32	20 (63%)	12 (37%)
15	42	21 (50%)	21 (50%)
16	44	27 (61%)	17 (39%)
17	39	23 (59%)	16 (41%)
18	37	29 (78%)	8 (22%)
19	44	30 (68%)	14 (32%)
20	33	29 (88%)	4 (12%)

7.4 Discussion

7.4.1 Aims and Hypotheses and Expectations

The two main aims of the present study were to quantify the observation of the apparently high number of IAMs experienced by the participant when driving, and to explore a new methodological approach, both in terms of the electronic technology used, and the repeated driving scenario, which is recognised as a low-demand, automatic activity. A high number of IAMs was expected based on the participant's prior observations, as well as some findings in the literature on the effects of the length of recording period, the reduced burden of recording, and the cognitive demand of the ongoing task on the number of reported IAMs.

7.4.2 **Key Findings**

Several novel and important findings emerged from this study. The first finding was the extremely high number of IAMs, probably higher than ever reported in the literature. Many IAMs were noted, even more than the participant anticipated before commencing the study. The rate was 0.9 per minute, equating to a mean time of 71 seconds between memories. The numbers across journeys were highly consistent, except where a highly absorbing radio programme dramatically diminished the number recorded causing that journey to be excluded. As such, the number of memories recorded in these journeys was considerably higher than in diary studies, where an average of about three IAMs per day have been reported. Consistent with other studies, where the reporting period or reporting burden was reduced, the rate of memories recorded increased.

This method enabled greater analysis of triggers than has been possible with daily paper diaries. The ability to audio-describe the thought processes enabled quicker analysis and description for the effects of chaining of memories, where one memory triggers the next. This was an unexpected outcome of the research method. Such features are usually missed, unless expressly requested and briefed for in daily paper diary studies. Participants can understand chaining but, in practice, consolidate chaining IAMs into one composite memory description, or pick just the most important aspect to describe.

By breaking down the internal memories into true thought-cued memories and memories that were cued by preceding memories, which could then be reclassified as chained memories, the number of true internally cued memories, compared with externally cued memories, was significantly smaller, as found by Berntsen (1998).

This method, perhaps uniquely, facilitated the breakdown of external triggers by whether they were cued by static (i.e. always there) versus dynamic cues (i.e. only present on one, or rare and unpredictable occasions). It is not usually possible to analyse static memory cues in naturalistic diary studies, as there is not a regular structure to the activities of participants that the experimenter can control. As the driven route was routinely repeated, it was easy to identify triggers that were always present in the scene, and those that were novel. This allowed for finer analysis of the memories by the types of cues that were identified for them.

About half of the identified static triggers cued only one IAM across all 20 journeys, while the other half cued between two and eight. Sometimes they were the same IAMs, other times different. It seemed that the static cues that were significant were ones that brought the participant back to attention, because of navigation decisions that needed to be made, or where care was needed with driving, or they related to highly salient events in the past.

In the majority of cases triggers were readily identifiable. Where no cue was initially identifiable while driving, on playback of the audio between a fifth and a third were plausibly explained by priming events some minutes earlier in the journey. On this basis, others may have been primed by events and circumstances prior to the start of the journey but which, for that reason, were not recorded on the audio.

The ability in this method to detect some priming effects of several minutes, and potentially from earlier journeys is probably unique to this study. Mace (2005) elegantly demonstrated priming by a mid-study voluntary memory recall exercise, but this study demonstrated the recall of memories that were readily linked to earlier involuntary memories, and unpredictable cues.

7.4.3 **Summary**

An advantage of this method was the ability to further analyse and trace triggers, and priming effects. Some of the triggers and primes were found by verbal exploration (thinking out loud) by the participant while driving, but others were picked up on later transcription of the audio. A feature of audio recording and vocalizing the thought processes was the ability to pick up primes to the “no cue” memories that occurred a few, or many minutes before. This was not something that could have been achieved in written logs of the memories, and as such provided a richer dataset.

The method here, while not trying to generate chains, allowed these chains to be observed and counted. While longer chains are rarer, it may be that the audio recording technique made them easier to detect and trace back. IAM chaining is important because it gives insight into the organisation of autobiographical memory (Mace et al., 2010) and is discussed in the closing chapter. An outcome of this study could be that participants are in future routinely briefed to notice such sequences, and are given the opportunity in diaries and apps to record them.

The opportunity to distinguish static and dynamic triggers is not generally feasible in diary studies, and has not been examined in laboratory studies. Yet it is highly pertinent to driving familiar routes, where much of the task becomes automatic, and where changes of attention are important.

Unlike earlier IAM experiments in this dissertation, this experiment also examined within-subject memory sampling, with longer gaps (several days, and several months) between measuring days, however, with the same stimuli. This is worthy of further analysis, as there did seem to be a consistency of certain memories recurring over the course of the experiment.

In conclusion, this method shows considerable promise as a new way of recording and analysing IAMs. This research adds to other recent research in confirming that the rate of IAMs is indeed more frequent than early measurements, and self-assessments suggested. As it stands, this method is not readily extendable to other participants, although in future it is possible that participants' car journeys could be video-recorded and played back to them in a driving simulator in a laboratory in order to mimic much of the experience. In the meantime, a new method based on findings from this experiment, and enhancing the campus walk method (Kamiya, 2013), led to Study 6 described in the next chapter.

CHAPTER 8: Two Measurements of Involuntary Autobiographical Memories: 30 Minute Campus Walk and 1-Day Paper Diary (Study 6)

8.1 Introduction

The previous chapter introduced a new method of gathering IAM reports in a low cognitive demand situation of driving a familiar route repeatedly. Results of Study 2 (1-day diary of IAMs) and Study 5 (the car audio diary) showed that a greater number of memories were recorded when the time period and the burden of recording was reduced. Study 5 also showed that the number can be affected by the medium of recording and the nature of activity. Unfortunately, the car audio method is not readily extendable to a wider pool of participants.

However, a memory walk method is more suitable. This technique was first used by Galton in his self-measurement in Pall Mall, London (Galton, 1909). It has been used by Berntsen and Hall (2004) to investigate voluntary memories, and by Kamiya (2013) to study IAMs. In a study by Berntsen and Hall (2004), a memory walk took place indoors, with psychology students taking a self-chosen route in their familiar psychology department. They were instructed to take 30 steps, then stop, focussing on a self-chosen cue (e.g. an object, sound, smell, etc.) and try to recall a (voluntary) memory in response to this cue. Participants had to ignore unbidden, involuntary memories, which was probably difficult to enforce as incidental conversations or other transient distractions may have been present. While occasionally participants could not recall memories in response to self-chosen cues, by design of the study, 15 VAMs were to be retrieved within 45 minutes.

Kamiya (2013), on the other hand, focussed on involuntary memories and investigated links between IAMs and cognitive failures. While cognitive failures were measured by self-report questionnaires, an interesting method was used to capture IAMs. Participants had to walk on a pre-planned route on the university campus, followed by the experimenter a few paces behind. If participants experienced an IAM during their walk, they were to stop, turn to the researcher and report the details. Kamiya (2013) found considerable individual differences in the frequency of IAMs, with an average of 7-12 memories recorded per participant during a walk of between 30 and 90 minutes (mean 60 minutes). While Kamiya (2013) demonstrated an interesting new approach, it seems that the proximity of the researcher to the participant, and the frequent interaction between the two compromised the experience for the participant and broke the flow, and was open to demand characteristics. Participants may have felt that every so often they should stop and give the researcher something to write down, potentially contaminating the IAMs with forced or voluntary memories or, worse, manufactured memories.

The rationale in this study was to adapt the audio recording method of Study 5 to a campus walk, improving on the method of Kamiya (2013). In addition, participants kept a 1-day paper diary so that a within-subject comparison of IAM counts and characteristics could be made. This study thus took elements of the earlier paper diary studies, particularly Study 2, and compared with elements of the audio recording method, described in the previous Chapter 7. In this study (Study 6), participants had to walk along a pre-defined route on a familiar campus and every time they experienced an IAM they had to record it verbally via a digital audio recorder. They then kept a paper diary of IAMs the following day, using the method of Study 2. It thus further developed the memory walk of Berntsen and Hall (2004) and Kamiya (2013) while enhancing their methods to address some of the limitations indicated above. In particular, the audio recording removes the demand characteristics as the audio was not played back until after the participant had left, and it removed the need for interaction with the researcher during the walk.

The in-car audio recording proved effective and demonstrated the feasibility of the audio recording technique, and the potential frequency of IAMs that could be observed in a relaxed activity in familiar surroundings. With the audio recording technique, participants needed only to stop briefly and speak inconspicuously into the microphone. This was expected to be less awkward than describing the memory to the researcher, and the burden on participants was much reduced. Although the audio transcription task does make the data analysis more labour-intensive, the short participation time means that more participants can be tested in reasonable times.

The 7-day versus 1-day studies showed that collecting diary data for one day was effective. So, this study compared participants with themselves on two modes, audio recording of a campus-walk versus 1-day paper diary, within-subject. In addition, arranging a walking study was considerably easier than audio recording in a car, given the number of participants involved in the study.

8.1.1 **Aims**

A better understanding of the frequency of IAMs is needed. Berntsen, Rubin, & Salgado (2015) have attempted to measure the frequency of IAMs by a new Involuntary Autobiographical Memory Inventory (IAMI) scale, but this is a self-reporting scale, tested online, and was not compared with diaries, or mechanical counters. It is of interest to know whether there is a stability across measures, and across time, within-subject.

The aim of this study was to conduct an ecological study, with laboratory-like conditions, and compare the frequency and characteristics of recorded memories with those obtained by the 1-day paper diary method. It sought to extend the audio recording technique, to improve the campus walk method, and compare it with the paper diary.

8.1.2 **Methods Used in the Study**

Where Studies 1 and 2 compared 7-day and 1-day paper diaries, this study compared 30 minutes versus 1 day and, while there paper and smartphone diaries were compared, here paper diaries and audio recordings were compared. A full day of audio recording would be impracticable for the privacy of participants and others around them, and not realistic for transcription, but the short audio recording is a novel approach to collecting IAMs, and reduces the participant burden.

To investigate the idea further, the study compared the number of IAMs recorded in a standardized walk, taking approximately 30 minutes, and data collected for one day (the following day) in a structured diary, as used in the previous 1-day study. Such a comparison has not been made before.

In the driving study (Study 5, Chapter 7), the participant tried to record relevant details while driving safely, but in this refinement of a campus walk, participants were given a list of questions on the back of the route map, so more details of the IAM characteristics could be collected. The paper diary method was identical to the method used in Study 2, Chapter 4, using the same diaries and briefing.

The participants first undertook the campus walk with audio recording. They carried a small MP3 digital audio recorder, with a tie-clip microphone attached to clothing, as used in the car audio experiment in the previous chapter. At the end of the walk they were briefed on the diary-keeping phase for the following day, and given a paper diary to carry.

When participants returned on the third day, after the diary keeping, to hand in the diary, they completed the Marlowe-Crowne Social Desirability (MCSD) questionnaire (Crowne & Marlowe, 1960), and a questionnaire about the diary keeping experience, including their compliance ratings.

To summarise, on Day 1 participants completed the 30-minute campus walk followed by the briefing for paper diary; on Day 2 they kept a paper diary (as in Study 2, Chapter 4); on Day 3 they returned the diary, and completed the MCSD and diary compliance questionnaire.

8.1.3 **Hypotheses**

Based on Kamiya's (2013) work, and Study 5 on the car audio-recording, as well as the earlier 1-day paper diary Study 2, it was predicted that the rate of recording of memories noted in the 30 minute walk would be greater than the one-day diary on the subsequent day. Higher rates of IAMs were expected when the collection period was shorter and when the burden was reduced. Also, when participants were engaged on the campus walk and not free to do anything else more IAMs were expected, as observed in short laboratory sessions.

It was further predicted that the individual differences would be a stable characteristic in the number of memories recorded across the two modes, and there would be a positive correlation between the number of IAMs recorded in the two modes over the consecutive days, i.e. participants recording more IAMs in the audio phase would log more IAMs in the diary the next day.

Participants were briefed clearly that there was no expected number of IAMs and, in the case of the audio recording, they were not overheard by the researcher, so it was not anticipated that social desirability would influence their tendency to record IAMs. There would therefore be no correlation between the social desirability score and the number of memories recorded (e.g. see Schlagman & Kvavilashvili, 2008; Study 2).

8.2 Method

8.2.1 **Research Design**

This was a two part within-subject study. The independent variable was the mode of recording IAMs (the campus walk with audio recording vs. 1-day paper diary). The dependent variables were the number of recorded memories and their characteristics. Correlational design was also used to examine any relationship between the number of recorded IAMs in audio and paper diaries and participants' scores on the Marlowe Crowne Social Desirability Scale.

8.2.2 **Participants**

A total of 32 participants (12 males, 20 females) with a mean age of 21.03 years (*SD* = 4.97; range 18-45) were tested. They were all University of Hertfordshire students who were familiar with the campus where the standard walk was conducted.

8.2.3 **Materials**

8.2.3.1 ***Map and Questions***

The campus walk was designed to take 20-30 minutes, and finished at the same point it started. The walk route was designed in collaboration with undergraduate students to pass significant areas for all students, regardless of the subject they were studying, and included common social areas, the library, the medical centre, and student services (rather than academic departments). Each participant was provided with a map of the route to follow (Appendix P). The questions were printed on the reverse of the map so that the answers could be dictated on to the audio recording. The prompts were:

1. Describe the memory
2. Vividness (7-point scale with 1= *very vague* and 7= *extremely vivid*)
3. Trigger type (*in your thoughts, in your environment, there was no trigger*)
4. If there was a trigger what was it?
5. Please estimate the time between the trigger and the memory
6. How much were you concentrating on following the route (1 = *not at all*, 5 = *fully*)
7. Pleasantness of memory now (1 = *very unpleasant*, 3 = neutral, 5 = *very pleasant*)
8. Pleasantness of memory then (1 = *very unpleasant*, 3 = neutral, 5 = *very pleasant*)
9. Was the memory General or Specific?

10. Age of memory (When did the original event occur? *Free description*)

11. Rehearsal frequency – Have you ever had this memory before (1 = *never, 2 = once or twice, 3 = a few times,4 = several times, 5 = many times*)?

8.2.3.2 ***Diary 32-page booklet***

The paper diary was identical to that used in the 1-day study in Study 2, Chapter 4, consisting of 32 identical pages for describing a memory in full, and a grid at the front for acknowledging memories if, for any reason, they could not be described in full (see Appendix C).

8.2.3.3 ***Debrief Session Materials***

The Marlowe Crowne Social Desirability Questionnaire (Crowne & Marlowe, 1960) measures the extent to which participants attempt to portray themselves in a socially desirable manner and consists of 33 statements (e.g., ‘I always try to practise what I preach’) with True/False response options (Appendix Q). The scores range from 0-33, where scores of 0-8 indicate low, 9-19 average, and 20-33 high levels of socially desirable responding.

A diary compliance and feedback questionnaire was completed after the diary-keeping phase. Participants had to estimate what percentage of all the IAMs that they had during the day they were able to record (fully and in the form of acknowledged or ‘ticked’ memories). Finally, they had to rate how easy they found (i) keeping the diary with them at all times and (ii) recording their memories in the diary (*Very easy, Somewhat easy, Somewhat difficult, Very difficult*).

8.2.4 **Procedure**

Participants were initially briefed on the nature of IAMs, with examples, and then told how the two parts of the experiment would be conducted. Participants were clearly briefed that there was no “right” number of IAMs.

For the first part, the campus walk, they were provided with the map, and briefed on how to perform the task. They were given an MP3 audio recorder to carry in a pocket (Olympus WS-811) and tie-clip microphone to attach to clothing. Test recordings were made to confirm that the participant understood the task, and that the audio recording was working. When ready, participants set off on the route following the map, with the researcher following a short distance behind. At any point where participants became aware of an IAM, they were to stop, turn the map over, and use the question prompts to speak their responses into the microphone. When complete they turned back to the map and continued the walk. Participants were told that they could stop and turn to ask the researcher questions (e.g. to clarify the route), but were otherwise to avoid interaction. The interaction between them was kept to a minimum to ensure participants were not distracted, nor prompted by the researcher. The audio recorder was switched on for the duration of the walk so that participants did not need to start and stop recordings. At the end of the walk, the researcher took back the recorder and stopped the recording.

In preparation for Day 2, participants were then given the paper diary booklet and briefed on how to use it the following day. As in IAM studies described in Chapters 3 and 4, they also had the option to make a tick to acknowledge any memories they could not record contemporaneously.

On Day 3, participants met with the researcher to return the paper diary, and to complete the MCSD scale and the compliance questionnaire. Finally, they were debriefed and thanked.

8.3 Results

8.3.1 Number of Recorded Memories

All participants completed the walk and 1-day diary. The total number of recorded involuntary memories during the walk was 225 (range 1-20). The total number of memories recorded in the 1-day paper diaries was 160 (range 1-14). Out of these, 118 memories (range 1-11) were fully recorded by completing a questionnaire on a diary page, and 42 memories (range 0-7) were acknowledged by putting a tick in a special section of the diary booklet.

Figure 1 shows the mean number of memories during the walk (M = 7.03, *SD* = 4.92) was significantly higher than the mean total number of fully recorded and acknowledged memories recorded in the diary (M = 5.00, *SD* = 3.50), $F(1,31) = 4.91$, $p = 0.03$, $\eta_p^2 = 0.14$.

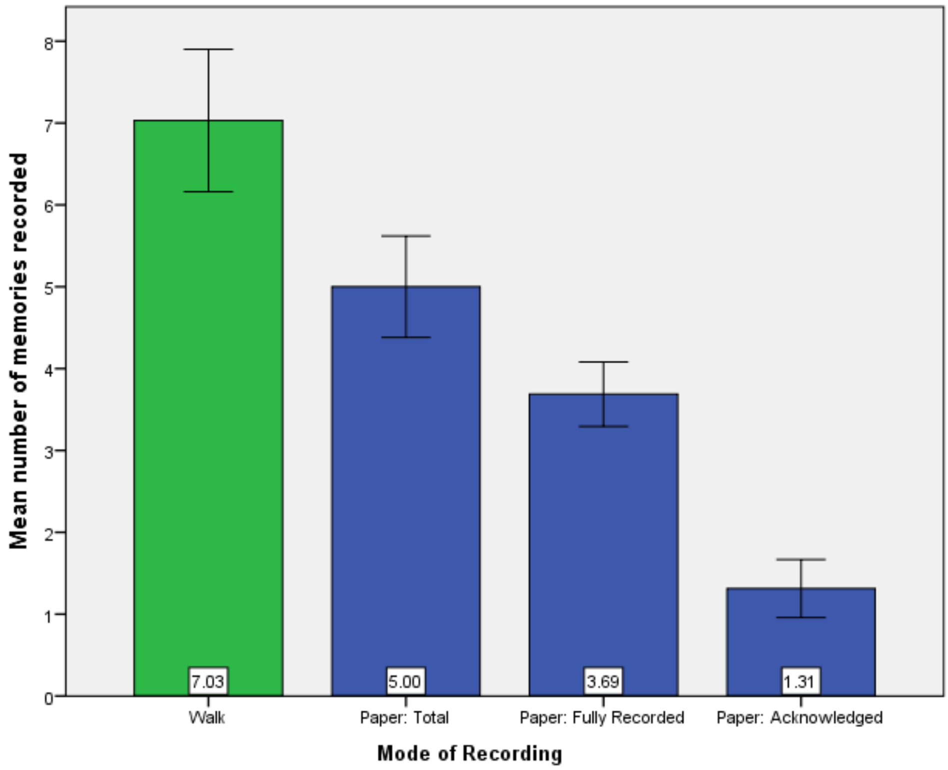

Figure 8-1. Mean number of memories recorded during the walk and in the diary (Error bars represent +/- 1 SD)

8.3.2 **Correlational analysis: Number of Recorded Memories and Social Desirability Scores**

Correlational analyses were carried out to see if there were any correlations between number of memories recorded during walk and in the diary, and scores on Marlowe Crowne Social Desirability Scale (see Table 8-1). Results showed that there was a significant positive correlation between the number of memories recorded during the walk and the number of fully recorded (i.e. full diary page) memories (r = 0.52, p < .01), but not with the number of diary acknowledged memories (r = 0.09) nor the total number of memories recorded in the diary (pages plus ticks) (r = 0.28). The number of recorded memories during the walk and in the diary did not correlate with the social desirability score.

Table 8-1. Correlations between number of memories recorded during the walk and in the diary and social desirability scores

	Number of memories during the walk	Number of fully recorded Paper Diary memories	Number of acknowledged Paper diary memories	Total Number of Paper Diary Memories
Number of fully recorded Paper Diary memories	0.52**	---	---	---
Number of acknowledged Paper diary memories	-0.09	0.37*	---	---
Total Number of Paper Diary Memories	0.28	0.85**	0.81**	---
Social Desirability Score	-0.17	0.03	0.14	0.10

** - Correlation is significant at the 0.01 level (2-tailed).
* - Correlation is significant at the 0.05 level (2-tailed).

8.3.3 **Memory characteristics across the two modes of recording**

A series of one-way ANOVAs were carried out on participants' mean ratings of various memory characteristics (see Table 8-2). The only significant difference found was in the ratings of "pleasantness then", $F(1, 31) = 5.282$, $p = 0.028$, $\eta_p^2 = 0.146$.

The mean number of fully recorded memories in this study (M = 3.69) was significantly less than the mean number recorded in the 1-day paper diary in Study 2 (Chapter 4) (M = 7.54). This difference remained significant even with square root transformed data and when some outliers were removed, $t(56) = 2.16$, $p = .035$. However, comparing the characteristics of the memories in the 1-day paper diary across this study and the 1-day diary in Chapter 4, there were no significant differences in the means, all $p_s \geq .246$ in unpaired t-tests, for the characteristics in Table 8-2.

Table 8-2. Comparison of Memory Characteristics across Modes of Recording

Characteristic	Campus walk	Diary	$F(1, 31)$	p	Effect size (η_p^2)
Concentration	2.94	2.79	0.43	0.52	0.01
Vividness	4.76	4.61	0.28	0.60	0.01
Pleasantness now	3.38	3.50	1.99	0.17	0.06
Pleasantness then	3.10	3.64	5.28	0.03	0.15
% specific memories	72%	73%	0.01	0.93	0.00
Previous rehearsal	2.33	2.49	0.70	0.52	0.02
Age of Memory	4.29	4.60	1.30	0.26	0.04

Notes. – Concentration ratings ranged between 1 and 5 (1 = not at all, 5 = fully concentrating). Vividness ratings were rated from 1 to 7 (1 = very vague, 7 = extremely vivid). Pleasantness now and then was rated between 1 and 5 (1 = very unpleasant, 3=neutral, 5 = very pleasant). Memories were rated as either 'General' or 'Specific' by participants. Previous rehearsals were reported on a 5-point scale (1 = never, 2 = once or twice, 3 = a few times, 4 = several times, 5 = many times).

8.4 Discussion

The present study had two main aims: to compare the frequency and characteristics of IAMs in a brief campus walk with a 1-day paper diary condition, and to examine individual differences in the tendency to experience IAMs by calculating correlations between the number of recorded IAMs in the 1-day diary and the campus walk.

The main prediction in this study was that when participants recorded IAMs for a short period (e.g. during the campus walk), they would be more observant of their memories than when they had to record memories in a paper-diary for a longer period of time, while they were going about their daily activities.

In line with the predictions, the mean number of memories recorded in the 30-minute walk was consistently greater than the mean number noted in a paper diary (full and acknowledged) in the whole of the next day. In addition, there was a positive correlation between the numbers recorded by participants on the walk and the numbers fully recorded in the paper diary the next day. There were no significant correlations between the social desirability scores and the number of memories recorded either in the campus walk, or in the 1-day diary. Finally, the characteristics of memories did not differ between those recorded on the walk and those written in the paper diary, with the exception of the “pleasantness then” rating, which was significantly lower on the campus walk.

One explanation for the increased rate of memories in the campus walk is that participants were in a more relaxed state of mind while walking. The purpose of their walk was clear to them, and they were more prepared to record their IAMs. They had no urgent or difficult tasks to complete, whereas in their everyday life participants were engaged in multiple, and possibly demanding tasks and hence were less likely to experience or notice involuntary memories. Increased rates of IAMs are consistently associated with undemanding activity (Kvavilashvili & Mandler, 2004). On the walk, participants really had nothing else to do so were undistracted and were more likely to monitor their consciousness for the occurrence of IAMs than the next day when they were going about their business, and would have occasionally forgotten they were in the study, unless perhaps prompted by the sight of the diary, or thoughts of meeting the researcher again the following day.

It is interesting that the mean number of IAMs recorded in the 30 minute campus walk ($M = 7.03$) was effectively the same as the number recorded in various laboratory studies. For example, in a study by Schlagman and Kvavilashvili (2008) participants recorded on average 7.21 memories in a 20 minute vigilance task, and 6.12 memories in a 15 minute vigilance task (see also Kvavilashvili & Schlagman, 2011). Furthermore, it appears that IAMs recorded on the campus walk were a representative sample of everyday IAMs, as memory characteristics of IAMs recorded on the campus walk were similar to those recorded in the 1-day paper diary. The only exception was the rating of the pleasantness of the original event, which was lower in the campus walk condition. However, the campus walk may have elicited memories in students of the early days at university, which might have been more stressful for them in a new and uncertain environment, and hence rated as less pleasant then. For example, “contracting a virus” was triggered by the University pharmacy, “summer exams” triggered by the library. Other examples were “getting lost and having to ask for help”, and “last minute stats exam prep”.

Finally, the positive correlation between the total number of fully recorded memories in the diary and the number of memories recorded in the walk suggests those who experience IAMs more frequently seem to do so regardless of the mode of recording. There is stability within the individual. This may be a genuine range of experience, or that some participants feel more motivated to help. However, as the scores on the social desirability scale did not correlate with the number of recorded IAMs, it would appear that participants were not recording more memories to please the researcher. There was also no significant correlation between the social desirability scores and the number of acknowledged (ticked) IAMs, which might be expected if participants with higher social desirability were more diligent in going back to record IAMs from earlier.

8.4.1 **Implications**

The results of this study further add to the evidence that in future we may not need to conduct such long diary studies to gather the information we require. The notion that the longer we record the more data, or information, we get does not hold, and there are diminishing returns, or even negative returns. There is certainly an inverse relationship on the rate – the rate increases as the diary-keeping time decreases. Hence, researchers might opt to record more participants for shorter periods, noting however that the circumstances are very different – the campus walk is not “life as it is lived”. Nonetheless, the short walk data gathering method provides a means of collecting good quality IAM samples, for in-depth research and is quicker, if IAMs gathered this way prove to be comparable with diary-gathered IAMs.

There are contrasting explanations for any difference between the walk and the paper diary. One might have thought that the audio walk would have provided practice and experience for noticing and recording the IAMs the next day, but conversely it might have used some of the goodwill, or interest in keeping the 1-day paper diary. We could argue that the audio diary is effectively day 1 of a 2-day study, and as seen in the 7-day IAM diary in Study 1 the means drop on subsequent days. This “day 2” effect is further supported by the fact that the mean number of IAMs recorded in the 1-day diary in this study was lower than the mean number of IAMs recorded in the paper diary condition of Study 2.

8.4.2 **Limitations in this Study**

All participants did the campus walk first and the paper diary the next day. A crossover design would have been the most efficient method of detection of any order effect, and whether the walk affected the paper diary results. An interesting question might be whether the campus walk makes people better at the diary? Or would keeping the diary for a day make people better at the campus walk? As the comparison between modes of recording showed, there was no difference in almost all of the measured characteristics of the IAMs. Looking at the memory descriptions for the 32 participants over these two days, and two modes, there is no apparent evidence of overlapping or similar memories, so no cases of self-priming from the walk experience.

There was no measure of the familiarity of the route to the participants, nor the salience of landmarks to individuals, beyond controlling for “home” campus. Neither this study, nor the Berntsen and Hall (2004) memory walk considered static or dynamic triggers that emerged as important in the car audio research. This would have been possible but had not become apparent from the car audio study at the time this study was designed.

8.4.3 **Summary**

In summary, the campus-walk, like the IAMs in the driving Study 5, creates an environment that is more realistic than the laboratory, with some loss of laboratory rigor, but it is not life as it is lived most of the time. It is a good way of collecting reasonable numbers of IAMs in a short period, and allows comparison of participants who, while individuals with different life experiences, at least experience some common cues, which cannot be achieved in a free-form diary study.

This study has made improvements on the previously published campus walk study (Kamiya, 2013), by significantly reducing the interaction of the researcher with the participant, hence reducing demand characteristics of that study. Further, the collection of paper diary data from the same participants has allowed the evaluation of the types and qualities of the IAMs across the two modes of the study.

CHAPTER 9: Discussion and Conclusions

9.1 Aims of this Research

The initial aim of this research was to take advantage of the widespread ownership of smartphones to investigate the new research opportunities available to cognitive psychologists, along with other social science and clinical disciplines. In particular, the aim was to evaluate how well participants' own smartphones would work in the collection of diary data on spontaneous and transient cognitive phenomena. We know that people carry, and look at their phones frequently. This seemed a compelling reason to make use of them for research purposes.

Two cognitive phenomena, IAMs and EMFs, were used in this research to demonstrate generalisability, but findings should extend to other uses in cognitive psychology and beyond. Smartphone apps were compared with paper diaries and it was predicted that more events would be recorded in the app, and sooner, because it was anticipated that the smartphone would always be carried and would be nearer to hand.

The second aim was to study the effects of the length of diary-keeping period on the number and qualities of diary entries. Based on observations in the first two studies, on IAMs, and findings in the literature, the diary-keeping period was varied to investigate increased reporting rates with reduced diary-keeping periods (i.e. the diary entry rate reduction effect). Diary-keeping periods ranged from 30 minutes (digital audio) to 28 days (paper diaries), with a smartphone app used for 1- and 7-day diary studies. This is probably the most systematic evaluation of diary period that has been conducted, and it was investigated across several studies (Chapters 4, 6, 7, and 8 all addressed the length of the diary recording period). The typical IAM diary-keeping period of one to two weeks was first reduced to one day (Study 2), and then to 30 minutes of audio recording (Studies 5 and 6). The typical EMF period was reduced from 28 days to 7 days (Study 4).

The third aim was to test the feasibility of the audio recording method to study IAMs, which has never been attempted before. This was achieved by testing a single participant undertaking regular car journeys from home to work (Study 5), and by testing undergraduate students undertaking a campus walk (Study 6). Although a campus walk had previously been used by Kamiya (2013) to study IAMs, and by Berntsen and Hall (2004) to study voluntary autobiographical memories, no previous study has used an audio recording method in combination with a campus walk or driving.

Fourthly, in relation to EMFs, a further aim was to investigate the feasibility of conducting paper diary studies entirely over the telephone and by post, which enhances rates of recruitment, and representativeness of tested samples (e.g. different ages, and when recruiting participants from different geographical locations).

In addition to focussing on developing and testing novel methods of studying transient phenomena in everyday life, a final aim of this research was to gain further theoretical insights into the two phenomena studied, and generate testable hypotheses for future studies using both diary and other methods.

9.2 Main Methodological Findings

In the six studies described in this dissertation, two cognitive psychological phenomena were examined, with paper diaries, a smartphone app, and audio recording, with recording periods ranging from 30 minutes to 28 days. The main finding that consistently emerged across the two phenomena was that, contrary to expectations, more IAMs and EMFs were recorded by participants using paper diaries than smartphone diaries, even though the paper diary participants forgot to carry their diaries on some days. While the smartphone diary users carried their phones all the time (as no doubt the paper diary users were also carrying their smartphones), they recorded only approximately half the number of entries recorded in 7-day and 1-day paper diaries. One way to summarise this highly counterintuitive finding is to say that paper diary users occasionally forgot to carry the diary with them but overall remembered the task of making diary entries, while smartphone diary users remembered to carry the diary app but often forgot the task of recording IAMs or EMFs.

The second major finding was that reducing the diary keeping period did not proportionally reduce the number of IAMs (seven days to one day) or EMFs (28 days to seven days) recorded. As this effect was seen for both IAMs and EMFs, it gives some confidence that it might also generalise to other spontaneous or transient phenomena. The diary entry rate reduction effect was further dramatically demonstrated in the 30-40 minute audio recordings of IAMs.

The third major outcome was the development of a novel method of audio recording of IAMs in a relatively controlled naturalistic environment. The method was initially tested on one participant, the researcher, sampling repeated car journeys over many months (Study 5). The hypothesis about greater recording frequency for shorter time periods was also supported, using this new method. The audio technique specifically enabled the analysis of different types of cues, static and dynamic, and the opportunity to investigate possible differences between cues and priming. The study that followed (Study 6) combined this novel audio method applied to a campus walk, with the 1-day paper diary, as used in Study 2. The audio technique also demonstrated an IAM frequency much greater than observed when using paper diaries. IAMs therefore seem more frequent than predicted by paper diary studies conducted over a few days.

Clearly this audio technique is not so applicable to EMFs, which occur in everyday life less frequently than IAMs, and less likely in situations like walking alone. However, with EMFs the telephone and postal technique was shown to work well, and this approach will enable increased rates of recruitment and sample representativeness in future studies.

9.2.1 **Comparing Paper and Smartphone Diaries**

Significantly better compliance rates were found in the smartphone diary conditions, using different measures of compliance: carrying the diary at all times, ease of carrying, and how promptly the events were recorded in the diary. This is why the research was started in the first place, and the finding supported the original hypothesis that a smartphone diary app would be more convenient than paper for recording relevant phenomena, and therefore greater numbers of diary entries were expected.

Despite this high rate of compliance, in both IAM and EMF studies, the smartphone participants recorded significantly fewer events, compared with those using the paper diary. Although this contrasting pattern was highly surprising, and counterintuitive, there are several possible explanations as to why the smartphone participants recorded fewer entries in the diary. One explanation is that the paper diary acted as an incidental reminder to participants that they were in the diary study and were supposed to be recording certain memory phenomena. In essence, participants had a two-fold prospective memory task (Takarangi et al., 2006). Not only did they have to remember to keep the diary with them every day but, in addition, they had to monitor for occurrences of the studied phenomenon throughout the day (Barzykowski & Niedźwieńska, 2016). This is not always possible and people may temporarily forget that they are in the study. Hence, in the paper-diary condition, it is possible that sight of the diary throughout the day reminded participants that they were in the study and renewed, or reinforced, their monitoring endeavour. This fits informal feedback from some participants that the sight of the diary reminded them that they were on the research study (*cf.* Kvavilashvili & Fisher, 2007). The effect of the physical diary as a visual cue has also been observed in intrusive memory research, with paper diaries (Kvavilashvili, Plimpton, & Brewin, 2016), and with loaned PDAs (Kleim et al., 2013).

In contrast to paper diaries, the smartphone is less likely to act as a cue. There is little doubt that participants were carrying the diary app and accessing their devices. According to a recent statistic, iPhone users on average unlock their phones 80 times a day ('Apple's Penchant for Consumer Security | Tech.pinions - Perspective, Insight, Analysis', 2016). However, the smartphone users probably recorded fewer instances because they were less aware of being in the study. This idea is also further supported by the analysis of day-to-day data in Study 1. Here, the number of recorded IAMs in the smartphone-diary condition dropped sharply after the first day and never picked up, suggesting that smartphone participants forgot that they were on the study. As the smartphone has rapidly become a personal and multifunctional device, it perhaps has no cueing effect for reminding participants that they are in a memory study, in the way that the alien paper diary does, with its one, out-of-the-ordinary, purpose. Although it was very convenient to carry and complete the diary, the app itself does not appear to stand out from the many other apps installed on the typical smartphone.

The second possibility is that participants self-monitored to the same extent, but when they picked up their phones to make a memory entry, they were immediately distracted by other apps competing for their attention with notifications of messages etc., which they tackled and then failed to complete the original intention of logging the IAM or memory failure. By way of example, while writing a results section in this dissertation, the researcher picked up his smartphone to use the calculator app. It was only when he returned to this document some minutes later that he realised he had not made the intended calculation. However, if this distraction explanation is valid then participants in the smartphone condition might have made a higher number of acknowledged entries. Indeed, having been distracted by notifications when first waking the phone, it is possible that, at a later time participants would have become aware of their lapse. If at that point some of the essential parts concerning the incident were lost, participants could still have acknowledged the memory using the button in the app. However, this was not the case given the number of acknowledgements in the smartphone condition. Of course, the same distraction effect could occur when returning to the phone to make the acknowledgment as when initially attempting to record the event.

Finally, it is also possible that smartphone-diary keepers were less motivated to record events on the phone because it was actually more tedious than the paper diary. In the study by Kajander et al. (2007), on average, participants took longer to complete an e-diary entry – they took two minutes to make a paper entry, and four minutes to complete an electronic entry – but this was on a PDA and one might argue with modern smartphone user interfaces that the entries would be faster. Of course, this depends on the number of entries and complexity of the questions, but nonetheless the simplicity of completing a paper form should not be overlooked. In these studies, completing the smartphone-diary entry took between one and two minutes, and the data suggest that completing the diary entries was not the issue, as entries were complete and descriptions were of similar length, but rather the problem was in initiating the diary entries. Indeed, if lack of motivation was the sole explanation for the reduced number of full entries in the smartphone, participants should have recorded significantly more acknowledged memories than those in the paper diary condition, but they did not. However, some caution should be exercised regarding the simplicity of using the paper diary, as it may have been easier for participants to make entries at the end of the day, with whatever was coming to mind, to boost the number of entries.

With hindsight, participants in the smartphone app condition could also have been asked to provide a subjective report about when they recorded a memory. This would have facilitated a better understanding of the difference between subjective perception of timing and objective data.

In summary, these three explanations are all of interest, and have merit, and open up avenues for future research. However, the first one concerning the lack of cueing of study participation with the smartphone diary seems the most plausible. Methods to establish whether this is indeed the case will be addressed later, in the discussion of future work.

9.2.2 Diary Entry Rate Reduction Effect

The finding of the effect of increased rates of recording in shorter diary periods, the *diary entry rate reduction effect*, was found in both paper and smartphone diaries comparing 7- and 1-day IAM diary studies. Similarly, the increased rate with the audio recording technique, both in car and on the campus walk, further demonstrated the effect. This is consistent with findings in the literature, which have shown high number of diary entries when people have kept a record of their IAMs for one day or 60 minutes (Kamiya, 2013; Rasmussen et al., 2015). However, the observation of this effect with the 28-day versus 7-day diaries of EMFs has not been reported in any previous study.

This effect is best explained by the reduced burden for participants and that they are more focussed on the task when it is for a shorter period. It does however raise the question whether diary-collected IAMs are a representative sample of all IAMs experienced or a distorted (or biased) sample of IAMs that are noticed (or break through a threshold) – and whether this threshold varies according to the recording period allotted to the participants. For example, participants may be more observant if they only have to record for a short period of time. Therefore, potentially in the longer diary periods participants may record only more noticeable or powerful IAMs that break through. However, the present data from the studies reported here do not support this, as there were no significant differences on any characteristics measured. In the case of the specificity of IAMs recorded in these studies, the percentages are remarkably consistent at between 70-80% specific in the 7-day diary, 1-day diary, car audio diary and campus walk. In contrast, in a laboratory study (Plimpton et al.,

2015) in which participants had to report any task unrelated thoughts, some of which were later classified as IAMs, the specificity of IAMs dropped to 57.72% (for similar low levels of reported IAM specificity see Vannucci et al., 2014). It is therefore possible that specificity of recorded IAMs depends not so much on the length of the recording period but whether participants know that their IAMs are being investigated. This important question clearly needs further investigation in the future.

9.2.3 **Remote Testing**

The study of everyday memory failures, using remote measurement in both 28-day and 7-day worked well. All participants completed the studies, and understood the instructions. The feasibility of telephone-based *laboratory* assessments was confirmed by obtaining highly significant negative age effects, which have been demonstrated by countless laboratory studies of cognitive ageing where testing has been conducted face-to-face. Similarly, it appears that conducting diary studies over the phone and by post is also feasible. This conclusion is supported not only by the findings of Studies 4a and 4b on EMFs showing that all participants were able to follow instructions and complete diaries correctly, but also comparing the data of 15 older adults (aged 60 and above) in the 7-day EMF (Study 4b) with unpublished data on 25 older adults in a similar 7-diary of everyday memory failures, where participants were tested face-to-face and were telephoned twice a day to remind them of the task of recording their EMFs. Despite these method differences, there was no significant difference in the number of EMFs recorded in these two studies of EMFs, $t(37) = 1.03$, $p = .310$. This outcome is a particularly helpful finding for researchers who wish to study older adults who are healthy for their age but are not mobile, or even house-bound. Overall, it is an effective and achievable alternative method.

Tools such as Amazon's web-based Mechanical Turk have proved effective for remote, low-cost recruitment and data gathering (Buhrmester, Kwang, & Gosling, 2011;

Mason & Suri, 2012; Paolacci & Chandler, 2014), and have therefore become popular. However, here the experimenter has much more control because participants are tested over the phone, leading to more reliable data.

9.2.4 **Audio Recording as a Method**

The audio recording method used in both car driving and campus walk studies also proved an effective new way of recording IAMs that researchers can use in future. As IAMs recorded in the audio method appeared much more frequent, the question arises whether they are equivalent to diary recorded IAMs. However, the characteristics of IAMs from the two methods were the same, as far as measured.

There may be circumstances where these audio recording methods are more convenient for participants, for example, in certain clinical disorders. However, audio recording was also important because numerous new insights were gained, particularly in the car audio study, that would not have been obtained with either paper or smartphone diaries. These will be discussed in more detail in subsequent sections.

9.3 Main Empirical and Theoretical Findings

In addition to addressing these important methodological issues, interesting insights were gained in the actual phenomena studied. These topic-specific findings help to formulate new research questions for the future, and development of deeper theoretical understanding of the phenomena, especially for involuntary autobiographical memories.

9.3.1 **The Frequency of Involuntary Memories**

The frequency of involuntary memories was examined in Studies 2, 5 and 6. The frequency of recorded entries appears to be affected by the length of the recording period, the burden of recording, and the medium of recording.

The rate of IAMs found in the car audio, Study 5, of nearly one per minute is substantially higher than found in paper diary studies (and by extension in the smartphone diary studies) in Chapters 3 and 4. Initial studies (Berntsen, 1996) found only 2-5 IAMs per day. Higher rates have been reported over time, but only more recent studies (Gardner & Ascoli, 2015; Kamiya, 2013) have found numbers approaching frequencies reported in Study 5. The key difference from other studies is the greatly increased number of IAMs captured in a short space of time, even more than proposed by Gardner and Ascoli (2015). Unfortunately, Gardner and Ascoli (2015) did not distinguish between voluntary and involuntary memories but, even with these pooled did not reach the rate observed in the car journey. The numbers recorded in the campus walk study by Kamiya (2013) were lower, but the participants needed to stop from time to time and interact with the researcher, which interrupted the flow, and likely reduced the state of relaxation of the participants.

There are several reasons why this rate was found in the car study. Firstly, the participant was monitoring during a highly automatic, relatively low demand activity. Secondly, the audio recording method made logging the events very easy. Thirdly, the participant had a clear understanding of what was being counted and was able to attend to the IAMs and note their cues. Fourthly, another explanation for the number of memories that occur when driving might be the high rate of change in the environment. When driving, the environment changes faster than when walking, presenting a richness of cues. Furthermore, the task of driving demands greater visual acuity. Driving may be one of a small number of activities where the demand is low, but a high level of observation and monitoring of the environment is required. As such, it may be an optimal everyday task for observing IAMs.

Across the methods and time periods, it does seem to be the case that meta-awareness plays a key part in the observed frequency of IAMs. This is an important discovery for IAM research that needs to be addressed in the methods that are currently being used.

This raises the question whether memories gathered by self-interruption method in diaries, are different from memories that can be captured by people being interrupted and asked what they were thinking about, for example in the ESM approach of Gardner and Ascoli (2015) and also laboratory methods (Barzykowski & Staugaard, 2015; Plimpton et al., 2015; Vannucci et al., 2014). This important question has not been fully answered and needs further investigation.

9.3.2 **Chaining of IAMs**

The high number of IAMs experienced in the car audio study (Study 5) was expected. However, the large number of chained memories obtained was somewhat surprising. Indeed, studying chaining was not part of the experimental aim, but when it became very apparent on playback of the recordings, it formed an important part of the analysis.

Chained involuntary remembering is where IAMs appear to be triggered by other IAMs, or by voluntary memories (Linton, 1986; Mace, 2006). Mace (2010) argued that this phenomenon is relatively uncommon, and is less familiar to researchers and participants. Mace (2005, 2006, 2007) estimated that approximately 15% of all naturally occurring IAMs result in a chain of memories. Typically, these are 2-3 memories long, and longer chains are rare. They are occasionally reported spontaneously in naturalistic diary studies, however Mace, Clevinger, and Bernas (2013) designed a diary where participants were encouraged to record chains by recording each on a separate page and linking them back by reference to the previous memory.

There is an important difference between chaining and multiple memories arising from the same cue. For example, the cue → memory → memory → memory… sequence is a chain. However, this differs from several memories being triggered by a single cue, such as when the participant remembered both a wedding reception and a financial seminar when seeing a particular hotel on one of the car journeys, which does not meet the definition of a chain.

In Study 5, 23% of all memories recorded were chained, in contrast to the 15% estimate cited above. However, the distribution of chain lengths was remarkably consistent between the diary of Mace et al. (2013) and the car audio study: chain length of one, 68% vs. 69%; chain length of two, 20% vs. 21%; and chain length of three 7% vs. 9%, with a small number of longer chains in both studies. The length of chains in the diary study is surprising because it would seem quite burdensome to write the sequences. Indeed, the act of initiating the logging may itself break the chain. However, in that study the participants were coached to be diligent in recording chains. In contrast, the audio recording approach proved very convenient, and allowed the participant to explore the cues spontaneously, and it was later that the many chains became apparent.

The chaining phenomenon has received little attention other than by Mace and colleagues (Mace, 2006, 2009; Mace et al., 2010). However, researching IAM chaining is important because it potentially gives insight into the organisation of autobiographical memory (Mace et al., 2010). Indeed, a key question concerning chained memories is how they relate to the initial memory, and other chained memories if the sequence continues. Mace et al. (2010) asserted that the chained memories were linked conceptually (i.e. a memory about one holiday may trigger memory of another holiday) in about 80% of cases, whereas just 20% were temporally linked (e.g. a memory close in time to that holiday, such as an incident at work on return from the holiday). The explanation given for this is that involuntary memory chains are naturally occurring and the automatic spreading of activation in the memory system follows the line of memory organisation, based on common themes.

It is interesting to see how this interpretation relates to other theories of autobiographical memory storage and retrieval. For example, Conway’s influential model of autobiographical memory (Conway & Pleydell-Pearce, 2000) proposes that memories are organised into a hierarchical structure, with lifetime periods at the top then, within each lifetime period, general events and then a more specific pool of event specific knowledge or information at the bottom. According to this model, voluntary retrieval of memories involves activation processes that spread top down via the system starting from lifetime periods, down the hierarchy via general events and reaching the bottom layer of specific events. Conway and colleagues conducted several priming studies that provided evidence for such a top down spreading activation process. For example, Conway and Bekerian (1987) showed that when participants were first primed by a certain life time period (being in the 6th form at school), and then presented with keywords relating to an event that had occurred in that lifetime period (e.g. a trip to Italy), this resulted in faster retrieval times than when no life-time period primes were presented. These findings support the idea of memories being organised within temporally related structures with activations spreading via event representations linked to a particular life time period. This model suggests that chained memories would be more easily retrieved if they were temporally related. However, if a holiday while in the 6th form reminds one of a more recent holiday when aged 50, this type of chaining suggests memories may not be organised in lifetime periods.

The number of chains, and the length of many of them, without any apparent effort to retrieve them, is in keeping with the model of Uzer, Lee, and Brown (2012) who found large numbers of directly retrieved memories even in voluntary autobiographical memory experiments. Based on these findings, Uzer et al. (2012) proposed that memory traces may not be always distributed across the temporally organised hierarchical structure, but may be instead organised in more stable clusters that get activated simultaneously without top down reconstructive processes taking place. In line with this view, chaining examples show that it is possible to quickly retrieve a memory from a completely different lifetime period. It is therefore possible that memory fragments cluster based on conceptual similarity, which means that spreading of activation can go directly to other conceptually related fragments, circumventing any need for top-down processes within a particular time period.

These findings with chaining are thus potentially theoretically very important, and raise fundamental issues about how AMs are organised. For IAMs, the idea of chaining remains an under-investigated area. Chaining may be happening more frequently than previously thought and therefore warrants further investigation (Mace et al., 2013).

9.3.3 **Dynamic versus Static Triggers**

The car audio method facilitated further analysis of external triggers. Mace et al. (2015) hypothesised that individuals are better at recognising IAMs cued by external tangible stimuli rather than internal cues (e.g. thoughts). There was a tendency in the car study to more external cues but it was not significant, in contrast to the findings of Berntsen (1998). No difference was found in this study initially because chained IAMs were first classified as being due to internal triggers. Once chained memories were excluded, the remaining number of internally cued IAMs was then significantly lower than externally cued IAMs.

The car audio method is unique in allowing the easy differentiation of external cues between dynamic and static types. The opportunity to distinguish static and dynamic (or novel) triggers is not generally feasible in diary studies, and has not been examined in laboratory studies of IAMs. However, it has been studied in a novel method developed by Berntsen to study involuntary episodic memories (Berntsen, Staugaard, & Sørensen, 2013), which demonstrated the cue overload effect. Here one or several pictures were associated with one or several sounds. Later when presented as cues, the ones with multiple associations elicited fewer memories. Does the cue overload effect suppress static cues, or something else, e.g. attention? There are two possibilities, one that people pay more attention to the novel cues, which are unique and perhaps have only one memory attached to them, rather than static. The other possibility is that static cues suffer from cue-overload, as potentially they have many memories attached to them, and they all compete so nothing comes out.

In most cases (15 out of 20 car journeys), the dynamic cues outweighed the static cues and the mean percentage of dynamic cues (66%) was significantly higher than the mean percentage of static cues (34%) (p = .01), suggesting that familiar surroundings were less conducive for eliciting IAMs. However, when attention was drawn to the novel, or out of the ordinary stimuli, IAMs were cued. Noticing the unusual is a beneficial skill when driving, and is consistent with the literature on driving, where drivers become more alert when the environment becomes less familiar, or is different from expected.

This novel distinction of static and dynamic cues should be explored further. The repeated journey along a consistent route creates the opportunity to make these observations, which gives further insight into the production of IAMs.

9.3.4 **Priming**

Almost every IAM study reports data on cues, and several studies have specifically investigated and/or manipulated the nature of cues (e.g., Mace, 2004; Mazzoni et al., 2014; Schlagman & Kvavilashvili, 2008; Vannucci et al., 2015). There is a strong link between cues and memories and it is universally accepted that IAMs occur because cues elicit them. However, many questions remain unanswered. For example, not all potential cues elicit IAMS, as if they did we would be flooded with them. On other occasions an IAM occurs, but there is no identifiable cue. A further important question concerns the length of time that elapses between the occurrence of a cue and retrieval of an IAM in response to the cue. At what point does it cease to be a cue and should perhaps be called something else?

A theoretical interpretation is that there is a very strong link between the cue and the memory. This raises an interesting question as to why certain memories repeat in response to the same cue, but also why the same memory does not constantly recur in response to the same cue. For example, in the car audio study sometimes the motorway sign to the town of Aylesbury prompted a memory of attending a music concert there, but other times a meeting attended in the town. Similarly, road signs to the airport sometimes prompted memories of holidays, while other times of business trips, but most times no memories. A working hypothesis adopted as a result of some of the findings obtained in the present dissertation is that for any given cue to elicit a particular memory its representation must be pre-activated (i.e. primed) by previous exposure to certain events in one's environments or in one's thoughts. Such pre-activation of memory representation, or parts of representation, would dictate when a subsequent cue does prompt a memory and when it does not.

There is currently almost no research on the effects of priming on IAMs. However, in a two-week diary study of IAMs (Mace, 2005), participants were prompted at the end of week 1 to spend 30 minutes in the laboratory deliberately recalling high school memories. IAMs pertaining to high school then appeared in the diaries in the second week. Interestingly, these primed IAMs were not simply repeats of the voluntarily recalled memories, but were related high school memories, showing evidence of spreading activation. While in Mace's (2005) study the priming manipulation was excessively strong (i.e. deliberately recalling as many memories as possible from one's high school period for 30 minutes), it is highly probable that accidental encounters with certain events or ideas, outside of researcher's control, can also prime, or activate memories, so that later when certain cues are encountered these memories pop into mind.

The research reported in this dissertation makes two contributions to the discussion of priming in IAMs. Firstly, the audio recording technique enabled the detection of priming events some time earlier in the journey. Secondly, it added the novel diary question asking participants to report the delay between the perceived cue and the IAM.

The observation in the car audio study was that the retrieval time was generally perceived to be near-instant. The participant saw a cue, say a particular model of car and immediately thought about a friend, or saw a road sign to the airport and immediately thought about a holiday or business trip. However, sometimes there was no apparent cue, but with the benefit of the audio playback it was often possible to identify "accidentally" primed memories. In the car journey study (Study 5), there were examples of delays of between 2 minutes and 20 minutes between some kind of priming event and a later IAM that were convincingly traceable. For example, in journey 1, memory number 20 offered an interesting priming example: the participant had been at a music concert the previous evening with a friend, noted at 16 minutes 2 seconds into the journey. Just over a minute later, at 17 minutes 23 second, he thought about a BBC radio recording event he attended, with no apparent cue. However, on playback and analysis, the friend at the concert also attends these radio recordings and the participant often sees him there. Therefore, it is likely that the activation of the initial memory of music concert with a friend primed and reactivated several other memories of similar events with the same friend so that sometime later one of those memories was recalled seemingly with no cue.

As well as resolving some "no cue" IAMs, the audio analysis could be applied where there was an identified cue, to see whether it is possible to trace back some precursor. For example, following a memory about one of the participant's computer consultancy clients, there was a later memory about that client cued externally, but it is possible that the second memory would not have occurred if not previously primed by the first. In some way, both components may be needed – the earlier prime to make a particular memory representation more active, and then some incidental cue that tips it over a threshold. Whereas Mace (2005) has demonstrated priming of several hours, or even days, the method in the car study has quantified examples of primes some minutes before the occurrence of IAMs. It is perhaps open for discussion whether these are the same mechanisms but, in both cases, they differ from the generally accepted cueing definition of near-instantaneous occurrence of an IAM in response to the cue.

A second indication of the priming effect in IAMs reported in this dissertation, was that participants were asked, for the first time, to estimate the time between any identified trigger and the memory. Retrieval time has not been considered before in diary studies, although has been measured in laboratory studies (Kvavilashvili & Schlagman, 2011; Schlagman & Kvavilashvili, 2008). Care was taken to ensure no expectations of delay were set, and in most cases participants said the time between the cue and memory was instantaneous, immediate or just a few seconds, in line with the current understanding of near instantaneous nature of cues that trigger IAMs. However, in a number of cases in the 7- and 1-day diary studies (Studies 1 and 2) delays of minutes, or hours were reported. While it was purely participants' perception, this could be interpreted as potential recognition of priming, and thus is worthy of further research. It supports the idea that some of the triggers participants reported were not actually cues of IAMs, but rather potentially earlier primes of those IAMs.

These observations raise an unresolved question regarding differences between cues and priming, in terms of both the mechanism and timing. The prime is some time before (minutes, hours, or potentially days as in Mace, 2005). But perhaps it is also possible to detect an interaction of an earlier priming with the cue just before the IAM, for example would the cue have been sufficient without an earlier prime?

To date, various modes of priming have been identified. Mace's (2005) study of high school memories demonstrated priming by *voluntary* recall. In contrast, Berntsen (2007) discussed *motivational* factors (e.g. one's current concerns) that may prime and therefore make some memories more accessible than others, for example, memories related to lifetime period or a particular person. As an example of such priming by one's current concerns, Berntsen describes a case of a participant who had been an *au pair* in the USA a year before the study in which she reported around 50% of her IAMs related to that period. Johannessen and Berntsen (2010) further investigated Klinger's (1978) idea of current concerns with relation to IAMs, and found that up to 50% of participants' recorded IAMs were related to their *current concerns*, for example, worry about work. These current concerns appear to sensitise participants to appropriate cues in the environment, or thoughts. Current concerns and motivational factors are often identifiable from themes apparent in diary entries, or by subsequent debriefing interviews. In the car audio study, the participant noted at the start of the audio recording, for context, things that had happened before the journey started, or what he was anticipating when he arrived at the destination. While this description was not exhaustive, he was able to identify IAMs that while apparently without trigger, were nonetheless the result of ongoing thought processes about these concerns.

The evidence from the car audio study suggests the third type of priming, namely *accidental* encounters. While this mode of priming is of no surprise, it has not been possible to detect these priming mechanisms readily before.

These three types of priming, and subsequent cueing of an IAM suggests a new model of primes and cues that should be tested experimentally. The model proposes that the occurrence of IAMs at any given time is a function of the interplay of various parameters such as deliberate recall, accidental encounters, and current concerns/motivational factors which can all pre-activate certain memory representations. If the ongoing activity is very demanding then no matter how highly activated or primed, the spontaneous recall of that memory representation may not take place. Conversely, if there is a very strong cue, pre-priming may not be necessary. There is then an interesting question of whether both prime and cue are needed, for a spontaneous recall to occur or whether one of these factors is sufficient if it is strong enough and when participant is not engaged in a cognitively demanding task. This model is illustrated in Figure 9-1.

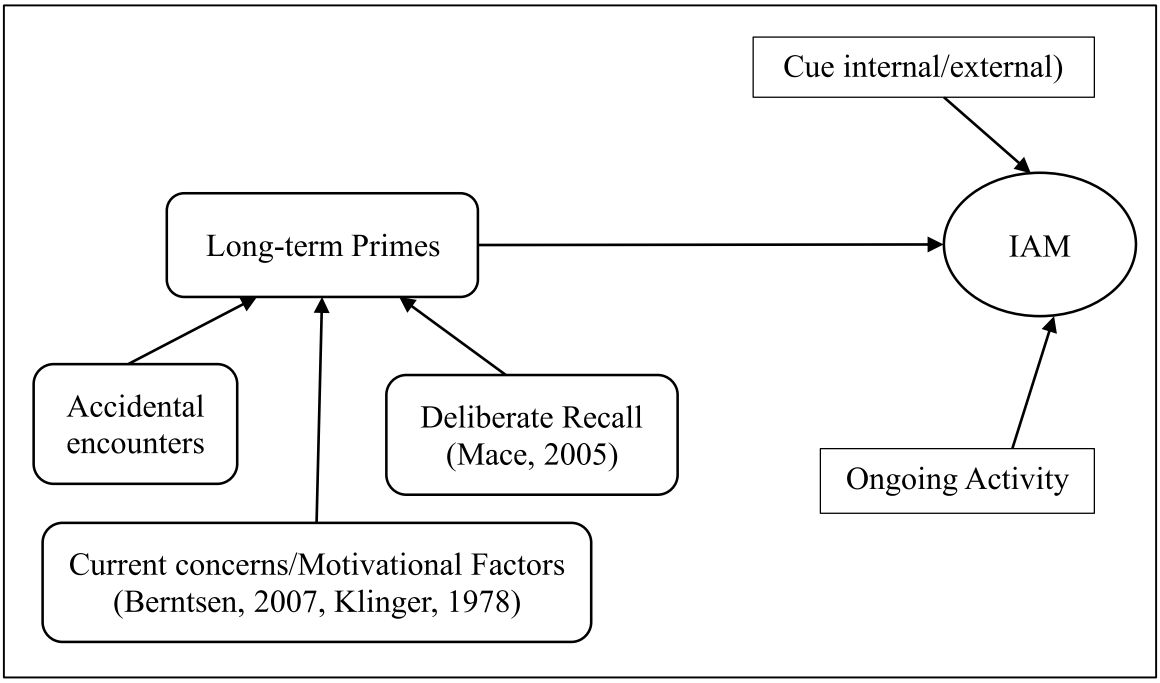

Figure 9-1. Proposed model for the interaction of primes, cues and ongoing activity

The next step is to try to test the model and this is an opportunity for future research using the audio recording method. The findings with the trigger-memory delay question in diaries suggests some potential awareness of earlier primes, in some cases, which could be explored with additional diary questions or post-diary interviews. However, experience in the audio recording playback revealed that priming events even a few minutes earlier were not recalled when trying to describe the IAM (see also Kvavilashvili & Mandler, 2004). Mace (2010) concluded that priming in IAM is not fully understood. It is a difficult phenomenon to study, but clearly warrants further, more detailed and systematic research, perhaps including variables, such as mood (e.g. Berntsen, 1996; Kvavilashvili & Schlagman, 2011). Further, the recently developed laboratory methods for IAMs might also be extended to study effects of incidental priming and time delays between a prime and a cue under more controlled conditions.

9.3.5 **EMF**

The findings regarding EMFs are important for research into normal and abnormal ageing. Participants in Studies 4a and 4b showed the classic negative age effects on laboratory test performance, using the telephone-based COGTEL and TICS-M instruments. However, there were no age effects with the number of errors recorded in the diary. Further there were no correlations of age with any of the metamemory questionnaire scores. These results show that the diaries and questionnaires are measuring something different from what the laboratory tests measure. This suggests issues of measurement that warrant further research to resolve.

For EMFs, there was very little meaningful correlation of the number of memory errors with questionnaires, and no correlation of questionnaires with laboratory scores. The negative correlations in the 7-day diary, suggesting those who performed better in the laboratory recorded more errors in the diary, disappeared when the outliers were removed. This negative correlation was interesting, however, as it suggests a possible effect where higher performing participants, by laboratory measurement, may be more observant of themselves and may actually record more errors.

9.4 Limitations in this Research

Two cognitive psychological phenomena were tested. As the superiority of paper over smartphone diaries, and diary entry reduction effect were observed in both, that provides evidence that the effects would generalise. However, these may not hold true for all transient phenomena. While generalisability has been shown for EMFs, in practice the reliability of smartphone as a diary would have to be confirmed for each phenomenon under test.

In other phenomena the diary cueing effect may change the results, and for example in the case of intrusive thoughts we would not want the diary to prompt as it could be unhelpful to the participant, or patient (Kleim et al., 2013), and from a research point of view, resulting in over-counting of the phenomena.

The car study was conducted on one participant only, the researcher, but nevertheless it was a valuable pilot study. While there is a precedent for this, certainly in psychology, the experiments would need to be extended to other participants, and further work with the audio recording technique should be considered for IAMs, perhaps with participants walking, rather than driving, a familiar route, or as a vehicle passenger on a familiar route. Alternatively, drivers could watch video recordings of their journeys in the laboratory.

The studies reported here are restricted to healthy individuals, although a start was made on studies of participants with mental health issues, and physical disease with cognitive impairment. Clinical participants (patients) may not report reliably, or in the same way, so this is an area for future research.

The 28-day diary EMF protocol described in Chapter 6 was also conducted with 15 Parkinson's Disease (PD) patients. Interest in PD was initially motivated by meeting PD patients at a medical technology seminar, many of whom were using smartphones and tablet devices to overcome motor issues with handwriting. Over 28 days, many participants dropped out due to the variability of the disease, and they were often unable to complete the study despite initial enthusiasm and commitment.

A 7-day paper-diary versus smartphone-app protocol for the study of voice hearing patients in young psychosis patients has also been started. A few participants have been recruited but commitment varied and participants were prone to changing their mind about participation or they lost motivation. Participants varied from lethargic to agitated and only certain energy levels are consistent with diary keeping. Furthermore, introducing medication, which was prescribed when the patients became more agitated, dramatically suppressed voices. It has therefore been hard to recruit patients at the right point in the treatment cycle.

There are also questions regarding whether patients with severe mental disorders can reliably complete surveys (Oorschot, Lataster, Thewissen, Wichers, & Myin-Germeys, 2012; Oorschot, Kwapil, Delespaul, & Myin-Germeys, 2009; Trull & Ebner-Priemer, 2009). Perhaps this is why there is so little research on voices. In future, it might be better to attempt this research initially with non-clinical groups of voice hearers that are not in the healthcare system, either because they do not have a medical diagnosis or are comfortable with their voice hearing. Such participants could be recruited via web forums, such as https://www.hearing-voices.org/.

It was also intended to test older populations of healthy versus mild cognitive impairment patients, using the smartphone app. However, at the time of recruitment participants were generally not interested in owning smartphones so recruitment was not feasible. This scenario will change as current generation of smartphone owners age.

In summary, clinical populations could engage, but recruitment was difficult. However, it is important that clinical populations are evaluated.

9.5 Where Next? Changes to Research Practice, Impact of Research and Contribution to Knowledge

Significant advances were made in this research in both methodological and theoretical aspects of studying IAMs and EMFs, but equally these studies raised a number of issues and questions for further research. The main, and surprising finding was that the smartphone diary app installed on participants' own smartphones did not increase the number of events logged in the case of IAM or EMF. This sounds a note of caution for researchers rushing to use the new technology. The lack of meta-awareness of being in the study in the smartphone condition seems the most plausible reason for this reduced number of recordings in the app, and the next step is to test whether the cueing effect of paper diaries can be replicated with the smartphone.

Further work should now be undertaken to find a means to cue smartphone diary participants that they are on a memory study, comparable with the implicit cueing of the paper diary. The cueing, however, needs to focus on maintaining the awareness of the study participation, but not the cueing of the phenomena. This could take the form of technological solution such as a daily, or more frequent, text (SMS) message, or other form of smartphone alert, although it is important to avoid escalating to an experience sampling model with explicit prompts, which has been argued is inappropriate for these phenomena. More simply, we might ask participants to make a change to the usual appearance of their phone (e.g. with a coloured phone case, or with a label, rubber band, ribbon, or modified screen image or colour), in order to mimic the implicit cueing of the paper diary. The initial approach being taken is to ask participants to change the appearance of their smartphones for the duration of the study by putting their smartphones in a coloured case. It is predicted that this will raise the number of recorded phenomena to the number recorded in paper diaries or, given the otherwise convenience of the smartphone, even make it superior to the paper diary. In summary, participants need a prompt that they are on the study, but not for actual events.

The second consistent finding was that the diary-keeping period can be greatly reduced, certainly in the study of these two phenomena. While the effect remains to be tested with other phenomena, it is predicted that the effect would be observed when measuring self-caught transient phenomena. These results have already impacted the approach used in our research group, and a recently completed study shows that keeping a paper diary for just three hours resulted in a higher number of recorded IAMs than in a 1-day diary (using a between-subjects design). Reducing the diary-keeping period therefore appears wholly justified in terms of the quantities and qualities of data collected, and because it reduces the burden both on the participants and the researchers, it allows more participants to be processed and increases the likelihood of recruitment. On the other hand, if there are therapeutic benefits of diary-keeping (e.g. Kvavilashvili & Brewin, 2013), or there are nuances that appear as time goes on, for example changing ratios of AM, PM and RM in EMF studies, then these are counter-arguments for extending the period. Broadly though, the outcome is that shorter diary periods are appropriate, unless the diary is gathering data to support or test an intervention, for example a medical or talking therapy.

The use of the acknowledge feature in paper and smartphone diaries was mixed. The event must be recalled later, and the participant must be sufficiently motivated to then acknowledge it. Furthermore, acknowledged events may be of a particular type, such that they are remembered later, but unfortunately it is impossible to know what they are as, by definition, no details are recorded. An enhancement to the method might be to allow the participant to record an abbreviated memory event record page, part way between the tick and the full page, as this would reduce the burden. Indeed, Berntsen's first IAM study (Berntsen, 1996) used a two-stage approach where keyword phrases were recorded in a notebook, later followed up at the participants' convenience filling in a more detailed questionnaire. This technique could be implemented easily with an app, even a simple note-taking app. It would be easy to consolidate the initial app entry with later paper entry, or have an app that prompted later for fuller completion of a started entry. The smartphone could be preferable for short forms, using buttons and menus rather than text fields, which are quick to complete, and would address any concerns that completing the app entry is more tedious.

The novel audio recording technique proved highly effective both as a methodological advance, but also in providing some theoretical insights into IAM mechanisms. The ease of recording details enabled the identification of potential earlier priming, and a reduction in the number of IAMs for which, originally, there appeared to be no cue. The standard driving route facilitated the distinction between static and dynamic cues. This audio diary method could now be further tested perhaps asking participants to keep an audio diary for 3-4 hours in a naturalistic setting rather than campus walk, although privacy issues would have to be addressed.

The somewhat unexpected outcome of this research is that the paper diary has received a boost to its reputation. While increasingly seen as unacceptable in clinical diary studies, paper diaries still seem appropriate for studying IAMs, memory failures, and other phenomena where self-monitoring and self-initiated recording is required, and where no expectation of the frequency is set. As there is no pressure to deliver a certain number of entries, and no penalty for low numbers of events, there is less, if any, reason to fabricate entries. These studies can therefore take full advantage of the implicit cueing feature of the paper diary method.

These findings are important for researchers as the momentum towards using smartphones in psychological, social science, and clinical research will only increase. Researchers must balance the convenience to participants, and themselves, of electronic data gathering on devices supplied by the participants, versus the limitations of the approach demonstrated in the paper versus smartphone app comparison. Researchers going straight to an app on a smartphone would be making a risky assumption that they will get equivalent or superior results.

There is justification for continuing with paper diaries, and reducing the diary keeping period, to an optimal three-day period (for IAMs), although shorter periods appear acceptable. Clearly, if we can reduce the period and get meaningful results, that is of greater convenience to both researchers and participants. They are labour intensive for the researcher and burdensome for the participants, so anything that can be done to reduce these is relevant.

A bespoke app was written for this research. However, this is not a viable long-term solution, and ideally a toolkit for psychology experiments will emerge. Alternatively, commercially supported experiment building and survey applications are becoming available. It will get easier to build or configure apps, without resorting to writing computer code.

Some researchers have tried to work with existing commercial apps, for example using game and puzzle apps for cognitive assessment (Thompson, Barrett, Patterson, & Craig, 2012). Others have attempted to monitor the use of smartphones, for example by examining social media and phone usage data as a means of assessing social connectivity to address mental health assessment (Arean et al., 2016; Areán, Ly, & Andersson, 2016).

In conclusion, there is little doubt that smartphones will be used in psychology studies in the future. Indeed, participants' expectations alone will drive the move, as they will not want to carry a second phone, or paper diary and will increasingly ask why they cannot use their own smartphone. However, this research has shown that care is required, and it cannot be assumed that the old paper diary can be replaced by the new smartphone diary, without due care. These studies serve as a timely reminder that each new generation of technology brings its challenges as well as opportunities.

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Appendices

Appendix A: Smartphone Use Questionnaire

QUESTIONNAIRE 1

Smartphone Users

Participant code:

Gender:

Age:

IT and mobile phone use

1. How long have you had any iPhone/Android phone (include previous ones)?

1a. How long have you had your current iPhone/Android phone?

1b. What is the model and operating system version? (Please ask for help if needed)

2. What do you use your mobile phone for?

Voice calls:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Data tethering (laptop access to Internet):	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Receive and read emails:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Sending emails:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Writing notes and lists:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Check voicemail:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
SMS:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Social networking:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Address book:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Calendar:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Playing games:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Accessing webpages:	❍ Yes, regularly	❍ Yes, sometimes	❍ No
Keeping a diary or journal:	❍ Yes, regularly	❍ Yes, sometimes	❍ No

Other uses: ....

How many apps do you have on your phone?

How many do you use regularly?

What are your top five most used apps?

What is your favourite app?

Which app could you not live without? If you could have just one app what would it be?

3. How would you rate your typing speed when using a mobile phone keypad?

❍	❍	❍	❍	❍
Very slow	Slow	Average	Fast	Very fast

4. When typing a message, using a mobile phone keypad, how many times do you make an error?

❍	❍	❍	❍	❍
Never	Once or twice	A few times	Several times	Many times

5. Do you like using a mobile phone keypad?

❍ Yes ❍ No

6. How often do you upgrade your mobile phone?

❍ Once a year or as soon as a newer version comes out

❍ About every 2 years

❍ About every 3 years

❍ About every 4 years

❍ About every 5 years of less often

7. How would you rate your ability to adapt to new technology?

❍	❍	❍	❍	❍
Very slow	Slow	Average	Fast	Very fast

Appendix B: Diary Compliance Questionnaire

QUESTIONNAIRE 2

Participant code: Date:

Below is a list of questions that relate to your experiences of keeping a diary of involuntary memories for a day. For each question please tick the answer that best applies to you. Some of the questions may seem to repeat sections of your diary entries. Please still provide an answer as the purpose of this questionnaire is to find out whether the use of a diary method worked well or not, and if you felt this was a useful or interesting experience.

There are no right or wrong answers so please answer honestly.

1. Did you keep your diary with you all day?

❍ Yes ❍ No

5. If you did not keep your diary with you all the time, was there a reason for this and if so please write what the reason was?

____

____

3. How did you find keeping your diary with you at all times?

❍ Very easy ❍ Somewhat easy ❍ Somewhat difficult ❍ Very difficult

4. What percentage of memories do you think you were able to record and acknowledge?

_____________%

5. How did you find recording your memories using the diary provided?

❍ Very easy ❍ Somewhat easy ❍ Somewhat difficult ❍ Very difficult

6. If you found it difficult, what made it difficult for you?

____

____

Appendix C: IAM Diary Double Page

1. a) When did you have a memory? Date____________Time________AM/PM

1. b) When did you record it? Date____________Time________AM/PM

Describe your memory. What was it about?

3. How vivid is your memory?

O Very vague O O O O O O extremely vivid

4. Was the memory triggered by something

O in your thoughts O in your environment O there was no trigger

If a trigger, what was it?

Please estimate the time between the trigger and the memory:

5. What were you doing?

6. How much were you concentrating on this activity?

O Not at all O O O O fully concentrating

7. How pleasant or unpleasant is the memory now?

O Very unpleasant O quite unpleasant O neutral O quite pleasant O very pleasant

8. How pleasant was the original event?

O Very unpleasant O quite unpleasant O neutral O quite pleasant O very pleasant

9. Is the memory of a general or specific event?

O General O Specific

10. When did the original event occur?

11. Have you ever had this memory before?

O never O once or twice O a few times O several times O many times

1. a) When did you have a memory? Date____________Time________AM/PM

1. b) When did you record it? Date____________Time________AM/PM

Describe your memory. What was it about?

3. How vivid is your memory?

O Very vague O O O O O O extremely vivid

4. Was the memory triggered by something

O in your thoughts O in your environment O there was no trigger

If a trigger, what was it?

Please estimate the time between the trigger and the memory:

5. What were you doing?

6. How much were you concentrating on this activity?

O Not at all O O O O fully concentrating

7. How pleasant or unpleasant is the memory now?

O Very unpleasant O quite unpleasant O neutral O quite pleasant O very pleasant

8. How pleasant was the original event?

O Very unpleasant O quite unpleasant O neutral O quite pleasant O very pleasant

9. Is the memory of a general or specific event?

O General O Specific

10. When did the original event occur?

11. Have you ever had this memory before?

O never O once or twice O a few times O several times O many times

Appendix D: IAM Diary 7-Day Cover Pages

- Indicate if there was something that triggered the memory. This might be something in your thoughts or something in your environment. For example, remembering about "my car accident in December 03" was triggered by "a letter from the insurance company", and memory about granddad was triggered by "my lecturer wearing a top with similar buttons." Memories can be triggered by just about anything or sometimes by nothing at all.
- If there was a trigger, describe what it was that triggered your memory.
- Please try to estimate the time that elapsed between the trigger and when you became aware of the memory.
- Write down what were you doing when the memory came to mind - what activity were you engaged in? For example, having a breakfast, typing an email, watching a TV show, talking to your friend, thinking something etc.
- Indicate by placing a tick on the scale, how much you were concentrating on the activity you were engaged in. Not concentrating means that, in your thoughts, you were probably "miles away" from what you were actually doing. For example, you could be washing up dishes and thinking about upcoming holiday. In contrast, if you were concentrating on the activity this would mean that you were not thinking about anything else (e.g., being engaged in a conversation and following it closely without having any irrelevant thoughts).
- Evaluate how pleasant or unpleasant your memory is now. Is it positive and pleasant to remember or is it negative and unpleasant to remember.
- Evaluate how pleasant or unpleasant the original event was at the time you experienced it, i.e., was the event that you remembered positive and pleasant or negative and unpleasant at the time you experienced it in your life.
- Indicate whether the memory is of a general or specific event/experience. A general event may refer to an extended event (e.g. a trip to Paris) or a single event that occurred repeatedly over an extended period (e.g., travelling on the tube every morning when working in the City; going to seaside every summer during your childhood). A specific event refers to a single episode in your life (e.g. the day you move into your new house or the day a family member was born).
- Estimate when the original event occurred. Please provide as accurate date as possible (for example, yesterday, 3 months ago, 10 years ago, 10 October 2007 if it is a special date like a birthday etc.)
- Indicate whether you have you had this memory before. It does not matter if memory has come to mind involuntarily before, or that you have deliberately recalled the memory before - as long as you indicate how often you have remembered the event/situation.

If you have any problems or questions while you are recording your involuntary autobiographical memories please contact me.

Diary of Involuntary Autobiographical Memories

Anonymity code:____________________

Acknowledge Memories that you were unable to record

DAY	UNABLE TO RECORD MEMORY
DAY 1	
DAY 2	
DAY 3	
DAY 4	
DAY 5	
DAY 6	
DAY 7	

Instructions for Keeping a Paper Diary

During the one week of the study you will have to keep a diary of involuntary autobiographical memories. There is one diary booklet for recording your involuntary autobiographical memories for the one-week period. You are asked to record all of your involuntary memories each day during the week. In the diary booklet there are 32 pages (one page for each memory). However, we don't expect a minimum or maximum number of memory recordings. You may have very few or quite many. If for several days you do not experience any memories at all that's fine, too. The most important thing is that you do record only genuinely involuntary memories. In other words you should not try to consciously force them to occur even when you have not recorded any memories for several days. If you find that you are running out of diary pages (that is, you experience more than 32 memories), please contact me and I will send you extra pages.

Please remember that it is essential that you carry the diary booklet with you all the time, so that you are able to record each memory immediately after it occurs. However, it is obvious that this may not be feasible on every occasion, for example, you will not be able to record the memory while you are driving or in the middle of the meeting. In such cases, record the memory at the earliest opportunity after its occurrence. If by the time you can record the memory you have already forgotten some essential details then you do not need to record it in the diary by filling in the questions. Instead, you will need to put a TICK on the first page of the diary.

For each involuntary autobiographical memory that will pop into your mind, you will have to answer 11 questions presented on each page of the diary. Some are structured (you should tick the appropriate response). Others are open (you describe something with your own words). I will now explain each question (please refer to one of the entries when reading the following instructions):

- Write down the time and date that the memory came to mind and when you recorded the memory.

- Describe your memory

Below are three examples given during a previous study:

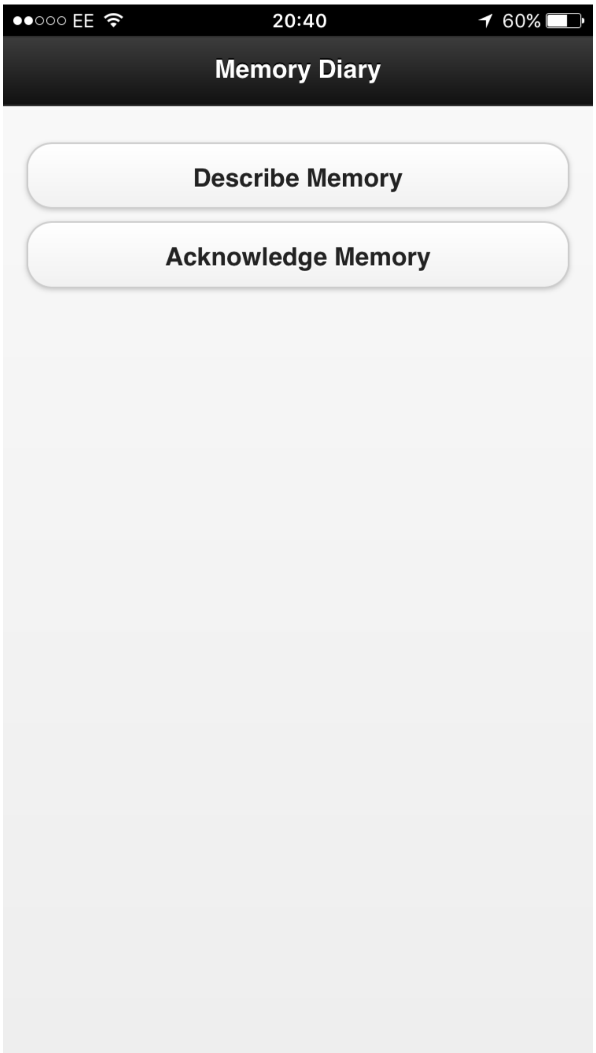
"The memory was about my car accident in December 03. I was remembering what actually happened." Triggered by "a letter from the insurance company."

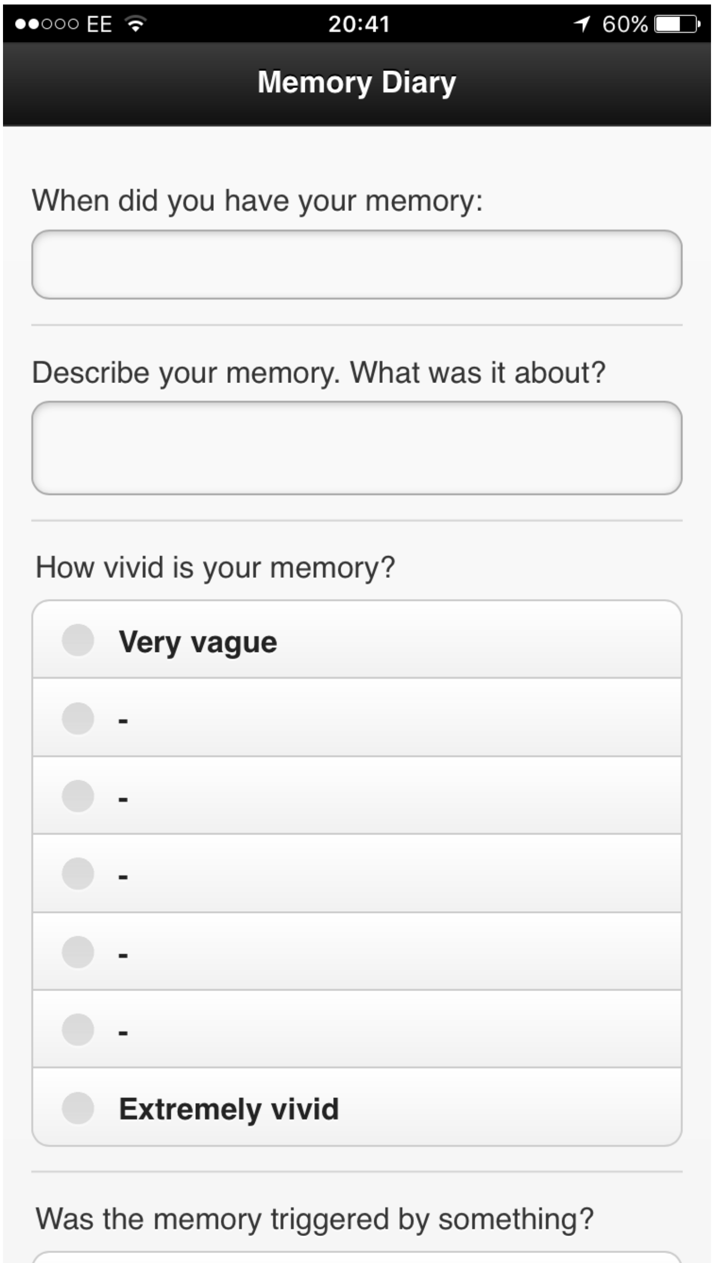
"I remember the 1st time I said I love you to my boyfriend. It was over a text message and he called me after to ask if I meant it. At the time I was pacing back and forth throughout my living room." There was no trigger.

"I was remembering my Granddad wearing his usual jumper with a particular type of button – I always used to associate them with him – he was sitting in his chair, but I also remembered him doing other things wearing the same style tops'. Triggered by, "my lecturer wearing a top with similar buttons"

Indicate how vivid this memory was, where very vague indicates the memory is blurry, or with hardly any image, and extremely vivid indicates the memory is almost like normal vision.

Appendix E: Smartphone Diary Screenshots


EE
20:40
60%
Memory Diary
Describe Memory
Acknowledge Memory


●●○○○ EE 20:41 60%

Memory Diary

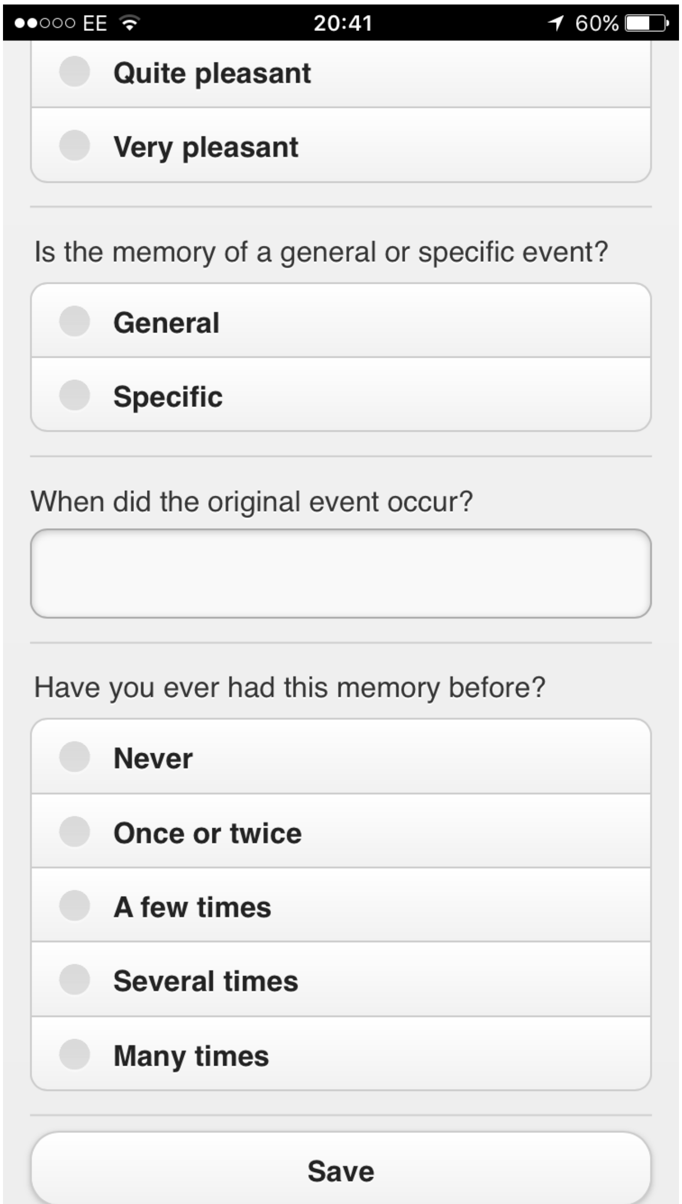
When did you have your memory:

Describe your memory. What was it about?

How vivid is your memory?

- **Very vague**
- **-**
- **-**
- **-**
- **-**
- **-**
- **Extremely vivid**

Was the memory triggered by something?


EE
20:41
60%
Quite pleasant
Very pleasant
Is the memory of a general or specific event?
General
Specific
When did the original event occur?
Have you ever had this memory before?
Never
Once or twice
A few times
Several times
Many times
Save

Appendix F: Instructions for IAM Smartphone Diary

Instructions for using a Diary App

During the one week of the study you will have to keep a diary of involuntary autobiographical memories. A Diary App will be installed on your smartphone. You are asked to record all of your involuntary memories each day during the week. When you experience a spontaneous autobiographical memory, open the Diary App on your phone and choose the “Describe Memory” option to start recording. We don’t expect a minimum or maximum number of memory recordings. You may have very few or quite many. If for several days you do not experience any memories at all that's fine, too. The most important thing is that you do record only genuinely involuntary memories. In other words, you should not try to consciously force them to occur even when you have not recorded any memories for several days.

Please remember that it is essential that you carry your mobile phone with you all the time, so that you are able to record each memory immediately after it occurs. However, it is obvious that this may not be feasible on every occasion, for example, you will not be able to record the memory while you are driving or in the middle of the meeting. In such cases, record the memory at the earliest opportunity after its occurrence. If by the time you can record the memory you have already forgotten some essential details then you do not need to record it in the diary by filling in the questions. Instead, on the starting page of the App choose the “Acknowledge Memory” option.

For each involuntary autobiographical memory that will pop into your mind, you will have to answer 11 questions. Some are structured (you should tick the appropriate response). Others are open (you describe something with your own words). I will now explain each question (please refer to one of the entries when reading the following instructions):

Record the time that the memory came to mind.

Describe your memory
Below are three examples given during a previous study:

(a) “The memory was about my car accident in December 03. I was remembering what actually happened.” Triggered by “a letter from the insurance company.”

(b) “I remember the 1st time I said I love you to my boyfriend. It was over a text message and he called me after to ask if I meant it. At the time I was pacing back and forth throughout my living room.” There was no trigger

(c) “I was remembering my Granddad wearing his usual jumper with a particular type of button – I always used to associate them with him – he was sitting in his chair, but I also remembered him doing other things wearing the same style tops’. Triggered by, “my lecturer wearing a top with similar buttons”

Indicate how vivid this memory was, where very vague indicates the memory is blurry, or with hardly any image, and extremely vivid indicates the memory is almost like normal vision.

Indicate if there was something that triggered the memory. This might be something in your thoughts or something in your environment. For example, remembering about "my car accident in December 03" was triggered by "a letter from the insurance company.", and memory about granddad was triggered by "my lecturer wearing a top with similar buttons." Memories can be triggered by just about anything or sometimes by nothing at all.

If there was a trigger, describe what it was that triggered your memory.

Please try to estimate the time between the trigger and your memory occurring.

Explain what were you doing when the memory came to mind - what activity were you engaged in? For example, having a breakfast, typing an email, watching a TV show, talking to your friend, thinking something etc.

Indicate by placing a tick on the scale, how much you were concentrating on the activity you were engaged in. Not concentrating means that, in your thoughts, you were probably "miles away" from what you were actually doing. For example, you could be washing up dishes and thinking about upcoming holiday. In contrast, if you were concentrating on the activity this would mean that you were not thinking about anything else (e.g., being engaged in a conversation and following it closely without having any irrelevant thoughts).

Evaluate how pleasant or unpleasant your memory is now. Is it positive and pleasant to remember or is it negative and unpleasant to remember?

Evaluate how pleasant or unpleasant the original event was at the time you experienced it, i.e., was the event that you remembered positive and pleasant or negative and unpleasant at the time you experienced it in your life.

Indicate whether the memory is of a general or specific event/experience. A general event may refer to an extended event (e.g., a trip to Paris) or a single event that occurred repeatedly over an extended period (e.g., travelling on the tube every morning when working in the City; going to seaside every summer during your childhood). A specific event refers to a single episode in your life (e.g., the day you move into your new house or the day a family member was born).

Estimate when the original event occurred. Please provide as accurate date as possible (for example, yesterday, 3 months ago, 10 years ago, 10 October 2007 if it is a special date like a birthday etc.)

Indicate whether you have you had this memory before. It does not matter if memory has come to mind involuntarily before, or that you have deliberately recalled the memory before - as long as you indicate how often you have remembered the event/situation.

If you have any problems or questions while you are recording your involuntary autobiographical memories please contact me.

Appendix G: EMF Diary Page

When did you have a memory error? Date: _______ Time: _______ AM/PM
Or when did you realise you made an error?

When did you record it here? Date: _______ Time: _______ AM/PM

Describe your memory error (what, when, where):

What was your mood immediately before the error? (tick)

☐	☐	☐	☐	☐	☐
Very unhappy		Neutral		Very happy	Don't Know

How relaxed or stressed were you immediately before the error? (tick)

☐	☐	☐	☐	☐	☐
Very relaxed		Neutral		Very stressed	Don't Know

How serious was the memory lapse? (tick)

☐	☐	☐	☐	☐
Insignificant	Minor	Somewhat significant	Significant	Very significant / potentially dangerous

Are there or will there be any consequences?

How upset are you by the memory lapse?

☐	☐	☐	☐	☐
Not at all upset	A little	Somewhat	Quite	Very upset

Describe the emotions you felt in response to your lapse, if any:

If you later recovered from this error, describe when and how:

When did you have a memory error? Date: _______ Time: _______ AM/PM
Or when did you realise you made an error?

When did you record it here? Date: _______ Time: _______ AM/PM

Describe your memory error (what, when, where):

What was your mood immediately before the error? (tick)

☐	☐	☐	☐	☐	☐
Very unhappy		Neutral		Very happy	Don't Know

How relaxed or stressed were you immediately before the error? (tick)

☐	☐	☐	☐	☐	☐
Very relaxed		Neutral		Very stressed	Don't Know

How serious was the memory lapse? (tick)

☐	☐	☐	☐	☐
Insignificant	Minor	Somewhat significant	Significant	Very significant / potentially dangerous

Are there or will there be any consequences?

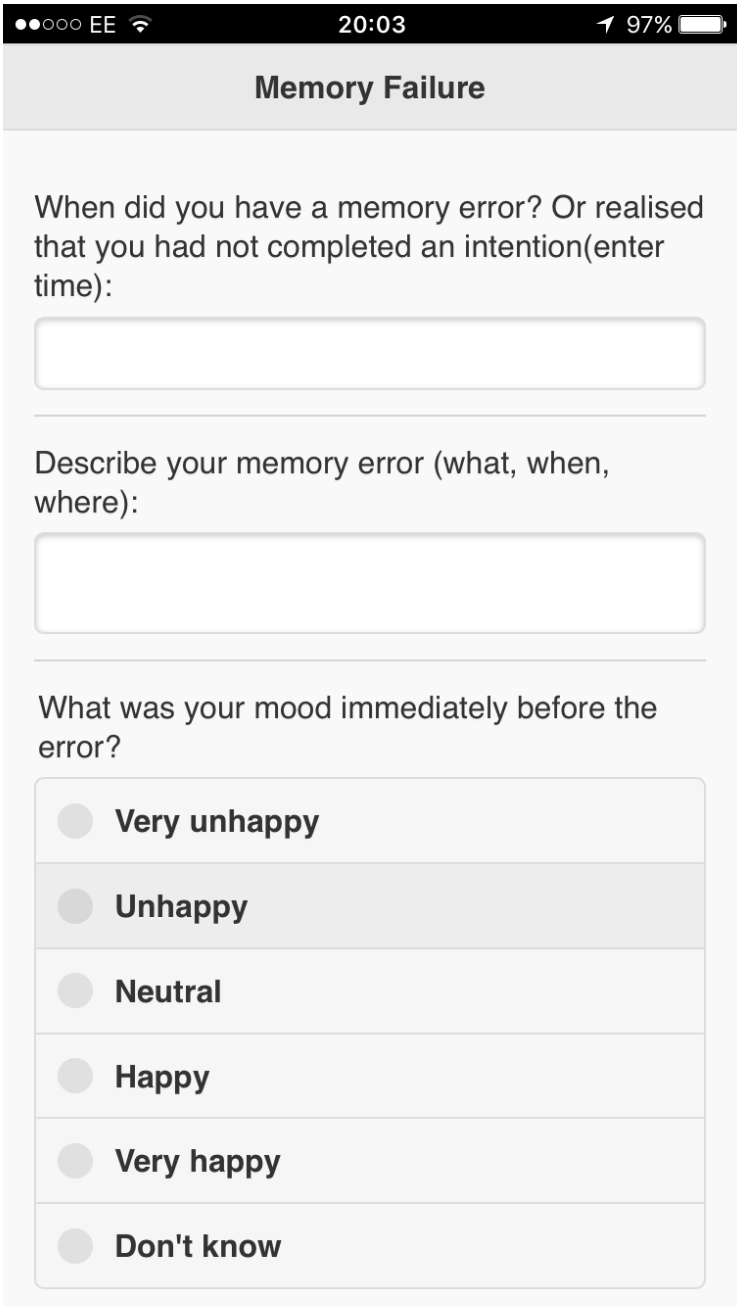
How upset are you by the memory lapse?

☐	☐	☐	☐	☐
Not at all upset	A little	Somewhat	Quite	Very upset

Describe the emotions you felt in response to your lapse, if any:

If you later recovered from this error, describe when and how:

Appendix H: EMF Smartphone Diary Screenshots


●●○○○ EE 20:03 97%

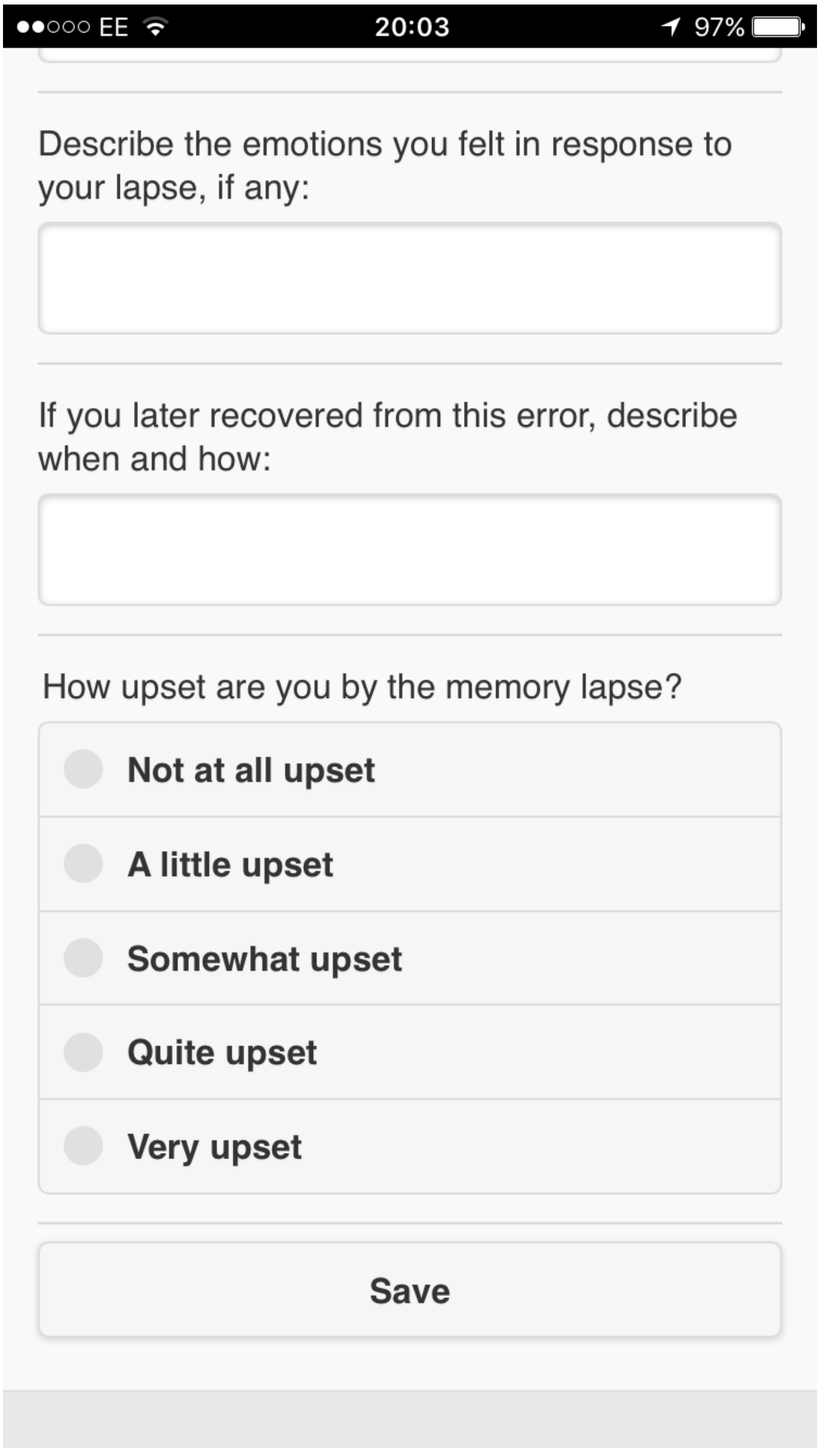
Memory Failure

When did you have a memory error? Or realised that you had not completed an intention(enter time):

Describe your memory error (what, when, where):

What was your mood immediately before the error?

- **Very unhappy**
- **Unhappy**
- **Neutral**
- **Happy**
- **Very happy**
- **Don't know**


●●○○○ EE 20:03 97%

Describe the emotions you felt in response to your lapse, if any:

If you later recovered from this error, describe when and how:

How upset are you by the memory lapse?

- Not at all upset
- A little upset
- Somewhat upset
- Quite upset
- Very upset

Save

Appendix I: EMF Diary Debrief Questionnaire

Everyday Memory Failures – Post Study Face-to-face Debrief

Participant code:		**Date of debrief:**		**Time:**	

I would like to ask you some questions that relate to your experiences of keeping a diary of everyday memory errors for 7 days. The purpose of this questionnaire is to find out whether the use of a diary method worked well or not and if you felt this was a useful or interesting experience.
There are no right or wrong answers so please answer honestly.

Did you keep your diary with you every day of the study? Yes No

If no, on how many days did you not have the diary? Please be as specific as possible.

If you did not keep your diary with you all the time, were there reasons for this and if so please tell me what the reason was/were? Did you forget? Was it not convenient? Did you choose not to for a reason? e.g. Social event, or it was inappropriate (funeral, working, felt awkward)

What percentage of *everyday memory errors* do you think you recorded and acknowledged (<u>on the days when you had the diary with you all the time</u>)?

Do you think a daily reminder (e.g. text message) that you were on a diary study would have helped?

How difficult did you find keeping your diary with you at all times? (scale 1-5)

1 Not difficult	**2 A little**	**3 Medium**	**4 Quite**	**5 Very Difficult**

How difficult did you find recording your everyday memory errors using the diary? (scale 1-5):

1 Not difficult	2 A little	3 Medium	4 Quite	5 Very Difficult

If you found it difficult, what made it difficult for you?

Did filling in the diary have any effect?

Do you feel reassured about your memory having taken part in the study?

1 Much Worse about memory	2 A little worse	3 No different	4 A little better	5 Much better about my memory

Do you feel that keeping the diary had any effect on your mood?

1 Much worse about mood	2 A little worse	3 No different	4 A little better	5 Much better about mood

Were the questions clear? If not which caused problems?

Were you clear on what types of thing to include/exclude?

Do you think there were times of day or days of the week where you made more errors?

Any other comments?

Appendix J: Telephone Interview for Cognitive Status (TICS-M)

Date of Test:
Startime:
End time (including COGTEL):

APPENDIX

Telephone Interview for Cognitive Status (TICS-M)

		Score '1' for each correct answer and '0' if incorrect	
Orientation			
1. (i) What day of the week is it?	Day	☐	
(ii) What is today's date?	Date	☐	
	Month	☐	
	Year	☐	
(iii) What season are we in?	Season	☐	
2. What is your age?	Age:	☐	
3. What is your telephone number? (Code + number)		☐	
Registration/Free Recall			
4. I'm going to read you a list of 10 words. Please listen carefully and try to remember them. When I am done, tell me as many as you can in any order. Ready?	Cabin	☐	
	Pipe	☐	
	Elephant	☐	
	Chest	☐	
	Silk	☐	
Now, tell me all the words you can remember	Theatre	☐	
	Watch	☐	
	Whip	☐	
	Pillow	☐	
	Giant	☐	
Attention/Calculation			
5. Please take 7 away from 100. Now continue to take 7 away from what you have left over until I ask you to stop.	93	☐	Use stop-watch. Record time from 93-65:
	86	☐	
	79	☐	
	72	☐	
	65	☐	
6. Please count backwards from 20 to 1	No mistakes	☐	
Comprehension, Semantic and Recent Memory			
7. What do people usually use to cut paper?	Scissors	☐	
8. What is the prickly green plant found in the desert?	Cactus	☐	
9. Who is the reigning monarch now?	E, QE, QE2	☐	
10. Who is the Prime Minister now?	Correct surname	☐	
11. What is the opposite of east?	West	☐	
Language/Repetition			
12. Please say this 'Methodist Episcopal'	Exactly right	☐	
Delayed Recall			
13. Please repeat the list of 10 words I read earlier	Cabin	☐	
	Pipe	☐	
	Elephant	☐	
	Chest	☐	
	Silk	☐	
	Theatre	☐	
	Watch	☐	
	Whip	☐	
	Pillow	☐	
	Giant	☐	
		☐ maximum of 39	

Appendix K: The Cognitive Telephone Screening Instrument

Cognitive Telephone Screening Instrument (COGTEL) VERSION A

1. Prospective Memory

At a later point in time during this test there will be a task in which you should name jobs or professions. Thus, when I later say Please try to name as many jobs and professions as possible during 1 minute, *please unsolicitedly tell me your year of birth. Do you have any questions about this task?* *Read twice Y/N*

2. Verbal Short-Term Memory

Now I will read a couple of word pairs to you. After that, I will name the first word and you should recall the associated second word. Let's suppose I say east–west *and* gold–walk, *then when I later say east you should say* west. *And when I say* gold, *you should respond* walk.

metal–iron
baby–cry
hustle–dark
school–baker
rose–flower
obey–yard
fruit–apple
salad–pen

Which word was associated with . . .?

	Answer	Wrong/don't remember/right
fruit		
obey		
rose		
baby		
salad		
metal		
school		
hustle		

Later, I will ask for these word-pairs once again, so don't forget them.

3. Working Memory

Now I will read a couple of digits to you. When I have finished, you should repeat these digits in reverse order. For instance, when I say 2–8, *then you should say (let the participant give the answer).* Read twice Y/N?

(If the participant does not say *8–2*): *No, I said 2–8, so you should say 8–2. Please try to repeat the following digits in reverse order: 3–6.*

	Right or wrong?		Right or wrong?
5–1		3–8	
4 –9 –3		5–2–6	
3–8–1–4		1–6–9–5	
6–2–9–5–2		4–8–5–2–6	
9–1–5–2–8–6		8–3–1–9–6–4	
4–5–3–9–1–2–8		8–1–2–9–3–6–5	

4. Verbal Fluency (Executive Functioning)

Now please try to name as many words as possible that begin with the letter A *during 1 minute. You should not repeat any words and you should not say any names, for instance,* Anna *is not valid.* Read twice Y/N? [STOP WATCH needed]

Number of named words:	
Number of proper names:	
Number of repeated words:	

Now please try to name as many professions as possible during 1 minute. You should not repeat any words and you should not name any words in an altered form. For instance, if you had said physician*, then the word* physicians *is not valid.*

Participant named his/her year of birth:	
Number of names:	
Number of repeated words:	

5. Inductive Reasoning

Now I will present you with sequences of numbers that are built up after a specific rule. Each sequence of numbers can be continued by applying this rule. Your task is to continue each sequence of numbers. In each case, I will present you with 5 numbers and you should add the sixth number. For instance, when I present you with the sequence 1–2–3–4–5, *then the rule would be +1 and you should add the number* 6. *Do you have any questions about this task?*

Read twice Y/N?

	Answer	Right or wrong?
3–6–9–12–15–	___ (18)	
2–5–8–11–14–	___ (17)	
63–91–65–94–67–	___ (97)	
25–13–27–16–29–	___ (19)	
10–2–11–4–12–	___ (6)	
2–4–7–11–16–	___ (22)	
8–10–13–17–22–	___ (28)	
21–20–18–15–11–	___ (6)	

6. Verbal Long-Term Memory

A short while ago, I read some word pairs to you. Now, I will again name the first words of each word pair and you should try to recall which words were associated with the words I name.

Which word was associated with . . .?

Word	Answer	Correct Answer	Wrong/Don't remember/Right
salad		(pen)	
baby		(cry)	
metal		(iron)	
school		(baker)	
rose		(flower)	
hustle		(dark)	
fruit		(apple)	
obey		(yard)	

Appendix L: Cognitive Failures Questionnaire (CFQ)

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know how often these things have happened to you in the last six months. Please circle the appropriate number.

	Very Often	Quite Often	Occasion - ally	Very Rarely	Never
1. Do you read something and find you haven't been thinking about it and must read it again?	4	3	2	1	0
2. Do you find you forget why you went from one part of the house to the other?	4	3	2	1	0
3. Do you fail to notice the signposts on the road?	4	3	2	1	0
4. Do you find you confuse right and left when giving directions?	4	3	2	1	0
5. Do you bump into people?	4	3	2	1	0
6. Do you find you forget whether you've turned off a light or a fire or locked the door?	4	3	2	1	0
7. Do you fail to listen to people's names when you are meeting them?	4	3	2	1	0
8. Do you say something and realise afterwards that it might be taken as insulting?	4	3	2	1	0
9. Do you fail to hear people speaking to you when you are doing something else?	4	3	2	1	0
10. Do you lose your temper and regret it?	4	3	2	1	0
11. Do you leave important letters unanswered for days?	4	3	2	1	0
12. Do you find you forget which way to turn on a road you know well but rarely use?	4	3	2	1	0
13. Do you fail to see what you want in a supermarket (although it's there)?	4	3	2	1	0
14. Do you find yourself suddenly wondering whether you've used a word correctly?	4	3	2	1	0
15. Do you have trouble making up your mind?	4	3	2	1	0
16. Do you find you forget appointments?	4	3	2	1	0
17. Do you forget where you put something like a newspaper or a book?	4	3	2	1	0

	Very Often	Quite Often	Occasion - ally	Very Rarely	Never
18. Do you find you accidentally throw away the thing you want and keep what you meant to throw away - as in the example of throwing away the matchbox and putting the used match in your pocket?	4	3	2	1	0
19. Do you daydream when you ought to be listening to something?	4	3	2	1	0
20. Do you find you forget people's names?	4	3	2	1	0
21. Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	4	3	2	1	0
22. Do you find you can't quite remember something although it's 'on the tip of your tongue'?	4	3	2	1	0
23. Do you find you forget what you came to the shops to buy?	4	3	2	1	0
24. Do you drop things?	4	3	2	1	0
25. Do you find you can't think of anything to say?	4	3	2	1	0

Appendix M: Memory Functioning Questionnaire (MFQ)

This is a questionnaire about how you remember information. There are no right or wrong answers.

Circle a number between 1 and 7 that best reflects your judgment about your memory. Think carefully about your responses, and try to be as realistic as possible when you make them. Please answer all questions.

How well you remember things that occurred…

	Very bad		Fair			Very good	
last month is:	1	2	3	4	5	6	7
between 6 months and 1 year ago is:	1	2	3	4	5	6	7
between 1 and 5 years ago is:	1	2	3	4	5	6	7
between 6 and 10 years ago is:	1	2	3	4	5	6	7

Seriousness of Forgetting
When you actually forget in these situations, how serious of a problem do you consider the failure to be?...

	Very serious		Somewhat serious			Not serious	
Names	1	2	3	4	5	6	7
Faces	1	2	3	4	5	6	7
Appointments	1	2	3	4	5	6	7
Where you put things (e.g. keys)	1	2	3	4	5	6	7
Performing household chores	1	2	3	4	5	6	7
Directions to places	1	2	3	4	5	6	7
Phone numbers you've just checked	1	2	3	4	5	6	7
Phone numbers used frequently	1	2	3	4	5	6	7
Things people tell you	1	2	3	4	5	6	7
Keeping up correspondence	1	2	3	4	5	6	7
Personal dates (e.g. birthdays)	1	2	3	4	5	6	7
Words	1	2	3	4	5	6	7
Going to the shops and forgetting what you wanted to buy	1	2	3	4	5	6	7
Taking a test/exam	1	2	3	4	5	6	7
Beginning to do something and forgetting what you were doing	1	2	3	4	5	6	7
Losing the thread of thought in conversation	1	2	3	4	5	6	7
Losing the thread of thought in public speaking	1	2	3	4	5	6	7
Knowing whether you've already told someone something	1	2	3	4	5	6	7

Retrospective Functioning

How is your memory compared to the way it was . . .

	Much worse		Same			Much better	
1 year ago?	1	2	3	4	5	6	7
5 years ago?	1	2	3	4	5	6	7
10 years ago?	1	2	3	4	5	6	7
20 years ago?	1	2	3	4	5	6	7
When you were 18?	1	2	3	4	5	6	7

Mnemonics Usage

How often do you use these techniques to remind yourself about things?

	Always		Sometimes			Never	
Keep an appointment book	1	2	3	4	5	6	7
Write yourself reminder notes	1	2	3	4	5	6	7
Make lists of things to do	1	2	3	4	5	6	7
Make grocery lists	1	2	3	4	5	6	7
Plan your daily schedule in advance	1	2	3	4	5	6	7
Mental repetition	1	2	3	4	5	6	7
Associations with other things	1	2	3	4	5	6	7
Keep things you need to do in a prominent place where you will notice them	1	2	3	4	5	6	7

Appendix N: Everyday Memory Questionnaire (EMQ)

Everyday Memory Questionnaire (EMQ)

For each question, please put a tick in the column that is most appropriate:

A. Speech

	Several times a day	About once each day	Once or twice a week	Once or twice a month	Once or twice a year	Never
1. Forgetting the names of friends or relatives or calling them by the wrong names.						
2. Forgetting the names of common things or using the wrong names.						
3. Finding that a word is "on the tip of your tongue". You know what it is but can't quite find it.						
4. Forgetting something you were told a few minutes ago. Perhaps something your wife/husband or friend has just said.						
5. Forgetting something you were told yesterday or a few days ago.						
6. Repeating something you have just said or asking the same questions several times.						
7. Forgetting what you have just said. Maybe saying "What was I talking about?".						
8. Losing track of what someone is trying to tell you. Unable to follow the thread of their conversation.						
9. Starting to say something then forgetting what it was that you want to speak about.						

	Several times a day	About once each day	Once or twice a week	Once or twice a month	Once or twice a year	Never
10. Letting yourself ramble on to speak about unimportant or irrelevant things.						
11. Forgetting to tell someone something important. Perhaps forgetting to pass on a message or remind someone of something.						
12. Getting the details of what someone has told you mixed up and confused.						
13. Repeating a story or joke you have already told.						

B. Reading and Writing

	Several times a day	About once each day	Once or twice a week	Once or twice a month	Once or twice a year	Never
14. Forgetting the meaning of unusual words.						
15. Forgetting what the sentence you have just read was about and having to re-read it.						
16. Unable to follow the thread of a story. Lose track of what it is about.						
17. Forgetting how to spell words.						

C. Faces and Places

	Several times a day	About once each day	Once or twice a week	Once or twice a month	Once or twice a year	Never
18. Forgetting where you put something. Losing things around the house.						
19. Failing to recognise friends or relatives by sight.						
20. Failing to recognise television characters or other famous people by sight.						
21. Getting lost or turning in the wrong direction on a journey or walk you have often been on.						
22. Failing to recognise places you're told you have often been to before.						
23. Finding television stories difficult to follow.						

D. Actions

	Several times a day	About once each day	Once or twice a week	Once or twice a month	Once or twice a year	Never
24. Forgetting to do some routine thing that you would normally do once or twice in a day.						
25. Discovering that you have done some routine thing twice by mistake.						
26. Having to go round checking whether you have done everything meant to do.						
27. Forgetting what you did yesterday for getting the details of what happened mixed up and confused.						
28. Starting to do something, then forgetting what it was you want to do. Maybe saying "What am I doing?".						
29. Being absent-minded. Doing something that you didn't really intend to do.						

E. Learning New Things

	On every occasion	On every other occasion	Only sometimes	Rarely	Never
30. Unable to remember the name of someone met for the first time recently.					
31. Failing to recognise someone you met for the first time recently.					
32. Getting lost on a journey or walk that you've only been on once or twice before.					

33. Unable to pick up a new skill such as a game or working some new gadget after you have practised once or twice.					
34. Unable to cope with a change in your daily routine. Following your old routine by mistake.					
35. Forgetting to keep an appointment.					

Appendix O: Prospective and Retrospective Memory Questionnaire (PRMQ)

Memory Questionnaire (PRMQ)

In order to understand why people make memory mistakes, we need to find out about the kinds of mistakes people make, and how often they are made in normal everyday life. We would like you to tell us how often these kind of things happen to you. Please indicate by ticking the appropriate box.

Please make sure you answer all the questions even if they don't seem entirely applicable to your situation. Please answer all the questions as accurately as possible.

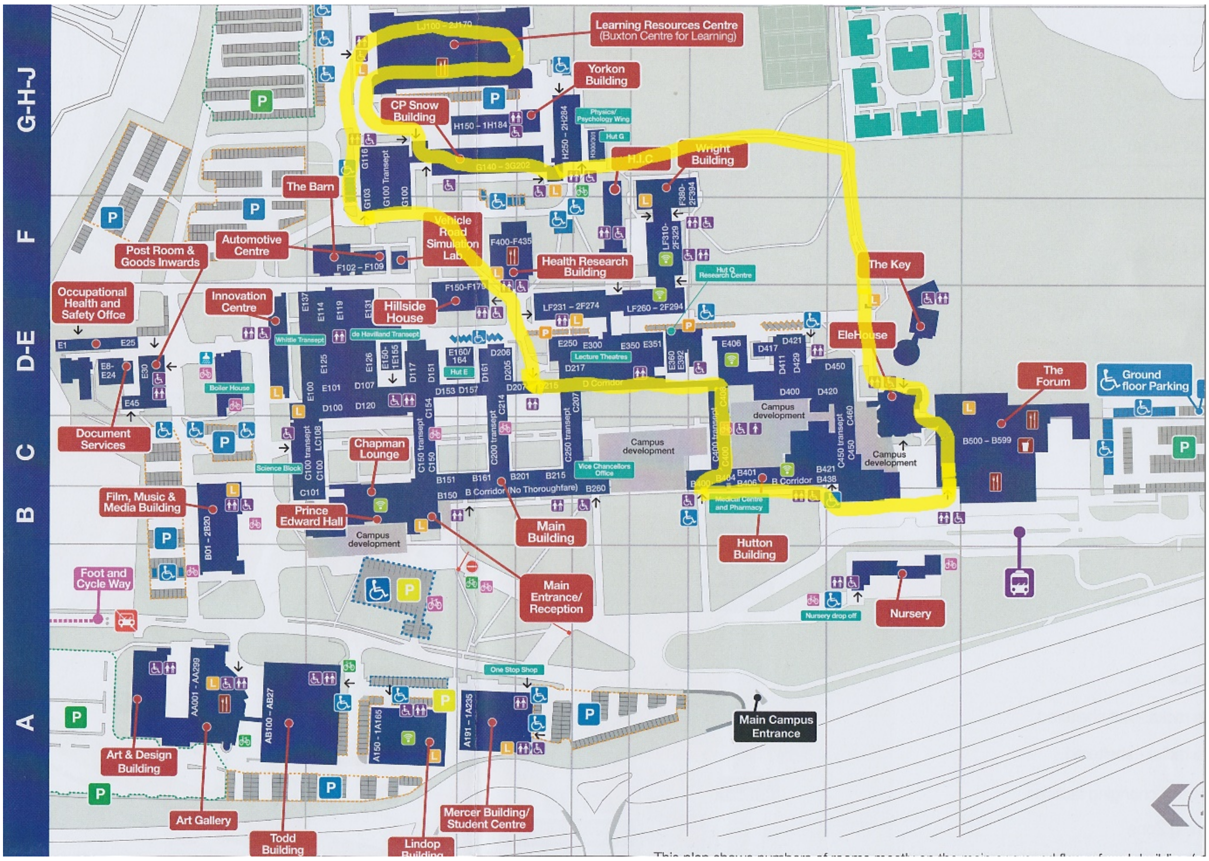
	Often	Quite Often	Sometimes	Rarely	Never
1. Do you decide to do something in a few minutes' time and then forget to do it?	☐	☐	☐	☐	☐
2. Do you fail to recognise a place you have visited before?	☐	☐	☐	☐	☐
3. Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?	☐	☐	☐	☐	☐
4. Do you forget something that you were told a few minutes before?	☐	☐	☐	☐	☐
5. Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	☐	☐	☐	☐	☐
6. Do you fail to recognise a character in a radio or television show from scene to scene?	☐	☐	☐	☐	☐
7. Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?	☐	☐	☐	☐	☐
8. Do you fail to recall things that have happened to you in the last few days?	☐	☐	☐	☐	☐
9. Do you repeat the same story to the same person on different occasions?	☐	☐	☐	☐	☐
10. Do you intend to take something with you, before leaving a room or going out, but	☐	☐	☐	☐	☐

minutes later leave it behind, even though it's there in front of you?					
11. Do you mislay something that you have just put down, like a magazine or glasses?	☐	☐	☐	☐	☐

	Often	**Quite Often**	**Sometimes**	**Rarely**	**Never**
12. Do you fail to mention or give something to a visitor that you were asked to pass on?	☐	☐	☐	☐	☐
13. Do you look at something without realising you have seen it moments before?	☐	☐	☐	☐	☐
14. If you tried to contact a friend or relative who was out, would you forget to try again later?	☐	☐	☐	☐	☐
15. Do you forget what you watched on television the previous day?	☐	☐	☐	☐	☐
16. Do you forget to tell someone something you had meant to mention a few minutes ago?	☐	☐	☐	☐	☐

Appendix P: Campus Walk Route Map

University of Hertfordshire College Lane Campus



Appendix Q: Marlowe Crowne Social Desirability Scale (MCSD)

Marlowe Crowne Scale

Listed below are a number of statements concerning personal attitudes and traits. Read each item and decide whether the statement is true of false as it pertains to you personally

		True	*False*
1	Before voting I thoroughly investigate the qualifications of all the candidates.	T	F
2	l never hesitate to go out of my way to help someone in trouble.	T	F
3	It is sometimes hard for me to go on with my work if I am not encouraged.	T	F
4	I have never intensely disliked someone.	T	F
5	On occasion I have had doubts about my ability to succeed in life.	T	F
6	I sometimes feel resentful when I don't get my way.	T	F
7	I am always careful about my manner of dress.	T	F
8	My table manners at home are as good as when I eat out in a restaurant.	T	F
9	If I could get into a movie without paying and be sure I was not seen I would probably do it.	T	F
10	On a few occasions, I have given up doing something because thought too little of my ability.	T	F
11	I like to gossip at times.	T	F
12	There have been times when I felt like rebelling against people in authority even though I knew they were right.	T	F
13	No matter who I'm talking to, I'm always a good listener.	T	F
14	I can remember 'playing sick' to get out of something.	T	F
15	There have been occasions when I took advantage of someone.	T	F
16	I'm always willing to admit it when I make a mistake.	T	F
17	I always try to practise what I preach.	T	F
18	I don't find it particularly difficult to get along with loud-mouthed, obnoxious people.	T	F
19	I sometimes try to get even rather than forgive and forget.	T	F
20	When I don’t know something I don't at all mind admitting it.	T	F
21	I am always courteous, even to people who are disagreeable.	T	F
22	At times I have really insisted on having things my own way.	T	F
23	There have been occasions when I felt like smashing things.	T	F
24	I would never think of letting someone else be punished for my wrong-doing.	T	F
25	I never resent being asked to return a favour.	T	F
26	I have never been irked when people expressed ideas very different from my ow	T	F
27	I never make a long trip without checking the safety of my car.	T	F
28	There have been times when I was quite jealous of the good fortune of others.	T	F
29	I have almost never felt the urge to tell someone off.	T	F
30	I am sometimes irritated by people who ask favours of me.	T	F
31	I have never felt that I was punished without cause.	T	F
32	I sometimes think when people have a misfortune they only get what they deserve.	T	F
33	I have never deliberately said something that hurt someone's feelings.	T	F