Changes in Playfulness with a robotic intervention in a child with cerebral palsy

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Abstract. Children with a severe motor impairment due to cerebral palsy have a free play deprivation due to their physical impairment. There is evidence that playfulness is affected in children with cerebral palsy. The objective of this pilot study was to investigate the effect of a home-based robot intervention that promotes free play, on the child's level of playfulness. A single-subject multiple baseline design (MBLD) was used in this study. The participant was a 4 year old girl with cerebral palsy who played with her mother at home. The 5 week intervention used a robot as an augmentative manipulation device for play. The playfulness level increased slightly during the intervention. Reflections for future studies are discussed.

Keywords. Robot, cerebral palsy, disability, playfulness.

Introduction

Free play occurs when an activity is spontaneous, intrinsically motivated, actively engaged and self-regulated [1, 2]. Free play provides children with the opportunity to discover their capabilities, try out objects, make decisions, comprehend cause-and-effect relationships, learn, persist, and understand consequences [2]. Playfulness has been defined as the main aspect of play, as the disposition to play [3]. It has been stated that the greater the playfulness shown by the player in a given activity, the closer to free play that activity is [1]. Playfulness is an indicator of free play.

Children with cerebral palsy that results in marked physical impairments have a free play deprivation. This is due to a lack of opportunities to interact and practice skills needed to control the environment [2]. There is evidence that playfulness is affected in children with cerebral palsy. Infants with cerebral palsy and developmental delays with at least moderate cognitive impairments are less playful than typically developing children [4]. Likewise, children with motor impairments including cerebral palsy have difficulties actively making decisions during play [5]. Children with motor impairment also spend less time concentrating on the play activity and their play is less complex than the play of typically developing children [6]. During play with objects children with disabilities and especially with motor impairments are highly dependent on their mother to play being the mother who manipulates the play material or toys [7].

Robots have the potential to help children with cerebral palsy engage in object play [8, 9]. Robots can allow children with severe motor impairments to interact with play materials that generally are part of typically developing children's play (e.g. buried objects, Lego bricks) [10, 11]. Robots have the potential to increase playfulness in children with cerebral palsy during occupational therapy sessions [12]. Lego Mindstorms ® robots are a low cost reliable alternative to traditional testing that can be used for estimating cognitive skills in children with severe motor impairments [13]. Research on robot-based play in children with cerebral palsy has shown that Lego robots may be successfully used to assist with play involving manipulation [14]. Because they are portable, appealing to children and affordable, Lego robots may be considered for long term use by parents and teachers at home or school [9]. Additionally these robots can easily be set up and operated by parents during play interactions with their children.

To the best of our knowledge, no study has investigated the effects of a robotic intervention on children's play at home, which is a naturalistic setting for the application of robots in the daily lives of children with cerebral palsy. Thus, the objective of this pilot study was to investigate the effect on a child's level of playfulness in a home-based robot intervention that promotes free play.

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1. Methods

1.1. *Participant*

Ethics approval was obtained from the Ethics Review Board of the University of Alberta. A 4 year 7 month old girl with a diagnosis of cerebral palsy with spastic quadriplegia participated in this study with her mother. Her gross motor skills were level IV according to the Gross Motor Function Classification System (GMFCS) [15] and level IV according to the Manual Ability Classification System (MACS) [16]. She was able to sit on the floor without equipment for positioning, and was also able to creep on her stomach and crawl on her hands and knees very slowly. Her verbal language skills were limited, and her speech was only understood by those who know her very well. However, she was able to say yes and no and follow two-step instructions. She could hit the switches controlling the robot with her hands. According the Pictorial Test of Intelligence (PTI-2), her cognitive age was lower than 3 years [17]. According to her mother the girl tended to play with the same toys in the same way all the time and had problems focusing and engaged in an activity.

1.2. *Design and intervention*

This study was a pilot study for a future multiple baseline design (MBD) across subjects. It was conducted at the participant's home where she played with her mother and her own toys. They chose 16 different toys (e.g. Ernie doll, walker toy, blanket, toy beaded necklace) to play with during the study. The mother-child dyad played on the floor. The toys were 1 meter from the participant. The 15 minute video recorded sessions were twice a week for 5 weeks. The study had two phases, a baseline and an intervention. During the baseline (two weeks), the girl and her mother played together with the set of toys. The child's playfulness was assessed through the Test of Playfulness (ToP) [1] by the researcher who was trained and calibrated on the test. The ToP is a standardized, reliable and valid measure for playfulness that consists of 29 items [1]. Once the level of playfulness was stable, the baseline phase was ended. The participant was then trained to make the robot move forward and turn according to a previous protocol [13] during 3 sessions over one week. Assessment of the robotic intervention started in the fourth week. The robot was available during the mother-child free play sessions.

1.3. *Materials*

The robot was a Lego MindStorms ® "rovertbot" vehicle with a shovel in front and was used in previous studies [13]. The participant operated the robot using three switches (forward, left turn and right turn) through an adapted infrared remote control. The robot was programmed using the Lego Intervention System 2.0 programming language.

1.4. *Data Analysis*

Raw ToP scores were graphically plotted for visual comparison between phases. Statistically significant changes in level were determined using the 2-standard deviation (2 SD) band method. At least two consecutive data points of the intervention phase must fall outside the two standard deviation band of baseline measures for there to be a significant difference [18].

2. Results

Figure 1 shows the visual analysis of the raw ToP scores. When the robot was introduced the child's playfulness increased (mean= -0.1) compared with the baseline (mean= -0.4), but the difference was small. The more negative the ToP score is, the lower the child's playfulness. Three data points fell outside the 2 SD band; thus, the child' playfulness significantly improved with the intervention (Figure 2).

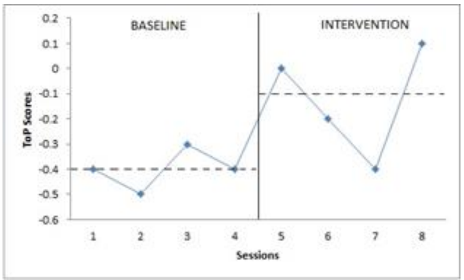

Figure 1. Mean ToP scores differences between phases.

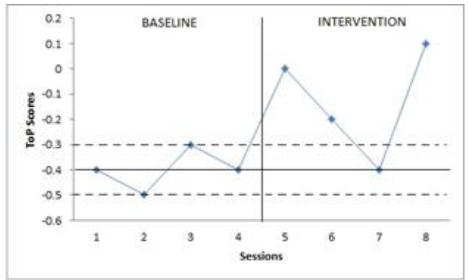

Figure 2. Changes according the 2 SD band method.

3. Discussion and Conclusion

Playfulness is reduced in children with a severe motor impairment due to cerebral palsy [3] and this was evident in the study participant. In this study, the playfulness of a child with severe motor impairments increased with the introduction of a robotic intervention. Although the girl was interested in the robot, she did not use it during the entire 15 minute sessions. Her use of the robot during the free play sessions increased as the intervention progressed. Her mother tried to modify their play by using the robot in combination with the other toys but her daughter preferred to perform the same play activities she did during the baseline. For these activities, she was able to reach and grasp objects in an unskilled way despite her impaired manual abilities. She enjoyed familiar easy play activities such as wrapping Ernie with a blanket or hiding the toy beaded necklace, and during the intervention she tended to return to these activities. This preference may be explained by the fact that children with a motor impairment are often less persistent and prefer less challenging activities than able-bodied children [6]. In the seventh session maybe the girl felt pushed to play with the robot by her mother who provided a lot of prompting and got frustrated.

Operating the robot demands cognitive skills that could be excessive for a child as young as 4 years old with a cognitive delay. The participant could make the robot move, stop and turn with prompting, but she was not able to use two switches to perform two different activations on sequential steps to accomplish a final result (e.g., sequencing: turn the robot, then go forward). Previous research has indicated that the child's cognitive age as determined by the PTI determines success for operating a Lego robot. Five year olds typically developing children successfully carry out the highest task (sequencing) required for controlling the robot in two dimensions, while 86% of the four year olds and 25% of the three year olds were successful in this task [19]. Thus, it is not surprising that the participant in this study, who had a PTI cognitive age of 3 years old, had difficulty learning to control the robot. More differences in the playfulness scores may be observed for children with a more severe motor limitation who are older than five years old. They may find it easier to operate the robot, so they may use the robot more frequently during play than in this case.

In the planned MBD protocol the number of participants will increase giving more confidence in the strength of the results. Additionally, a second calibrated rater will assess 20% of the videos for inter-rater reliability, and a Rasch analysis will be done with the raw ToP scores for statistical analysis by the ToP's author. A longer intervention may be needed in order to provide more time for the child to practice the skills for operating the robot. Some instructions to mothers will be adjusted in order for mothers to not feel pressure to make the children to use the robot, but encouraging the child to play with the robot as another toy.

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