Scenarios of Robot Assisted Play for Children with Cognitive and Physical Disabilities

Ben Robins[a*], Kerstin Dautenhahn[a], Ester Ferrari[a], Gernot Kronreif[b], Barbara Prazak-Aram[c], Patrizia Marti[d], Iolanda Iacono[d], Gert-jan Gelderblom[e], Bernd Tanja[e], Francesca Caprino[f], Elena Laudanna[f]

[a] Adaptive Systems Research Group, University of Hertfordshire, U.K.

[b] Austrian Center for Medical Innovation and Technology, Austria

[c] AIT Austrian Institute of Technology GmbH, Austria

[d] University of Sienna, Italy

[e] Zuyd University, Research Centre for Technology in Care, The Netherlands

[f] University of Valle d'Aosta, Italy

Abstract

This article presents a novel set of ten play scenarios for robot assisted play for children with special needs. This set of scenarios is one of the key outcomes of the IROMEC project that investigated how robotic toys can become social mediators, encouraging children with special needs to discover a range of play styles, from solitary to collaborative play (with peers, carers/teachers, parents etc). The target user groups in the project were children with Mild Mental Retardation[1], children with Severe Motor Impairment and children with Autism. The play scenarios were developed against specific educational and therapeutic objectives that were discussed with panels of experts (teachers therapists parents) in various countries, during several user panel meetings for each of the above mentioned target user groups. These objectives were

[1] The term Mental Retardation was replaced in the UK by the Disability Discrimination Act, with the term Learning Difficulties. However, as it is still being widely used in continental Europe, this was the term chosen to be used within the IROMEC project

classified with reference to the ICF-CY, the International Classification of Functioning – version for Children and Youth. The article presents a detailed description of the play scenarios, each with its relevant educational and therapeutic objectives in five key developmental areas (i.e sensory development, communication and interaction, cognitive development, motor development and social and emotional development). While the play scenarios described in this paper originally were developed for and tested with the above user groups and with the IROMEC robot, the play scenarios can potentially be applied to other user groups and to a wide range of other applications involving human-robot interaction using different robotic toys.

1 Introduction

The work presented in this article was developed as part of the FP6 European project IROMEC[2] that investigated how robotic toys can become social mediators (IROMEC, 2010). The project's state of the art research emphasised the important role of play in child development as a crucial vehicle for learning about the physical and social environment, the self and for developing social relationships. IROMEC targeted children who are prevented from playing, either due to cognitive, developmental or physical impairments which affect their playing skills, leading to general impairments in their learning potential and more specifically resulting in isolation from the social environment. The target user groups in the project were children with Mild Mental Retardation, children with Severe Motor Impairment and children with Autism.

The crucial role of play in a child's development has been widely accepted. The World Health Organisation in its ICF-CY (International Classification of Functioning and Disabilities, version for Children and Youth) publication considers play as one of the most important aspect of a child's life to be considered when assessing children's quality of life (WHO, 2001). During play children can learn about themselves and their environments as well as develop cognitive, social

[2] The work described in this article was conducted within the EU project IROMEC (Interactive Robotic Social Mediators as Companions) and was co-funded by the European Commission in the 6th Framework Program under contract IST-FP6-045356.

and perceptual skills (Ferland, 1977). The literature suggests that play is an essential activity during childhood, and that its absence provides an obstacle to the development of a healthy child possibly leading to general impairment in their learning potential and cognitive development and may result in isolation from the social environment (Bruner et al., 1972; Piaget, 1962; Vygotsky, 1978; Winnicott, 1971).

For children with special needs, play can be a difficult experience, as they might have limited access to this activity and may show subsequent problems in skill acquisition in various developmental areas. However, their cognitive and social development can be improved by giving them the same play opportunities as their typically-developed peers. In order to do so, it is important to provide them with the right stimuli for their developmental levels, strengths and needs. In that sense, robotic systems can be a valuable tool for children with special needs to learn through play interactions and can help them to reach the developmental steps of their chronological and/or mental ages (Besio., 2001).

The IROMEC project investigated how robotic toys could provide such opportunities for learning and enjoyment. The developed play scenarios and a newly designed robotic system[3] were tailored towards becoming a social mediator, empowering children with disabilities to discover the range of play styles from solitary to social and cooperative play (with peers, carers/teachers, parents etc).

In recent years there have been many examples of robots being used to involve children with special needs in play activities for therapeutic or educational purposes. Research shows that robots can provide a focus of attention (Werry et al., 2001) and promote spontaneous play in children with developmental disorders (Kozima et al., 2007). Remotely controlled robotic systems being used in rehabilitation (Lathan & Malley, 2001), artificial pets such as the baby seal Paro (Marti et al., 2005) the teddy bear Huggable (Stiehl et al., 2005), small, simple creature-like robots such as Keepon (Kozima et al., 2007) and the huggable creature-like Probo

[3] The robot developed within the IROMEC project is called the "IROMEC robot" in this article. We do not provide details of this robot in this publication since the scenarios developed for this robot, which are the focus on this work, are not restricted to the specific IROMEC robot. For details of the robot see Marti et al., (2009).

(Saldien et al., 2008), humanoid robots such as the robotic doll Robota (Robins et al., 2005; Robins et al., 2004a; Robins et al., 2004b), the humanoid structure on wheels Tito (Michaud et al., 2007) and the child-like KASPAR (Dautenhahn et al., 2009) have all been used to engage children in playful interactions and helped them in developing social skills.

The added value of the play scenarios presented in this article is that they have been developed in close consultation with several panels of experts (therapists, teachers, parents) to cover the play needs of children with a variety of disabilities (e.g. cognitive impairments, physical impairments, developmental impairments) taking the children's specific strengths and needs into consideration. The play scenarios were developed with specific therapeutic and educational objectives in five key developmental areas: sensory development, communication and interaction development, motor development, cognitive development and social and emotional development. The play scenarios presented in this paper are on the one hand specific enough to allow implementation by other researchers, but on the other hand are sufficiently generic to be adapted to different user groups and different robotic systems.

As stated above, the main aim of this article is to present the comprehensive and previously unpublished set of play scenarios in detail (see section 2). The remainder of this section briefly summarizes the developmental process that ultimately leads to the play scenarios. Full details of this process can be found in Ferrari et al. (2009); Robins et al. (2010b); Robins et al. (2007).

1.1 Target user groups and expert user panels

At the onset of the IROMEC project, different main user groups were considered (e.g. children with physical impairments such as Cerebral Palsy, Spina Bifida, Motor impairment, children with cognitive impairments such as Autistic Spectrum Disorders, children with cognitive disabilities such as mental retardation, Down syndrome, etc.). At the same time, several panels of experts made up by 45 professionals from different medical centres and special education schools, including teachers, medical doctors, therapists (e.g. psychotherapists, speech therapists, play therapists, physiotherapists, occupational therapists, neuro-psychologists), as well

as parents and family members, were organized by the project's partners in different European countries (i.e. Spain, Italy, The Netherlands, Austria, UK). These panels were related to different end-user groups (children with different disabilities; e.g. physical disabilities, cognitive disabilities, autism), and were set with the aim to inform and provide feedback at every stage of the project from eliciting the requirement of the various user groups, to developing play scenarios against specific therapeutic and educational objectives. As an example, the UK panel involved professionals from different schools, as well as parents and family members of children with autism. The panel consisted of 7 teachers from 3 different schools, 5 therapists (psychotherapist, speech therapist, play therapist, physiotherapist, occupational therapist) and two parents and family members. More details on the set-up and the role of all the user panels can be found in Gelderblom et al. (2007); Robins et al. (2007).

The discussion with the panel of experts showed high correlation in needs between some of the above target user groups and identified two main target groups: the physically impaired group of children and children with cognitive impairments. It was found that by focussing on these two main groups, many needs of other user groups can also be addressed. The final selection of user groups consisted of:

- AUT - children with autism
- MMR - children with mild mental retardation
- SMI - children with severe motor impairment

1.2 Scenarios design process

The development process of the play scenarios (see Figure 1) is based on a user-centred perspective. After the initial phase of an extended literature review related to existing technology used in play activities, the play scenarios have been developed based on information from the users panels regarding play activities, limitations, needs and the range of interactions that robotic devices can facilitate.

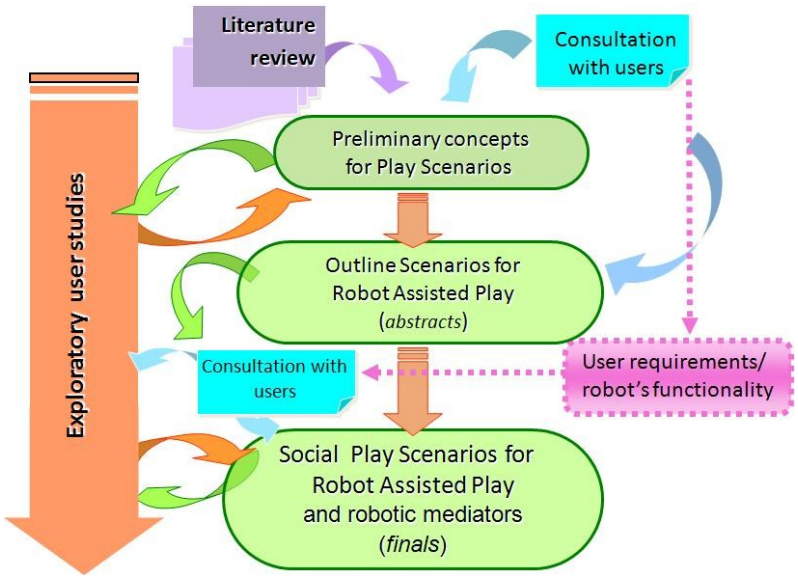

Figure 1. Developmental process of scenarios for robot assisted play, based on Robins et al. (2010)

The involvement of the users took place throughout the different stages of development of both the play scenarios and the robotic platform. From the very beginning, the panel of experts provided the understanding of children's needs from the various user groups, helping eliciting the requirements through regular feedback on ongoing design iterations and at the end of the project (verification and user validation).

The play scenarios were developed in three phases:

I) preliminary concept of play scenarios

II) outline scenarios (abstract)

III) social play scenarios (final)

Ongoing consultations with panels of experts (Ferrari et al., 2009; Robins et al., 2010b) have been conducted to collect information related to the play activities of children with special needs. They informed the design process about the children's likes, dislikes, abilities and needs, and the ways the experts envisage the use of robotic toys in therapy or education.

Given the nature of the children's impairments, children were not directly included in the user panels; instead, the involvement of the children occurred during *experimental investigations* where specific aspects of the scenarios were tested as part of phase I. Different aspects of the

user requirements, as expressed in these user panel meetings were subsequently implemented in experimental play scenarios that focussed on specific play activities and were investigated in field trials using existing available technology.

In Phase II the feedback from the above experimental investigations, in conjunction with the outcome of further consultation with the panel of expert users, were then merged to form the Outline Play Scenarios. These are abstract scenarios that reflect the user requirements and are *not* related to any specific technological solution/robot.

In phase III the Outline Play Scenarios were further developed in consultation with the panel of experts against specific therapeutic and educational objectives. Taking also into account results of ongoing experimental investigations of the different functionalities of the IROMEC robot that took place with the different target user groups, the final set of play scenarios was developed. These are the Social Play Scenarios for robot assisted play that are reported here. Further description of the various stages of the scenarios' design process including examples from the exploratory user studies can be found in Robins et al. (2010b).

The remainder of this article is structured as follows. The next section (2) represents the main novel contribution of this article, namely a detailed description of the final IROMEC play scenarios. Section 3 illustrates the use of some of these scenarios in an exploratory human-robot interaction study involving a small group of children with special needs. Conclusion and future work are discussed in section 4.

2 Social Play Scenarios for Robot Assisted Play and Robotic Mediators

Ten play scenarios for robot assisted play and robotic mediator were developed (see Figure 2), adopting the ESAR system (Garon et al., 1996) that identifies four different types of play[4]. These types of play help children to socialize by teaching them how to take turns, observe rules and respect the opinions and actions of fellow players. Moreover, they have a vital role in

[4] The four types of play are: exercise play, assembling play, symbolic play, and games with rules.

acquiring different types of knowledge and skills, and helping to develop basic interaction functions, memory, attention, communication functions, perceptual and motor skills.

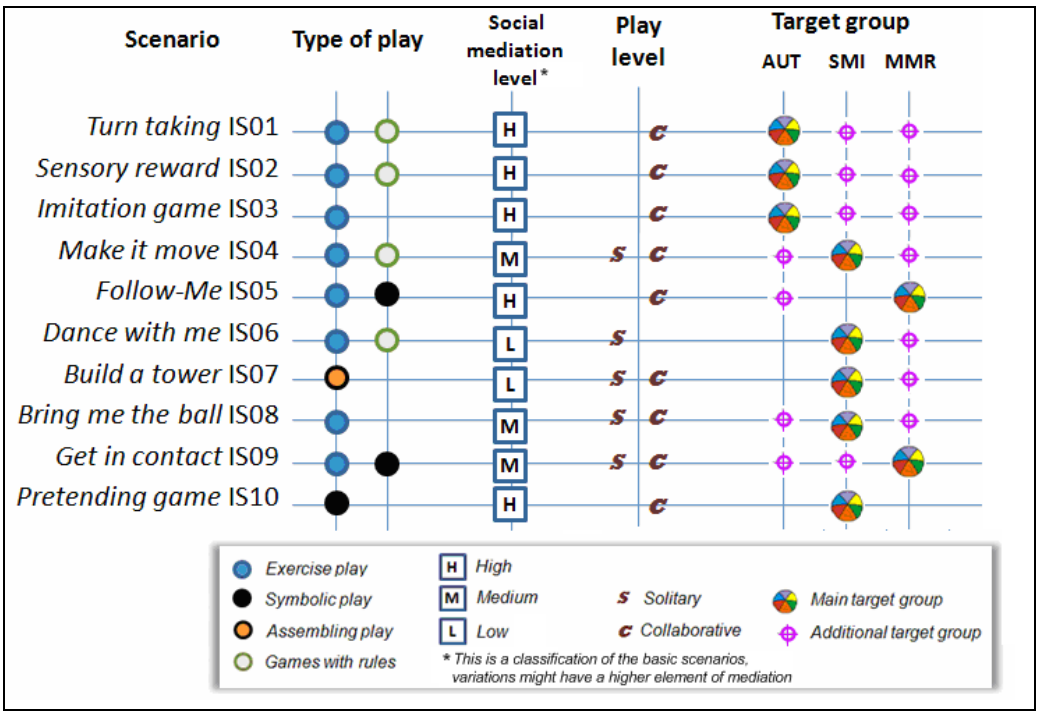

Figure 2 IROMEC Play Scenarios

Two different symbols (and) have been used in Figure 2. For each scenario they indicate the main target group ( ), and the additional target user groups, if any ( ). The main target group is the one for which a scenario has mainly been developed, while the additional ones are the target user groups that can still benefit from playing it. As mentioned above, it is thought that these play scenarios are not limited to the IROMEC's target user groups only (i.e. AUT, SMI and MMR) and could also benefit *other users* with special needs.

For each scenario, a comprehensive set of therapeutic and educational objectives has been drawn on, in close collaboration with therapists and teachers. These objectives have been

developed according to the ICF-CY classification (WHO, 2001).

2.1 IROMEC Play Scenarios

The IROMEC scenarios are higher level conceptualizations of the 'use of the robot in a particular context'. The scenarios have the form of textual narratives describing an activity in its context. Their structure has been adopted and modified from the scenario based design methodology (Carroll, 1995; Rosson & Carroll, 2002; Rozzo et al., 2003) and consists of the description of actors and their roles, the type of play, the description of the activity, the recursive model, the place and setting, the robot configuration, and the duration of the activity.

All the IROMEC play scenarios can be played in an educational, therapeutic, or home setting, where the second player can be an adult (e.g. teacher, therapist, family member, etc) or a child (with or without special needs). As a general note, in the scenarios where the robot is placed on a table, the robot's movement on the table is disabled for safety reasons.

The next sections detail the ten IROMEC play scenarios and their variations. Each play scenario is followed by a list of the identified therapeutic and educational objectives relevant to that specific scenario.

2.1.1 Scenario IS01 "Turn-taking with a mobile robot"

The IS01 play scenario is an exercise play with very simple rules. It consists of a collaborative turn-taking activity with a mobile robot. It has mainly been developed to be played by low functioning children with autism, but it can also be played by children with SMI and MMR. Four variations of the basic scenario have been developed.

BASIC SCENARIO
Main target user group: AUT

Additional target user groups: SMI, MMR

Play Type	Exercise play, very simple game with rules.
Actors	Two actors are involved in the game. These actors could be a child and an adult, or two children.
Activity	The game consists of a collaborative turn-taking activity with a mobile robot. The mobile robot has a start/stop activation mechanism that can be controlled by the user. Sitting on the floor at a distance from each other, the first player turns the robot to face the second player and presses the start button causing the robot to move toward the second player. When the robot reaches a predefined distance from the second player, it stops. The player then turns it around, presses the start button and sends it back towards the first player.
Setting	The game is played on the floor in a room with a large empty space.
Time	The game is made up of a short sequence of actions. The basic phase can repeat itself many times, thus the duration of the activity is unlimited and can take place as long as the participants are interested.
Robot configuration	A mobile robot with a start/stop user interface mechanism that also includes status and sensory displays (light, sounds, etc.).

VARIATIONS:

Variation 1 – Player positions

Target group	AUT - MMR – SMI
Activity	➢ *players positions* (depending on the ability of the child) During the activity the players change their position. For example: a) the player who is waiting for the robot can go to a different position in the room before giving the instruction to 'release' the robot, and the player with the robot needs to aim it at the new position of the other player; b) one of the players can choose/declare where s/he will direct the robot and ask/request the other player to move and change his/her position so the robot can reach him/her.
Setting	The game is played on the floor in a room with a large empty space that can allow the participants to go to different points in the room, or to run around and wait in anticipation for the robot to reach them.

Variation 2 – Game's rule

Target group	AUT - MMR – SMI
Activity	➢ *introduce a new rule* (depending on the ability of the child) The player with the robot has to wait for an instruction (e.g. "Go", clapping of the hands, etc) from the other player before 'releasing' the robot (the instruction signal is not aimed at the robot itself; it is aimed at the other player, telling him/her when to 'release' the robot).

Variation 3 – Group of players

Target group	AUT - MMR – SMI
Actors	➢ *number of players* Instead of two players, the activity can involve a group of children.
Activity	The player with the robot has to choose and aim the robot towards one of the other players.

Variation 4 – Two remote controls

Target group	SMI - MMR
Activity	The users are controlling the robot via remote control. Sitting on their wheelchairs at a distance from each other, the first player by using his/her remote control 'sends' the robot toward the second player. When the robot reaches the second player it stops. The second player then turns and 'sends' the robot (using his/her remote control) back towards the first player.
Additional Robot characteristics	➢ *Two remote controls to activate the robot (one for each player)* - Two buttons on each remote control: one to make the robot move and one to turn it in order to face the other player (there isn't a 'stop button' to stop the robot movement – it stops when reach the player) - Remote control functionality for robot (turn and start movements) - Remote controls toggle active/passive status - Light feedback: e.g. the button is illuminated when active - not illuminated when inactive. The robot reacts only if the player presses the button when it is active. Once a button has been pressed, it turns inactive and the button on the other remote control turns active.

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visual perception	⌖		
	• to improve visual spatial awareness	◔		◔
Communication and interaction	**Communicating – producing – nonverbal messages** • to improve non verbal aspects such as gestures and pointing	⌖		⌖
	Basic interpersonal interaction • to improve turn-taking	◔	◔	⌖
	• to foster taking initiative	◔	◔	⌖
	• to improve gaze shift and eye contact with others	⌖		⌖
	• to improve level of response to social cues	⌖		
	• to improve level of response to others	◔		⌖
	Particular interpersonal relationships • to establish a therapeutic alliance	⌖		⌖
	• to foster a therapeutic relationship	⌖		
	• to encourage participation with classmates	◔	⌖	⌖
Cognitive Dev.	**Global intellectual functions** • to improve understanding of cause and effect	◔	◔	⌖
	Higher-level cognitive functions • to improve organization and planning → **VARIATION 1**		⌖	⌖

Area	Educational and therapeutic objectives	AUT	SMI	MMR
	Attention • to improve focusing attention	⊕	⊕	⊕
	• to improve the ability to maintain attention	⊕	⊕	⊕
	• to improve joint attention	⊕	⊕	⊕
	Thinking • to foster hypothesizing		⊕	⊕
Social and emotional	**Engagement in play** • to foster shared cooperative play	⊕	◕	⊕
	Community social and civic life • to improve the ability to understand and apply play rules → **VARIATION 1 & 2**	⊕		⊕
Motor dev.	**Mobility (fine hand use)** • to improve coordinated hand use		⊕	

2.1.2 Scenario IS02 "Turn-taking for sensory reward"

The IS02 play scenario is an exercise play with very simple rules. It consists of a collaborative turn-taking activity with sensory rewards. The scenario has mainly been developed to be played by children with autism as a collaborative play, but it can also be played by children with SMI and MMR. Two variations of the basic scenario have been developed.

BASIC SCENARIO

Main target user group: AUT
Additional target user groups: SMI - MMR

Play Type	Exercise play, very simple game with rules.
Actors	Two actors are involved in the scenario. These actors could be a child and an adult, or two children.
Activity	The game consists of a collaborative turn-taking activity with sensory rewards. There are two different input channels such buttons to activate (in the way of 'cause and effect') a corresponding sensory output display (e.g. coloured light display, sounds, etc.). The robot has two rows of 3 coloured lights each (e.g., a row with 3 red lights and a row with 3 green lights), and two play buttons, one for each player. The players have to press their 'own' button in turns, in order to activate the lights in the row that corresponds to them. Sitting on the floor close to the robot, one player starts the game by pressing a button on one side of the robot. As a result a coloured light (e.g. red) goes on. The other player presses in his/her turn another button on the other side of the robot, and as a result a different coloured light (e.g. green) goes on. The first player presses again the first button and another red light goes on in 'his' row. The other player then presses again the button s/he pressed before and another green light goes on. This continues three times, thus the players see a visual progression in the rows of lights towards the end.

	Then when the first player (the one who started the game) presses again 'his/her' button something different and new occurs: a major sensory reward of a kind (e.g. a white light flashes on/off, sounds and movement). Each button need to be pressed in turn otherwise the robot will not respond. The whole sequence can be repeated, and the players can swap roles, i.e. the player that started first, now starts second. As this is a very repetitive game, the adult may introduce variations in the way the game is played (e.g. calling out the colour of the light, etc.).
Setting	The game is played on the floor/carpet. The robot is placed on the floor and the participants are sitting around it. In this context, the players are likely to move around it, so there needs to be enough space around them.
Time	The game is made up of a short sequence of actions. The basic sequence can repeat itself many times, thus the duration of the activity is unlimited and can continue as long as the participants are interested. Also there is no time restriction on how quickly the buttons need to be pressed.
Robot configuration	- A stationary robot (no movement in space, but possible turning around on the spot as part of the sensory reward) - Inputs: two buttons on opposite sides of the robot. - Visual feedback: two rows of coloured lights (e.g. one row of red lights and one row of green lights). - Additional major sensory output[5]. It is important that the final reward can be adjusted according to the needs and preferences of a specific child.

VARIATIONS:

Variation 1 – Two remote controls

Target group	SMI – MMR
Activity	The players have a remote control to activate the lights on the robot. Sitting on the floor, the first player presses a button on his/her remote control and as a result a coloured light on one of the rows of lights on the robot goes on (e.g. red light); the second player presses a button which activates a light on the other coloured row of lights (e.g. green light).
Additional robot characteristics	In the basic scenario there are two buttons (one for each player) on the robot. In this variation, two remote controls are used (one for each player), replacing the need of pressing the buttons on the robot. - Remote controls with one coloured button each - Remote controls toggle active/passive status

Variation 2 – Numbers of turns

Target group	AUT – MMR – SMI
Activity	In the basic scenario the additional major sensory output goes on after 3 turns. The complexity of the activity can be adjusted by increasing or decreasing the numbers of turns before the final sensory reward is activated

[5] The final sensory rewards (e.g. flashing light, sounds, image, etc.) will depend on the technical characteristics of the specific robot and the interaction module.

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions**			
	• to improve visual perception	⊕	⊕	⊕
Communication and interaction	**Basic interpersonal interaction**			
	• to improve turn-taking	◕	◕	◕
	• to foster taking initiative	◕	◕	◕
	• to maximise proximity between peers → **NO VARIATION 1**	◕		⊕
	• to improve gaze shift and eye contact with others	◕		◕
	• to improve level of response to social cues	⊕		⊕
	• to improve level of response to others	◕		⊕
	Particular interpersonal relationships			
	• to encourage participation with classmates	◕	⊕	⊕
Cognitive Development	**Global intellectual functions**			
	• to improve understanding of cause and effect	◕	◕[6]	◕
	Higher-level cognitive functions			
	• to improve the control of the wish for or delay of gratification	◕		◕
	Attention			
	• to improve focusing attention	⊕		⊕
	• to improve the ability to maintain attention	◕	⊕	◕
	• to improve joint attention	◕	⊕	◕
Social and emotional development	**Engagement in play**			
	• to foster shared cooperative play	◕	◕	⊕
	Community social and civic life			
	• to improve the ability to understand and apply play rules	⊕		⊕
Motor development	**Mobility (body)**			
	• to increase gross motor control to improve coordination and balance		⊕	
	Mobility (fine hand use)			
	• to improve fine coordinated hand use		⊕	
	Psychomotor functions			
	• to improve psychomotor control	⊕[7]	⊕	⊕

2.1.3 Scenario IS03 "Imitation"

The IS03 play scenario is an exercise play with a robot that has moving parts which can be identified as 'body parts' for the child to imitate. It consists of an imitation game where one of

[6] Only if children are very young or with a very small experience of action on objects.
[7] If the reward is given specifically to a child with stereotypic behaviour, the scenario can be used to moderate or modify his/her stereotypical behaviour.

the players operates the robot remotely and the other player imitates its movement. The scenario has mainly been developed to be played by children with autism as collaborative play, but it can also be played by children with SMI and MMR.

BASIC SCENARIO
Main target user group: AUT
Additional target user groups: MMR, SMI

Play Type	Exercise play
Actors	Two actors are involved in the scenario. These actors are a child and an adult. The adult's role is to remotely operate the robot. The child's role is to engage in an imitation game both as an imitator and as an initiator.
Activity	The activity consists of an imitation game where the adult operates the robot remotely and controls its behaviour (turning around on the spot and /or moving various 'body' parts), in a 'Wizard of Oz'[8] mode to begin with (i.e. where the child cannot see the hidden remote control, and doesn't know that the robot is being operated by the adult). Sitting on the floor, the adult asks the child to imitate the robot. The adult makes the robot give positive feedback to a correct imitation. Once the child has learnt and practised all of the robot's possible movements, the adult asks the child to initiate similar movements for the robot to copy. The child would have to wait for the robot's response before initiating another behaviour for the robot to copy, otherwise the robot (via the adult) will not respond. After few sequences, the adult reveals that s/he is operating the robot, and the game continues. Because the child knows that s/he is playing with the adult through the robot, this might encourage the child to have more eye contact with the adult as well as share excitement and affection with him/her.
Setting	The game can be played on the floor/carpet or around a table, where the players could sit, stand or move in front of it.
Time	The duration of this activity is unlimited and can take place as long as the participants are interested.
Robot configuration	- A robot with a simple 'face' to indicate the front of the robot - Moving components which can be identified as 'body parts' (e.g 'arms', 'head') - A remote control user interface with different buttons to control all moving elements of the robot (e.g. head, arms, trunk) to be used by the adult.

VARIATIONS:

Variation 1 – I am in control

Target group	AUT – MMR – SMI
Actors	In this variation the two players involved in the scenario could be two children or a child and an adult.

[8] The Wizard-of-Oz technique is a widely used evaluation technique in Human-Computer Interaction and, more recently, Human-Robot Interaction research e.g. (Dahlback, Jonsson, and Ahrenberg, 1993). It involves a human who (unknown to the test subjects) is controlling the behaviour of the system, ranging from full tele-operation to partial control of 'higher level' decision-making processes.

Activity	The game starts with the child operating the robot remotely. The other player responds by imitating the robot's movements. The child that operates the robot needs to check the other player's action and to make the robot give positive feedback to correct imitation (by pressing the 'global positive feedback' button). Only then the child can initiate another robot movement, otherwise the other player will not respond.
Additional robot characteristics	A remote control to be used by the player.

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory devel.	**Perceptual functions** • to improve body awareness			
Communication and interaction	**Basic interpersonal interaction** • to improve turn-taking			
	• to improve gaze shift and eye contact with others			
	• to improve level of response to others			
	Particular interpersonal relationships • to foster a therapeutic relationship			
	• to encourage participation with classmates			
Cognitive Development	**Energy and drive functions** • to improve motivation to act → **VARIATION 1**			
	• to feel in control			
	Global intellectual functions • to improve understanding of cause and effect			
	Copying • to improve the ability to mirror and imitate simple and complex movements			
	Attention • to improve focusing attention			
	• to improve the ability to maintain attention			
	• to improve shifting attention			
	• to improve dividing attention			
	• to improve joint attention			
Social and emotional development	**Emotional functions** • to improve self esteem			
	Experience of self and others • to improve the sense of self and the awareness of one's own body and identity			
	Engagement in play • to foster shared cooperative play			

Area	Educational and therapeutic objectives	AUT	SMI	MMR
	Community social and civic life • to improve the ability to understand and apply play rules	⌖		⌖
Motor development	**Mobility (body)** • to increase gross motor control		⌖	
	Mobility (fine hand use) • to improve fine coordinated hand use →**VARIATION 1** (e.g. using fingers and hands to carry out coordinated actions such as pressing a button)		⌖	
	Neuromusculoskeletal functions • to improve control of simple voluntary movement		◔	
	• to improve coordination of simple movement		◔	
	Psychomotor functions • to improve psychomotor control	⌖	◔	⌖
	• to improve organization of psychomotor functions	◔	⌖	◔

2.1.4 Scenario IS04 "Make it move"

The IS04 play scenario is an exercise play with simple rules using a mobile robot where the players can make it move around the room. The scenario has mainly been developed to be played by children with severe motor impairment as a collaborative play, but it can also be played by children with MMR and AUT. Four variations of the basic scenario have been developed.

BASIC SCENARIO

Main target user group: SMI
Additional target user groups: MMR, AUT

Play Type	Exercise play, simple game with rules
Actors	Two or more actors are involved in the scenario. These actors could be a child and an adult, or two or more children.
Activity	The game consists of clapping[9] in order to make the mobile robot move around the room. Sitting on the floor, the child produces a sound by clapping the hands once or by VOCA (Voice Output Communication Aid. This sound triggers the robot and makes it move forward for a short distance. To keep it moving the child has to clap his/her hands again. To change the direction of the robot the child has to clap his/her hands twice or three times in order to make it turn left and right respectively.

[9] Clapping or any similar (i.e. short and sharp) acoustic signal like a horn signal, a drumming signal, etc

	The game can be played with several participants as a turn-taking game, either with a simple rule, where each player is responsible for moving the robot to one of the directions (forward, left, right), or with no rules, where the players simply take turns to make it move.
Setting	The game is played on the floor in a quiet room with a large empty space, to enable the child and the robot to move around.
Time	The activity is unlimited and can continue as long as the child is interested.
Robot configuration	- Sensors to detect and discriminate sounds (i.e. hands clapping). - For SMI clapping could be by means of a combination of a switch+signal generator (e.g. a Voice Output Communication Aid with the required pre-registered sounds) - A remote control to activate the robot in a 'Wizard of Oz' mode, as an alternative to sensing capabilities if unavailable.

VARIATIONS:

Variation 1 – Vocal input / Speech sound

Target group	AUT - MMR - SMI
Activity	In the variation instead of using clapping to make the robot move around the room, the player can use speech sound.
Additional robot characteristics.	Vocal input: speech sound[10]

Variation 2 – Change speed

Target group	AUT - MMR - SMI
Activity	In the variation the robot moves when one of the players claps his/her hands, and it stops when the player stops clapping. The robot moves according to the frequencies (time between two claps) of the clapping (e.g. if the player claps quickly, the robot moves quickly, if the player claps slowly the robot moves slowly).
Additional robot characteristics	Identifies frequency of (clapping) signals and changes speed accordingly. Basic moving patterns (e.g. Bump and Turn)

Variation 3 – Solitary play

Target group	MMR - SMI – AUT
Activity	In this variation the child is playing alone and the adult is there to support and sustain the activity.

Variation 4 – Circadian rhythm

Target group	MMR - SMI
Activity	Depends on the setting: at the beginning of the activity the robot can be 'lazy' (it reacts with longer delay), requiring more effort from the player to make it move. As the game progresses the robot becomes more active, requires less effort from the player and becomes 'lazy' again at the end of the game.

[10] It is important to highlight that *speech* is an element of verbal communication, while *speech sounds* (for example 'baba') and *non speech sounds* are vocal communication elements. *Speech sound* is an individual sound unit of speech without concern as to whether or not it is a phoneme of some language. As a result neither vocal articulation (from the children) nor voice recognition (for the robot) are aspects of that variation.

Additional robot characteristics	The robot has pre-defined rhythms or states such 'lazy' or 'active' (speeds for its responses - e.g. if the robot is in a 'lazy' state (after lunch) then it reacts not as quickly as it would in an 'active' state). These slow/'lazy' or 'active' circadian rhythms are not controlled dynamically during the play but are part of the robot's pre-defined behaviour as set by the adult according to the child's need.

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visuospatial perception (spatial awareness)	⊕	⊕	◔
Communication and interaction	**Voice and speech functions** • to improve articulation functions →**VARIATION 1**	⊕		⊕
	Communicating- Producing – Pretalking • to improve verbal and preverbal vocalization →**VARIATION 1**	◔	◔	◔
	Communicating – producing – nonverbal messages • to improve non verbal aspects such as gestures and pointing	⊕		⊕
	Basic interpersonal interaction • to improve turn-taking	⊕	◔	◔
	• to foster taking initiative	⊕	◔	⊕
	• to improve gaze shift and eye contact with others			⊕
	• to improve level of response to others	⊕		⊕
Cognitive Development	**Global intellectual functions** • to improve understanding of cause and effect	◔		◔
	Memory functions • to improve short term memory		⊕	
	Higher-level cognitive functions • to improve abstraction →**VARIATION 4**		⊕	
	Attention • to improve focusing attention	⊕		⊕
	• to improve the ability to maintain attention	⊕	⊕	⊕
	• to improve joint attention	⊕	⊕	⊕
	Making decisions • to improve decision-making abilities			⊕
	Undertaking single/multiple task • to improve the ability to undertake a single task	⊕		⊕
Social and emotional development	**Emotional functions** • to improve self esteem		◔	⊕
	Experience of self and others • to improve sense of agency	⊕	⊕	⊕
	Engagement in play • to foster solitary play →**VARIATION 3**		⊕	⊕
	• to foster parallel play		◔	
	• to foster shared cooperative play	⊕	◔	⊕
	Community social and civic life • to improve the ability to understand and apply play rules	⊕		⊕

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Motor development	**Psychomotor functions** • to improve organization of psychomotor functions			
	Neuromusculoskeletal functions • to improve control of simple voluntary movement			

2.1.5 Scenario IS05 "Follow me"

The IS05 play scenario is an exercise play and a simple symbolic play, with a mobile robot that can follow the player moving around the room. The scenario has mainly been developed to be played by children with mild mental retardation as collaborative play, but it can also be played by children with SMI and AUT.

BASIC SCENARIO

Main target user group: MMR
Additional target user groups: SMI, AUT

Play Type	Exercise play, simple symbolic play
Actors	Two children are involved in the game.
Activity	The game consists of playing with a mobile robot that can follow a player and stay in place if told to do so. The robot can be guided in 'follow-me' mode from a child to another child. The players are in a room, located some distance from each other. The game starts when the first player activates the 'follow-me' mode (e.g. by clapping or pressing a button). The robot starts to move, searching for a child. When it finds a child it follows him/her within a predefined distance (e.g. 50 cm). If the child stops, the robot stops too. The child can also give a signal to the robot to suspend or reactivate the 'follow-me' mode. When the child and the following robot reach the second player, and the robot is closer to the second player, it starts to follow the second player.
Setting	This scenario is performed on the floor in any area with sufficient space, to allow the robot and the children to move. Ideally the activity can be spread over more rooms.
Time	The activity is unlimited and can continue as long as the child is interested. The game can be repeated as long as wished by the actors. The robot can be told to wait at a specific location by using a "stay where you are" signal and might be re-activated later.
Robot configuration	- To activate or deactivate the 'follow-me' mode: sound recognition system (clapping) or button on the remote control. - Sensors to detect the child's movement - Following distance: e.g. 50 cm (it is important to be able to adjust the distance and proximity to child's preferences). - A remote control to activate the robot in a 'Wizard of Oz' mode, as an alternative to sensing capabilities if unavailable.

VARIATIONS:

Variation 1 – Move together

Target group	AUT – MMR - SMI
Activity	In the basic scenario the robot is guided from one player to the other one. A variation of the activity can be a cooperative game where the two children have to move together in order to let the robot move. In this variation the robot moves only if both children are moving together at the same time and in the same direction and it stops when one of the children is not moving or the children start to move in two different directions
Additional robot characteristics	- Sensors to detect children's movement - Search and follow facility (e.g. coloured tag) - A remote control to activate the robot in a 'Wizard of Oz' mode, as an alternative to sensing capabilities if unavailable.

Variation 2 – Control the robot movements

Target group	AUT - SMI - MMR
Activity	One child is remotely controlling the robot's movements. The other child is either following the robot or being followed by the robot.
Additional robot characteristics	Remote control to control the robot's movements

Variation 3 – Follow the robot

Target group	AUT - SMI - MMR
Activity	In this variation the child is the one that follows the robot. The robot starts to move around (simply avoiding obstacles) and at the same time it detects if a child is following it (i.e. a child is present within a pre-defined distance, just outside the obstacle avoidance zone e.g. in an area between 0.5 and 1.5m). Once detecting a child behind it, the robot will continue moving around and avoiding obstacles as long as it can detect the child (i.e., the child is following the robot). The robot will adapt to the child's speed.
Additional robot characteristics	Basic moving patterns (e.g. Bump and Turn)

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visuospatial perception (spatial awareness)			
Communication and interaction	**Communicating- Producing – Pretalking** • to improve verbal and preverbal vocalization			
	Communicating – producing – no nverbal messages • to improve non verbal aspects such as gestures and pointing			
	Basic interpersonal interaction • to improve turn-taking →**NO VARIATION 1**			

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Cognitive Development	**Energy and drive functions** • to feel in control	⊕	⊕	⊕
	Global intellectual functions • to improve understanding of cause and effect	⊕		⊕
	Higher-level cognitive functions • to improve organization and planning		⊕	⊕
	Copying • to improve the ability to mirror and imitate simple and complex movements →**VARIATION 1**	⊕	◔	⊕
	Attention • to improve focusing attention	⊕	⊕	⊕
	• to improve the capacity to attend to the human touch, face and voice			⊕
	• to improve the ability to maintain attention	⊕	⊕	⊕
	• to improve shifting attention	⊕	⊕	⊕
	• to improve joint attention	◔	⊕	◔
	Thinking • to foster pretending		⊕	⊕
Social and emotional develop.	**Engagement in play** • to foster shared cooperative play	◔	◔	◔
	Community social and civic life • to improve the ability to understand and apply play rules →**VARIATION 1**	⊕	⊕	⊕
Motor development	**Mobility (body)** • to improve coordination and balance		◔	
	• to improve the capacity to walk and move around using equipment		◔	
	Mobility (fine hand use) • to improve fine coordinated hand use →**VARIATION 2**		⊕	
	Neuromusculoskeletal functions • to improve control of simple voluntary movement		⊕	
	Psychomotor functions • to improve psychomotor control	⊕	◔	⊕
	• to improve organization of psychomotor functions		◔	◔

2.1.6 Scenario IS06 "Dance with me"

The IS06 play scenario is an exercise play with simple rules with a mobile robot that can move to the rhythm of a pre-recorded piece of music in a pre-programmed set of 'steps', that the child can copy, in order to 'dance together'. The scenario has mainly been developed to be played by children with severe motor impairments as solitary play, but it can also be played by children with MMR.

BASIC SCENARIO

Main target user group: SMI
Additional target user groups: MMR

Play Type	Exercise play, game with rules
Actors	A child is involved in the game. The adult (a therapist or a teacher) has only a supportive and rewarding role.
Activity	In this game a child makes the robot 'dance' – i.e. move to the rhythm of a pre-recorded piece of music in a pre-programmed set of 'steps', that s/he can copy, in order to 'dance together'. The robot is placed in the central position on a 3x3 carpet (chess-type). The activity starts when the child triggers the robot to play the child's favourite songs or music and the robot starts to 'dance' a simple pre-defined choreography. The robot does 5 or 6 moves on the carpet according to the beats of the music. By moving on the carpet the robot gives the child visual feedback of its movements. At the end of the 'dance' the robot uses a pre-recorded message to invite the child to do the same 'dance' (set of movements) and the child will copy the robot's moves on his/her carpet, either after the robot or simultaneously with it. The adult via remote control can give positive feedback when the child copies the moves correctly.
Setting	The game is played on the floor, in a room where there should be enough free space for placing the 2 carpets (3x3 chess-type).
Time	The basic phase can repeat itself many times, thus the duration of the activity is unlimited and can take place as long as the player is interested.
Robot configuration	- Music reproduction - Up to 5 different pre-set 'dance' choreographies which are simple sets of moves in pace ('steps'), each set matched to the bit of a different pre-recorded piece of music. - Remote control for the adult to give feedback if the child imitates the 'dance' correctly -2 carpets (3x3 chess-type) - Sensory display during the dance (e.g. projections, lights etc) - A remote control to activate the robot in a 'Wizard of Oz' mode, as an alternative to the pre-set dance choreographed movements.

VARIATIONS:

Variation 1 – Positions

Target group	MMR - SMI
Activity	In this variation the child is the one who composes the dance (as opposed to the basic scenario where the robot is moving to pre-programmed choreography). The child selects on an input device a sequence of different positions for the robot to move to[11]. When the child finishes 'teaching' the robot the set of the dance moves, the robot can reproduce the sequence of movements (according to pre-defined rhythms/speed related to the choice of the pre-recorded music and they can dance together.
Additional robot characteristics	- Pre-programmed music with a given number of 'beats'. - Input device (e.g. remote control or touch screen) allowing the child to choose the sequence of robot movements.

[11] The "taught" choreography is then automatically segmented into basic moves (i.e. turning and moving to the next neighbouring field). The segments then are synchronized with a pre-defined time-line according to the rhythm/speed of the music and executed accordingly.

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visuospatial perception (spatial awareness)		⊕	
Cognitive development	**Global intellectual functions** • to improve understanding of cause and effect			⊕
	Memory functions • to improve short term memory			
	Higher-level cognitive functions • to improve abstraction		⊕	
	• to improve organization and planning		⊕	⊕
	Copying • to improve the ability to mirror and imitate simple and complex movements		⊕	
	Attention • to improve focusing attention		⊕	⊕
	• to improve the capacity to attend to changes in the environment		⊕	⊕
	• to improve the ability to maintain attention			
	• to improve shifting attention			
	• to improve dividing attention			
	Solving problems • to improve the ability to solve problems		⊕	⊕
	Thinking • to foster hypothesizing			⊕
	Making decisions • to improve decision-making abilities →**VARIATION 1**			
	Undertaking single/multiple task • to improve the ability to undertake a complex task			
Social and emotional development	**Engagement in play** • to foster solitary play		⊕	⊕
	Community social and civic life • to improve the ability to understand and apply play rules			
	• to improve the ability to change play rules		⊕	⊕
	• to improve the ability to negotiate play rules		⊕	
Motor development	**Mobility (body)** • to increase gross motor control		⊕	
	• to improve the capacity to walk and move around using equipment			
	Neuromusculoskeletal functions • to improve control of simple voluntary movement		⊕	
	Psychomotor functions • to improve organization of psychomotor functions			⊕

2.1.7 Scenario IS07 "Build the tower"

The IS07 play scenario is an assembly play with simple rules. A mobile robot with simple 'arms' or other gripping capabilities can help the child to build a tower out of cubes. The scenario has mainly been developed to be played as solitary play by SMI children, but it can also be played by children with MMR.

BASIC SCENARIO

Main target user group: SMI
Additional target user groups: MMR

Play Type	Assembly play
Actors	A child is involved in the game.
Activity	With the help of the robot the child is able to build a tower out of cubes. The cubes are lying on the floor and are picked up by the robot randomly (e.g. the cube that has been detected first by the robot is taken). After picking up the cube the robot moves back to the starting position (i.e. the position of the tower) and adds the cube. The play continues until all the cubes are used for the tower. When the construction is over, the robot can destroy the tower at the child's whim.
Setting	The game is played on the floor.
Time	The basic phase can repeat itself many times, thus the duration of the activity is unlimited and can take place as long as the player is are interested.
Robot configuration	- A mobile robot - Program execution in automatic mode or stepwise (triggered by button) - Gripper to pick up the cube (maybe with sensors detecting presence of cube) - One/two arms able to lift up the gripped cube sufficiently (cf. defined maximum height of the tower) - Self-localisation (and sensors) to enable moving back to cube position - sensory system to detect and navigate to the cubes - Size of the tower: about 70 cm. (i.e. from 5 to 7 cubes with cube size 10/15cm - To activate the building/destroy mode: sound recognition system[12] or button on the remote - A remote control to activate the robot in a 'Wizard of Oz' mode, as an alternative to sensing capabilities if unavailable.

VARIATIONS:

Variation 1 – Next colour

Target group	MMR - SMI
Activity	If a set of coloured cubes is used, the child could choose the colour of the next cube with the help of a remote control.
Additional robot characteristics	- Remote control to choose the colour of the next cube - Special colours for the cubes; maximum of 3 different colours (e.g. neon pink, neon yellow, neon green). The adult will make sure that the colours of the cubes are not around in the environment.

[12] Simple sound recognition system already available on the market.

Variations 2 – Remote controls and sub-functions

Target group	MMR - SMI
Actors	Two children.
Activity	In this variation the robot's actions are divided into several high level sub-functions/instructions (e.g. 'fetch a cube', 'put the cube on the tower'). Each child controls one instruction at a time, via a remote control.
Additional robot characteristics	Two remote controls

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visuospatial perception (spatial awareness)		⊕	◔
Cognitive development	**Global intellectual functions** • to improve understanding of cause and effect			⊕
	Memory functions • to improve short term memory		◔	
	Higher-level cognitive functions • to improve abstraction		⊕	◔
	• to improve organization and planning		⊕	⊕
	Copying • to improve the ability to mirror and imitate simple and complex movements		⊕	◔
	Attention • to improve focusing attention		⊕	⊕
	• to improve the capacity to react to changes in the environment		⊕	⊕
	• to improve the ability to maintain attention		◔	◔
	• to improve shifting attention		◔	◔
	• to improve dividing attention		◔	◔
	Solving problems • to improve the ability to solve problems		⊕	⊕
	Thinking • to foster hypothesizing			⊕
	Making decisions • to improve decision-making abilities →**VARIATION 1**		◔	◔
	Undertaking single/multiple task • to improve the ability to undertake a complex task		◔	◔
Social and emotional development	**Engagement in play** • to foster solitary play		⊕	⊕
	Community social and civic life • to improve the ability to understand and apply play rules		◔	◔
	• to improve the ability to change play rules		⊕	⊕
	• to improve the ability to negotiate play rules		⊕	

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Motor development	**Mobility (body)** • to increase gross motor control			
	• to improve the capacity to walk and move around using equipment			
	Neuromusculoskeletal functions • to improve control of simple voluntary movement			
	Psychomotor functions • to improve organization of psychomotor functions			

2.1.8 Scenario IS08 "Bring me the ball"

The IS08 play scenario is an exercise play with a mobile robot. The game consists of throwing and fetching a ball. The scenario has mainly been developed to be played by children with severe motor impairments as collaborative play, but it can also be played by children with MMR and SMI.

BASIC SCENARIO

Main target user group: SMI
Additional target user groups: MMR - AUT

Play Type	Exercise play
Actors	Two children are involved in the game. One player is throwing the ball, and the other is taking control of the robot.
Activity	The game consists of throwing and fetching a ball. One player has a coloured ball, and the other has a remote control. The game starts when the child with the ball throws, pushes or rolls it. Then the other child takes over the job of controlling the robot. With the help of a special remote control, s/he moves the robot to the ball, lets the robot pick up the ball, lets the robot bring it to the starting point and release it. These functions are performed in a semi-automatic mode (the child has just to select different robot behaviours, such as 'find the ball', 'pick up the ball', and 'bring it to the other child') or stepwise in a pre-defined sequence. The robot could give sensory feedback when moving (e.g. a light) and when it performs the different tasks (e.g. when it picks up the ball, it could emit a sound). Afterward the whole sequence can be repeated and the players can swap roles; the player that throws the ball can now take over the job of controlling the robot.
Setting	The game is played on the floor, in a room where there should be plenty of uncluttered floor space.
Time	The game is made up of a short sequence of actions. The basic phase can repeat itself many times, thus the duration of the activity is unlimited and can continue as long as the players are interested.
Robot configuration	- Mobile robot - Programme execution in semi-automatic mode

	- Remote control for triggering/selecting next step. - Sensor(s) to detect a ball (the ball itself needs to be brightly coloured; not too heavy; easy to grasp e.g. made of spongy rubber) - Self-localisation to return to starting position - Sensory feedback during the different actions (e.g. sound and/or light effects) - Gripper to pick up a small soft ball - One/two arms to lift a ball.

VARIATIONS:

Variation 1 – Solitary play

Target group	MMR - SMI - AUT
Actors	One child is involved in the scenario. The robot is interacting with the child autonomously (the child throws the ball – the robot brings the ball back to the starting point).
Activity	When the child is playing alone with the robot s/he learns to throw or push the ball and to watch it move (sensing moving objects). Then the robot runs in automatic mode, and is able to find and pick up the ball and bring it back to the starting point, thus offering it for a new start of the game.
Additional robot characteristics	- Programme execution in automatic mode - Detect wheelchair in order to detect child's presence and bring the ball back to him/her

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visuospatial perception (spatial awareness)		⊕	◔
Cognitive development	**Global intellectual functions** • to improve understanding of cause and effect			⊕
	Memory functions • to improve short term memory		◔	
	Higher-level cognitive functions • to improve abstraction		⊕	◔
	• to improve organization and planning		⊕	⊕
	Copying • to improve the ability to mirror and imitate simple and complex movements		⊕	◔
	Attention • to improve focusing attention		⊕	⊕
	• to improve the capacity to attend to changes in the environment		⊕	⊕
	• to improve the ability to maintain attention		◔	◔
	• to improve shifting attention		◔	◔
	• to improve dividing attention		◔	◔
	Solving problems • to improve the ability to solve problems		⊕	⊕
	Thinking • to foster hypothesizing			⊕

Area	Educational and therapeutic objectives	AUT	SMI	MMR
	Making decisions • to improve decision-making abilities →**VARIATION 1**			
	Undertaking single/multiple task • to improve the ability to undertake a complex task			
Social and emotional development	**Engagement in play** • to foster solitary play			
	Community social and civic life • to improve the ability to understand and apply play rules			
	• to improve the ability to change play rules			
	• to improve the ability to negotiate play rules			
Motor development	**Mobility (body)** • to increase gross motor control			
	• to improve the capacity to walk and move around using equipment			
	Neuromusculoskeletal functions • to improve control of simple voluntary movement			
	Psychomotor functions • to improve organization of psychomotor functions			

2.1.9 Scenario IS09 "Get in contact"

The IS09 play scenario is an exercise and simple symbolic play where the children explore the robot. The scenario has mainly been developed to be played by children with MMR as a collaborative play, but it can also be played by children with SMI and AUT.

Main target user group: MMR
Additional target user groups: SMI, AUT

Play Type	Exercise play, simple symbolic play
Actors	There can be one or more players. The adult has a supportive role. S/he mediates the activity and controls the behaviour of the robot.

Activity	The adult can dynamically select the robot's behaviour from pre-defined behavioural patterns throughout the activity. Each behavioural pattern is characterized by a certain configuration of robot movement, colours, patterns and shape transformation. At the beginning the adult selects the behavioural pattern expressing a 'feeling of fear'. The robot does not approach the child and tries to maintain a pre-defined ('safe') distance from him/her. So when the child tries to approach the robot, it retreats and changes its appearance to 'fear appearance' (e.g. its colour gets darker, its skin gets rough). If the robot cannot move back because of an obstacle (wall, other children) s/he still continues changing its appearance to the 'fear appearance'. Such pattern creates a context that encourages the child to interpret the robot's behaviour and then change his/her approach/behaviour towards the robot accordingly (e.g. to approach the robot slowly). When the child gently approaches the robot, the adult modifies the behavioural pattern into 'communicative' mode: the robot now approaches the child, trying to maintain a short pre-defined distance and shows warm colours in order to invite the child to a more intimate interaction. The adult can now select a tactile exploration mode. In this mode, the robot is not moving but as it is positioned next to the child, the child may touch and explore the robot's surface. The robot responds by vibrating as if it were purring and getting smoother and smoother.
Setting	The game is played on the floor.
Time	The activity is unlimited and can continue as long as the child is interested.
Robot configuration	- Mobile robot configuration. - Robot can operate in different modes and change its appearance and movement/distance accordingly, e.g. 'Fear' mode – the robot tries to keep (a wide) minimum distance from the child(ren), 'Communicative' mode - the robot tries to keep a (small) maximum distance from the child(ren) and 'Tactile' mode where the robot is not moving if objects are within the defined distance and is following moving objects that are moving out of the defined distance - Remote control for the adult for setting different modes - Expressivity potentialities of the robot: colours and visual patterns; shape; movement. - Additional sensing: touch

VARIATIONS:

Variation 1 – Child control

Target group	SMI – MMR
Actors	Two children are playing
Activity	In this variation, one child is controlling, via a remote control, the robot behavioural modes (e.g. 'fear mode' 'communicative mode' etc) whilst the other child is playing. Thus the child who has the remote control manages the 'friendliness' of the robot, making it more inclined to approach the other child or more inclined to stay away from him/her etc. By controlling the robot's behaviour, the child can also delay the robot's responses by making the robot appear to be 'lazy' in order to encourage the other child to intensify his/her interaction with the robot.

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory development	**Perceptual functions** • to improve visual perception	⊕	⊕	◔
	• to improve tactile perception	⊕		⊕
	• to improve visuospatial perception (spatial awareness)			⊕
Communication and interaction	**Basic interpersonal interaction** • to improve the ability to respond to social cues	⊕		⊕
	• to improve the level of response to others	⊕		◔
	Particular interpersonal relationships • to encourage participation with classmates		⊕	⊕
Cognitive Development	**Energy and drive functions** • to improve motivation to act		◔	⊕
	Global intellectual functions • to improve understanding of cause and effect	⊕		⊕
	Higher-level cognitive functions • to improve abstraction		⊕	⊕
	• to improve organization and planning		⊕	⊕
	• to improve cognitive flexibility		⊕	◔
	Attention • to improve focusing attention	⊕	⊕	⊕
	• to improve the capacity to react to changes in the environment	⊕	⊕	◔
	• to improve the ability to maintain attention	⊕	⊕	⊕
	• to improve dividing attention	⊕	⊕	⊕
	• to improve joint attention	⊕	⊕	◔
Social and emotional development	**Emotional functions** • to improve regulation of emotion and range of emotion			⊕
	Experience of self and others • to improve sense of agency	◔	⊕	⊕
	Engagement in play • to foster onlooker play	⊕	⊕	⊕
	• to foster shared cooperative play → **VARIATION 1**	⊕	⊕	◔
	Community social and civic life • to improve the ability to understand and apply play rules		⊕	⊕

2.1.10 Scenario IS10 "Pretending to be a character"

In the IS10 play scenario the game consists of a symbolic play with the robot, where the robot is a mediator to express feelings and to make simple movements or sequences of simple

movements or other actions in a pretend play game. The scenario has mainly been developed to be played by children with severe motor impairments as a collaborative play, but it can also be played by children with MMR.

BASIC SCENARIO

Main target user group: SMI
Additional target user group: MMR

Play Type	Symbolic play
Actors	Two or more actors are involved in the scenario. These actors are a child and one or more peers.
Activity	The child uses the robot as a mediator to express feelings and to make simple movements or sequences of simple movements or other actions in a pretence play. S/he remotely operates the robot in order to change its appearance and behaviour in pretence play involving peers. Through a suitable interface (e.g. usable with a single switch scanning mode) the child directly operates the robot by selecting simple actions among a defined set of possible choices (for example platform movements, movement of platform components e.g. arms, action on objects e.g. grasping and lifting, visual and audio feedback, etc) on a defined set of objects. The robot can also display a set of basic emotions such as happiness, sadness, fear, surprise, disgust, anger - e.g. becoming red, swelling and snarling if 'upset' or trembling and whimpering if 'scared' as already mentioned in IS9. Combining the choice of action, objects and emotion the child can play very simple symbolic play activities with predefined objects.
Setting	Classroom, home, therapy session
Time	The interaction continues until the child gets tired or bored.
Robot configuration	- Facial features to be displayed if possible - Acoustics output (pre-recorded messages or sounds) - Moving parts that can be identified as 'body parts' (e.g. arms, head) - sensory feedback: colour, surface texture, size, sound - sensors: audio sensor (to detect the intensity of sound), tactile sensor (to detect the intensity of touch), proximity sensor (to detect a person/object in the surroundings of the robot), colour detection (to differentiate between defined objects) - Remote control for robot and component movement, selection of 'behaviour primitives' from defined set

Objectives:

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Sensory dev.	**Perceptual functions** • to improve visual perception		⌖	⌖
	• to improve proprioception			⌖

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Communication and interaction	**Communicating - Producing – Speaking** • to improve speaking			
	Communicating – producing – non verbal messages • to improve non verbal aspects such as gestures and pointing			
	Basic interpersonal interaction • to improve turn-taking			
	• to improve gaze shift and eye contact with others			
	• to improve the ability to respond to social cues			
	• to improve level of response to others			
	Particular interpersonal relationships • to encourage participation with classmates			
Cognitive development	**Global intellectual functions** • to improve understanding of cause and effect			
	Higher-level cognitive functions • to improve abstraction			
	Copying • to improve the ability to mirror and imitate simple and complex movements			
	Attention • to improve the ability to maintain attention			
	• to improve joint attention			
	Solving problems • to improve the ability to solve problems			
	Thinking • to foster pretending			
	• to foster hypothesizing			
	Making decisions • to improve decision-making abilities			
	Learning through action with objects • to improve the ability to carry out actions relating to objects, toys or materials symbolically, for example, feeding or dressing a toy animal or doll			
	• to improve the ability to carry out actions involving pretence, substituting a novel object, body part or body movement to enact a situation or event .			
	• to improve the ability to engage in make-believe activities involving imaginary persons, places, things or events			
Social and emotional development	**Emotional functions** • to improve regulation of emotion and range of emotion			
	Engagement in play • to foster shared cooperative play			
	Community social and civic life • to improve the ability to understand and apply play rules			
	• to improve the ability to negotiate play rules			

Area	Educational and therapeutic objectives	AUT	SMI	MMR
Motor development	**Mobility (objects)** • to improve the ability to lift, to carry, to put down […] objects through AT devices			

3 Using IROMEC Scenarios in Interaction Studies – an example

The play scenarios presented in this paper can guide the child through different play types (e.g. exercise play, symbolic play, games with rules etc) , engaging him/her in turn-taking activities, action and coordination games, and imitative interaction games (for detailed description of play types see Robins et al. 2010b). The play scenarios were implemented and evaluated by the project partners during interaction studies in different countries. The following section briefly summarises the evaluation study in two primary schools in Italy. The study was exploratory in nature and involved only a small group of children, however, it illustrates the use of the IROMEC scenarios in the envisaged context of robot assisted play for children with special needs. Further extensive evaluation of the IROMEC robot will be reported elsewhere.

3.1 The experimental design

The main aim of the study was to investigate the achievement of specific educational objectives in play activities with the robot. The study has been conducted in two different schools in Siena (Italy) for almost 3 months with 3 sessions per week. The trials involved 4 children (3 female and 1 male) from 6 to 11 years of age, with different disabilities, i.e. global cognitive disability, Tuberous Sclerosis, Attention Deficit Hyperactive Disorder (ADHD) and motor impairment. (Marti & Iacono, 2011).

The play sessions were organized in individual and group sessions. In the group sessions each child played with 3 or 4 classmates with normal development. One special education teacher and a facilitator attended the trials. They were directly involved in the activity. The sessions

were defined as adult-facilitated (structured) play conditions for individual sessions and peer to peer play conditions for group sessions. Each session lasted approximately 40 minutes. The sessions were recorded by two cameras. Each session was divided into three steps: *Introduction to the robot*, *Play scenarios*, *Complete the scenario and Time to say goodbye*.

Five different play scenarios were performed by each child (**Figure 3**):

1) Turn-taking with a mobile robot (IS01, cf. section 2.1.1),

2) Turn-taking for sensory reward (IS02, cf. section 2.1.2),

3) Make it move (IS04, cf. section 2.1.4),

4) Follow me (IS05, cf. section 2.1.5),

5) Get in contact (IS09, cf. section 2.1.9).

Figure 3 Trials performed at primary school in Siena (Italy)

3.2 Data Collection Methodology

The evaluation was performed administering a questionnaire based on a review of consolidated and validated assessment tools (e.g. Vineland Scale of Adaptive Behaviour; Test of Gross Motor Development; Imitation Battery) used to evaluate children's development in different areas.

We asked the special education teachers to fill in the questionnaire twice, namely once before the play sessions (as a pre-test) in order to evaluate a baseline for each child and a second time

at the end of the play sessions (as a post-test) to evaluate any changes. The questionnaire is divided into items related to five developmental areas: Sensory; Communicational and Interaction; Cognitive; Motor; Social and Emotional. Each area is divided into sub-functions (e.g. the Sensory Development Area is divided into Perceptual functions). Each item on the questionnaire was assessed with a five point Likert scale with nominal values ranging from NEVER to ALWAYS. The questionnaire was composed of 158 items, subdivided into 5 developmental areas and 20 sub-functions. The nominal values from the questionnaire were converted into numerical values (1 = NEVER to 5 = ALWAYS) in order to facilitate the analysis.

3.3 Results

The analysis was performed in three different steps: computation of the mean value of the developmental areas and functions (pre- and post- test); computation of the difference between the mean value obtained in post-test and pre-test, and the computation of the number of items that changed between post-test and pre-test. Incomplete items were excluded from the analysis. The number of items we collected differed for each child. For all 4 children we recorded some changes for each developmental area. In particular, we did not record any positive changes for the Sensory developmental area, even if these data were not confirmed from the qualitative analysis or from the comments of the special education teachers. In fact, the video recording of the activity shows a clear interest of the children in the visual and sound interface of IROMEC. The attention of the children was caught mainly by the robot's face. The visual and sound interfaces are an important feature in order to sustain the interaction with children with cognitive disabilities. The Motor development area was the only one which did not report any negative change.

We collected for the children 1 and 4 a total of 144 items while for the children 2 and 3 a total of 147 items. Most of the items were unchanged, as it is reasonable to expect, due to the limited duration of the experiment. However, we recorded for child 1 and child 4 respectively a number

of 49 and 41 items incremented from the pre-test. These items were related to the Communication and Interaction developmental area and to the Cognitive Development only for child 4. Most of decremented items for child 3 were in the Communication and Interaction area, whilst most of the incremented items were related to the Motor Development area.

3.4 Discussion

Some results, although to be considered as preliminary, show a significant improvement for some children. These results are more meaningful if considered in relation to the specific disability. For example child 3 has a severe disability (Tuberous Sclerosis) and motor impairments. She does not possess fine motor skills and has difficulties in controlling her strength of upper limbs. During the sessions she improved her ability to coordinate movements and to control her strength during the interaction with the robot. She did it at the beginning of the sessions with the help of the teacher and was able to do it herself afterwards. These positive improvements underline the ability of IROMEC to support the children in their motor development. Its ability to move autonomously and to follow the children allows them to achieve a better understanding of their body.

Child 2 had a positive increment in two developmental areas and no decrease in the others. This child has difficulties in maintaining the focus of attention on the same activity and his attention span is extremely short. The hyper-activity which characterizes his behaviour was rarely observable during play with the robot. He felt at ease in respecting his turn and the rules of the game.

As a general lesson learnt, we experienced that creating a more inclusive and welcoming atmosphere was important to encourage the conversation and to facilitate better interaction with IROMEC. The presence of the facilitator was not perceived as intrusive by the children. The individual sessions let the disabled child become the main protagonist of the play session. Through the individual sessions the children had the opportunity of getting to know IROMEC

better and understand the rules of the play scenarios. The group sessions were important to identify interaction dynamics in a peer to peer context. For example, we observed an active involvement of the disabled children's classmates as well as a situation of peer to peer learning. These behaviours were reported by the teachers too.

The younger children preferred the scenarios *Make It Move* and *Turn-Taking with Sensory Reward*, whilst the older children preferred the *Get in Contact* scenario. The emotional states that the children associated with IROMEC from its visual interface were fear and happiness. The ability to recognize emotions and to be able to distinguish between them suggests a developed emotional intelligence. In particular the older children associated the image of a heart that appeared during the symbolic play scenario (*Get in Contact*) as a way for the robot to mean "I like you!" No spontaneous negative comments were recorded.

4 Conclusion and future work

In recent years there have been many examples of robots being used in play activities of children with special needs, for therapeutic or educational purposes (Kozima et al., 2007; Kozima et al., 2009; Lathan & Malley, 2001; Marti et al., 2005; Michaud et al., 2007; Robins et al., 2005; Robins et al., 2004a; Robins et al., 2004b; Robins et al., 2009; Stiehl et al., 2005; Stiehl et al., 2009). These robots have shown to be useful in promoting spontaneous play in children with developmental disorders, engaging them in playful interactions. Many different research methods were used to conduct evaluations, pointing out the need for a shared framework that would help the process of developing play activities against therapeutic objectives, and the evaluation and integration of research results.

The article presented a set of play scenarios, each with its relevant educational and therapeutic objectives in five key developmental areas (i.e. sensory development, communication and interaction, cognitive development, motor development and social and emotional development).

Although the play scenarios were originally developed for and tested with the user groups identified in the IROMEC project (i.e. AUT, SMI and MMR) and with the IROMEC robot, the play scenarios may be considered for use with other user groups or in other applications involving human-robot interaction and with other robotic toys.

One example of such application is the use of this framework within the European FP7 project ROBOSKIN (ROBOSKIN, 2011) where there was a need for the development of social play scenarios for tactile interaction with a humanoid robot in order to develop skin-based robot assisted play. Here, once the higher level user requirements for tactile interaction for children with autism were identified (Amirabdollahian et al., 2009; Robins et al., 2010a), the framework of play scenarios and therapeutic objectives presented in this paper was adopted and used in the development of initial tactile play scenarios with the humanoid robot KASPAR (Dautenhahn et al., 2009) that were based on turn-taking and imitation games, together with the related educational and therapeutic objectives relevant for children with autism (Robins & Dautenhahn, 2010). This example of research in the ROBOSKIN project already demonstrates that the scenarios described in this article can be used in a different context with a different robot.

IROMEC play scenarios have also been used in a recent long-term study involving both the IROMEC robot and the robot KASPAR, see initial results presented in Iacono et al. (2011); Lehmann et al. (2011).

In this article we provided detailed descriptions of 10 novel play scenarios for robot assisted play in relation to specific therapeutic objectives. It is hoped that this work will contribute to further advancement in the field of robot assisted play by providing a common basis for play scenarios that other projects can utilize or build upon.

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