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Preface

Five years ago, the Teiresias Centre (Support Centre for Students with Special Needs) at Masaryk University started a tradition of international meetings for professionals with practical experience of applying universal accessibility design in tertiary education. The first Universal Learning Design conference was held at Masaryk University in Brno, Czech Republic, on 8–11 February 2011.

Now, in 2016, the Proceedings of the 5th ULD conference – organized as a track of the 15th International Conference on Computers Helping People with Special Needs in Linz on 13–15 July 2016 – is being delivered to you. The proceedings cover varied topics as well as target groups and thus reflect the real situation present at tertiary education of students with special needs; at the same time a few papers transcend the primary focus of the conference and examine topics connected with early childhood pupils.

All submissions have been peer-reviewed: each paper has been evaluated by at least three professionals, all of them either from Masaryk University or members of the ICCHP Conference Programme Committee (listed below).

We wish to thank all those who contributed to the preparation of the proceedings as well as the ULD track, and believe the experience and good practices shared in the present volume can contribute to further development of a universally accessible environment.

June 2016 ULD track organizers

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Is Play Easier for Children with Physical Impairments with Mainstream Robots? Accessibility Issues and Playfulness

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1 Introduction

Play "is a range of voluntary, intrinsically motivated activities normally associated with recreational pleasure and enjoyment" [6]. It is irreplaceable for human development, being the main support for the child's physical, cognitive and social development [4], [9], [14].

Children with physical and motor impairment (PI) experience substantial physical motor limitations, due to a damage to the performing system (skeleton, neuromuscular system, joints) or to the directive system [15]. Often PI is associated with intellectual and neuropsychological impairments, language and speech disorders, sensory impairments, as well as emotional and social difficulties [13]. Cerebral Palsy (CP) is a type of PI caused by brain damage occured around the time of childbirth, causing generalized disorders.

In children with CP, practice play can be limited because they cannot manipulate and use the objects. Symbolic, constructive, and rule play can show difficulties as well, given the needed integrity of the gross and the ne motor functions [1]; this situation can be even worse if there are also additional impairments – cognitive, sensorial. As to social dimension of play, children with PI have been described as frustrated by their motor impairment and with poor trust in themselves as players and play companions [10]. They feel "included"in a physical activity when they gain entry to play, feel like a legitimate participant, have friends [12]. Nevertheless, according to Skär [11], they can improve their self-perception if they use assistive technologies that can give them more autonomy in play activities without recurring to the aid of an adult.

Robotic toys could be considered as an opportunity to offer play opportunities to children with PI. Some prototypes have been developed but their efficacy with children with PI is controversial (Iromec [2], PALMIBER [5]). While research is still needed in this field, robot development is very expensive. Thus, mainstream robotic toys assume particular interest for research purposes, because a wide variety of robots is available, they allow different play scenarios and interactions modalitie, they are easily purchasable on the web. Consequently, it is possible to experiment the use of many different robots, chosen accordingly to specific criteria. Obtained results could be useful for further research and development of new tools.

2 The GioDi project

The Italian project GioDi (*Gioco per la Disabilita* – Play for Children with Disabilities)[1] exploited exactly the idea of experimenting a certain number of robots of the mainstream market with children with severe PI, to verify the playfulness of these tools and suggestions for further studies in the field of play for children with disabilities.

GioDi aimed at assessing the ludic use of 5 robots during interactions between a child with PI and other partners (peers or adults) in different contexts. The project encompassed four main objectives:

1. to analyze these robotic toys' accessibility in play session with children with severe CP;
2. to study the playfulness of these experiences, that is the degree to which the child is involved in play and is having fun during the activity [8];
3. to develop modifications to the toy input systems for making them more accessible and usable;
4. finally, to develop guidelines for parents, for using robotic toys for the play of their children.

The current paper reports the first results of the GioDi Project, with respect to the evaluation of the toys accessibility: this has been described in detail both in relation to the different scenarios proposed by the robots and to the needed child's requirements, functional and cognitive. Additional information has been introduced with respect to possible critical environmental aspects.

In this way, the analysis conducted gave the possibility to describe the experimentation outcomes with respect to the children's abilities from one hand and to the robot characteristics from the other hand; and this information will be precious to realize the next steps of the research, with special reference to the development of toy modifications and the creation of playful contexts of play.

In this paper, while the overall results of the toys' accessibility analysis are described, we will focus in particular to the details related to two very different robots:

1. **Edison**, which can elicit different types of play and present various levels of interaction complexity with the child;
2. **Zoomer**, which proposes an elementary interaction and only one type of play.

2.1 Method

Seven children (1 girl) were involved in the study; they had been selected according to their diagnosis (severe PI: PC in 6 children and degenerative muscle disease in 1 child) and their age (between 6 and 12 years).

After a targeted research on the Internet, 5 robotic toys of the mainstream market were identified according to:

- types of play allowed by the toy (practice, symbolic, constructive, rule [3]);
- types and variety of behaviours allowed by the toy;

1 Funded by the CRT Foundation (Turin, Italy) to L'Abilità onlus (Milan), Università della Valle d'Aosta, Politecnico di Milano, and Universita di Torino

- types of input systems, modiable through technological interventions according to the children's needs;
- variety of aesthetic features and congurations;
- affordable price.

The following robots were acquired from the market:

- Air Swimmer[2]
- Cubelets[3]
- Dash & Dot[4],
- Edison[5]
- Zoomer[6]

Children were observed while playing with the robots in three different situations, involving different partners:

- Laboratory (controlled context) in interaction with two adults expert in robotic toys and play interaction;
- Home (natural context) in interaction with familiar partners (parents, siblings, peers, etc.);
- Leisure center (natural context) in interaction with unknown peers.

Each play session lasted about 45–55 minutes, and was focused on two or three toys, accordingly to the child's interest in the activity.

2.2 Toy Description

In this section Edison and Zoomer will be described, reporting the main play activities they can offer and the cognitive, physical, and motor qualities they require for a proficient interaction.

2.2.1 Edison

Characterized by its essential look and versatility, Edison is a simple autonomous robot with Lego interfaces. It shows extraordinary resistance (can sustain heavy weights), and has several sensors (sound, light, and line reader) and actuators (lights, speaker, and motors).

Edison can be programmed through a bar code, choosing among 6 different coded games, or via a connection with a computer through a programming interface, possibly used by operators to devise new games. To complete the toy experience several complements can be downloaded from the product website; as an example a *game mat* is available: a printable poster reporting the barcodes and a playing area. Moreover, it is possible to design its program through an open source simplified IDE (Integrated Development Environment), enabling the user to decide directly the behavior of the robot. Finally Edi-

2 William Mark Corporation – http://airswimmers.com/

3 Modrobotics website – http://www.modrobotics.com/cubelets/

4 Wonder Workshop official website – https://www.makewonder.com/dash

5 Meet Edison – https://meetedison.com/

6 Zoomer official website – http://zoomerpup.com/

son can be integrated as intelligent core in Lego projects or even assembled with other robots, sharing information.

For this research purposes, it was possible to play only with the 6 pre-coded games: letting the children design the device program was beyond their capabilities. The available programmed games are:

- Line Tracking: Edison follows a black line on the plan (game mat);
- Follow Torch: a light attracts Edison;
- Avoid obstacles: Edison uses its sensors to avoid hitting obstacles;
- Clap controlled driving: One clap makes Edison turn, two make it move forward;
- Bounce in borders: Edison wanders inside a closed shape drawn on the plan (game mat);
- Sumo Wrestling: Edison seeks its opponent and try to push it out of the ring (a track on the game mat).

The player interacts with Edison in many different ways, at different levels. The robot programming and activation requires the timely interaction with 1cm-large buttons and the correct placement of the robot to scan the barcode. This activity requires quite fine fingers, hand control, and coordination. The same qualities are required for the construction of decorations made of Lego components. Nonetheless, depending on the chosen game, the player can interact with the toy though objects (e.g., torch, obstacles) or with his/her body (clapping hands, putting hands in front of the robot to make it changing its direction), requiring a less precise motor control. It is worth noting that the simplest game, controlling Edison with clap, can also be performed at the table, simply hitting the surface once or twice.

2.2.2 Zoomer

This toy is a robotic pet dog, able to recognize vocal commands. It can act autonomously, emulating the behavior of a dog which explores a random environment. It is programmed to perform several different actions, most of which can be funny or intriguing for the children, making Zoomer a stimulating play companion. Just to make few examples, it can roll, play dead, sing, pee, and much more. The actions can be triggered by the children in two main ways: pressing a button which runs a random action, or issuing a specific vocal command.

The intended game flow starts by putting Zoomer in listen mode (by pressing gently his head), to issue the command, and the execution of the action, after which the dog returns in listen mode waiting for the next request. After some time in autonomous mode, it goes in standby mode, miming sleep.

The interaction with the toy requires the capability to produce clear and quite loud speech. Zoomer is designed to adapt and learn the owner voice, facilitating the commands recognition. A few physical interaction is anyway necessary to put the dog in listen mode. Whenever speech is not sufficient, it is still possible to trigger random actions, requiring a fair hand and fingers control. Even if possible, the toy encounters difficulties acting on a table or a desk: its movements are fast and broad, more suited for floor activities, requiring unimpaired walk or at least autonomous movement on wheelchair. It is not no neglect that it is possible to enjoy Zoomer passively, when activated by another child or an adult. Finally, it is worth noting that the commands to be issued are fixed, and are not interpreted by the toy, requiring a good memory and a precise speech.

3 Results: crossing toys characteristics, play scenarios and children's abilities

Tables 1 (Edison) and 2 (Zoomer) report the crossing between the toy features, the children's functional and cognitive abilities required by the toys to be used, the environmental aspects necessary to support the play activity, and the GioDi experimentation outcomes.

4 Discussion: crossing toys' characteristics, play scenarios and children's abilities

In Table 1 (related to Edison) and Table 2 (Zoomer), the toys' characteristics and the play scenarios have been crossed with the needed children's characteristics, in terms of functional and cognitive abilities. Critical environmental aspects necessary to support the play activity have been also included. In this way, accessibility is described as the "encounter between a person's functional capacity and the design and demands of the physical environment". The last column presents the outcomes of the use of the robots during the experimentation activities with the children; it is intended to give exhaustive information about the obstacles detected in the play sessions, so that modications can be planned for future improvements, as well as the positive peculiar aspects, so that they can be implemented and stabilized. Even if only 2 of the 5 robots are here presented in detail, some results of the experimentation can be reported as common; generally speaking, the robots were not easily accessible to these children according to their functional abilities. This implied two main consequences:

- a passive use of the robots by children (an onlooker play) was required;
- the adults had to play a relevant role in the play activity.

Nevertheless, some of these robots were evidently playful for these children, also in the "passive mode": they were happy to take part to the activity and to interact with them as they could. Adults acted to increase the potential playfulness of these passive activities by creating a persuasive playful background (narrative, motivational, supportive), in which both the robot and the child could find their own place.

Another important finding is that playfulness increases if the children are able to interact personally and autonomously with the robot, and if they can understand clearly what happens to the robot as a consequence to their actions. This could confirm that self-efficacy and a feeling of control on the play situation is important for playfulness [8].

Both functional and cognitive abilities are implied in creating obstacles to the robots' use; in some cases, the robot is mainly not accessible because of the type of physical interaction it requires, in some cases because of the type of scenarios it proposes, and in further cases both aspects are implied to prevent a child from being able to use these robots as play tools. However, while – at least in some cases – some assistive solutions can be studied and implemented to overcome physical obstacles, cognitive requirements are more challenging, since they are related to the quality and the type of scenarios, and consequently to the intellectual abilities of the child and the type of play he/she is able to manage.

[Table 1] Relationship Child/Robot – Edison

Child Abilities		Environmental Aspects	Experimentation Outcomes
Functional	Cognitive		
• Move the small lever of activation – Coordinated use of the two hands – good ability to separate the use of one finger per hand to move effectively the small lever • Hand-clapping to activate the robot – Hand-clapping effective enough to be detected – Speed of the clapping • Use of the buttons needed to implement the new program on the robot (through a bar code) – good ability to separate the use of one finger to press – pressing of one button three times in a short time – precise pressing and speed of another button after a short pause	**Passive Use** (little signicant) • Maintaining the attention on the robot's action • Understanding of the concept of "winner" when observing a simple play with rules (scenario "Sumo wrestling") **Active Use** • Understanding of the relationship between one's own action and the robot's behaviour • Counting up to three • Capacity to recognize different buttons and to manage times to press them • Selection and planning of robot's uses in relation to play scenarios • Use of robots within symbolic scenarios by adding Lego bricks • Planning of symbolic scenarios by adding Lego bricks	• Necessity of playing on a wide horizontal at surface, where Edison can be easily seen • Potential adjustment of the relationship child (wheelchair)/horizontal surface to favor the best autonomous use of the robot • During inclusive play with other children, necessity of optimizing the solution to share the play surface • When programming the robot with other children, necessity of coordinating the activities accordingly to each child abilities and proposals, supporting negotiation	**Passive Use** • The most used Edison play scenarios were "Line tracking" and "Sumo wrestling" • The small lever of activation has been always managed by the experimenter **Active Use** • The only play scenario in which children could act was "Clap control" **Proposed Play Background** • Car race: based on the play scenario "Line tracking", a car race was realized, among Edisons with Lego bricks on the top to personalize them, so that each child could recognize his/her own car, in order to end up with a winner

Child Abilities		Environmental Aspects	Experimentation Outcomes
Functional	Cognitive		
Programming • Programming new scenarios through sequences of actions within a devoted software – Reference should be made to accessibility of hardware tools and software environments • Use of the remote control – Possible critical aspects related to the type of remote control	**Programming** • Planning of activities or sequences of activities to implement in the robot • Capacity to evaluate the outcomes obtained with the planned robot and to modify the programming on the basis of the needs or of the planning • For programming: – Understanding and using symbols – Understanding and using schemes and graphic representations – Creating and modifying sequences **Note** • When playing with other children, capacity to express one's planning and to negotiate them with the others, in a collaborative way		• The scenario "Sumo wrestling" was realized, among Edisons with Lego bricks on the top to personalize them, so that each child could recognize his/her own robot, in order to end up with a winner • The personalization of Edison was supported by the experimenter who helped the child fixing the Lego bricks, or who fixed the Lego bricks for the child **Playfulness** • The scenario "Clap" was particularly funny for the children, because it allowed them to voluntary control Edison • The hand clap was substituted by hitting the table: this movement was effective but less difficult because it did not required the movement and the strength control

[Table 2] Relationship Child/Robot – Zoomer

Child Abilities		Environmental Aspects	Experimentation Outcomes
Functional	Cognitive		
• Move the small lever of activation – Co-ordinated use of the two hands – good ability to separate the use of one finger per hand to move effectively the small lever • Activation of the robot through verbal pronunciation of commands made of words and sentences: – adequate tone of voice, fluency of the sentences – correctness of the sentence under any aspect (phonological, lexical, grammatical, prosodic) – introduction of the name "Zoomer" before each command – lowering the dog's head before each command	• Understanding the relationship between one's own action and the robot's behavior • Selection of different uses of the robot • Control over the verbal language under various respects: – Phonetic correctness and adequacy (phonemes, tone of the voice) – correctness of the repetition of strings, also as to prosody • Wilingness to exercise one's verbal production until the dog can recognize it • Memorization of sequence of actions and word to produce for activating the robot (Zoomer + touch the head + command) • Counting up to two	• Necessity of playing on a wide horizontal at surface, where Dash & Dot can be easily seen (in case of a table, pay attention to possible falls) • Potential adjustment of the relationship child (wheelchair)/horizontal surface to favor the best autonomous use of the robot	**Active Use** • One child only succeeded in controlling Zoomer through his voice, given the required vocal and linguistic precision of the command • Probably a stable use of the robot improves this possibility (Zoomer gets used to a specific voice) • The easiest modality was activating the robot through the button that generates casual behaviors • The robot activation was easy because the button was big enough; nevertheless, some children faced difficulties in understanding that just one pressure was needed; they faced difficulties in stopping pressing the button to observe the robot behavior (one child ended up in pressing continuously the button)

Child Abilities		Environmental Aspects	Experimentation Outcomes
Functional	Cognitive		
• Activation of the robot through hand-clapping – Hand-clapping effective enough to be detected – Speed of the clapping • Activation of the robot through a button – Pressing of the button, which can be easily found and usable as to its dimensions			**Playfulness** • Zoomer was very interesting for the children, because of its "real animal" shape and movements • The difficulty of giving a precise vocal command ended in a negative feedback by the robot and this created frustration and demotivation in the children

Zoomer is an interesting case in this sense, because it is funny and could be used in an autonomous way; there are problems to control it by voice, but the pressure of a button can be considered a good alternative. However, the scenarios it proposes and the types of play it is related to are really elementary. The cognitive gain with respect to usual non-robotic toys is not really evident; it is only possible to refer to a sort of "emotional" gain, because the small dog is really nice and funny, to the point that also a passive use can be considered. From the theory of play point of view, it is very rigid, since it proposes only a basic practice play, based on cause-effect relationship. Edison can be considered at the opposite side. Per se, it is not very attractive, and a passive use is not very interesting. It can raise curiosity if the user can understand, enjoy, and, above all, control its numerous functions to move, to follow a track, to bounce. Moreover, it becomes a real challenging and good tool to play with peers, if the user is able to program it, to realize sequences of actions to the point of creating complex play scenarios. From the theory of play point of view, it is quite flexible, it allows different types of play and it supports play development. However, Edison presents nontrivial obstacles to accessibility, as it is described in Table 1; in fact, the most interesting scenarios are activated via the PC after programming, while the basic scenarios lead only to a passive attitude. For a playful use of Edison both physical and cognitive abilities are implied, and perhaps a totally different design should be needed to make the robot accessible – or at least more usable – for children with PI.

5 Conclusions

The first results here presented of the GioDi project will be completed in the next future by further deepening of the following areas:

- the development – and the testing – of possible modifications to the robots, according to the functional and cognitive abilities of the children;
- an improved accessibility of the robot will give children the possibility to play in an autonomous way: their play abilities should be differently exploited and playfulness should also increase;
- the implementation of suitable changes in the play contexts, so that play backgrounds proposed by the adults are no more surrogates for a lack of playfulness of the toy, but only a support for play development.

Many further areas of research have been opened by this first experience, that could be faced in the future; one area that seems particularly promising is related to the social aspects of play, being unavoidable a specific consideration of the inclusive aspect of the play activity. This could be done, for example by studying the playfulness of the toys' scenarios, by including also the variables related to the partners of play (peer vs. adult, familiar vs. unfamiliar) and the contexts in which play occurs (home vs. laboratory, dyadic vs. group interaction). In conclusion, mainstream toys have proved as potentially interesting solutions to support play of children with disabilities. Anyway, they also proved to be very far from being accessible to these children, and consequently they could not be used in an autonomous way, thus decreasing their playfulness. Nevertheless, assessing their accessibility in strict relationship with the children's functional and cognitive abilities can inspire interesting general considerations for increasing the usability of mainstream robots and for developing new robotic toys.

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