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Published citation:
Encarnacao, P., Cook, A., M., Adams, K., D., Azevedo, L., Gil, I., C., Londral, A., R., Rodrigues, S. (2012). Comparison of Physical and Simulated Assistive Robots for Cognitive Skills Assessment. Paper presented at the International Society for Augmentative and Alternative Communication (ISAAC) Conference, Pittsburgh, PA.

Comparison of Physical and Simulated Assistive Robots for Cognitive Skills Assessment

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Abstract
Adapted Lego robots have been used as augmentative manipulation assistive technologies allowing children with motor disabilities to actively participate in play activities and demonstrate their cognitive skills. To overcome physical robots limitations, virtual robot use was explored. This study compares the performance of children with and without disabilities executing play activities with a physical robot and a matching virtual robot. The activities involve cause-effect, choice making, and sequencing skills that are also very important for successful use of AAC devices. Results show that children's performance is independent of the robot, encouraging the development of virtual robots as augmentative manipulation tools.

Introduction

Robots have been used to enable children with motor disabilities to actively participate in play activities [1]. Using the robots as tools to manipulate, explore and interact with the environment, children with disabilities have opportunities to learn social, cognitive, and language skills as their typically developing peers do. Additionally, through participation in those activities, children can demonstrate cognitive skills that are important in AAC device use. Standard tests rely on verbal or motor responses by the child, and even tests that require only choice making by adapted methods (e.g. eye gazing) are limited. As a result, children's capabilities might be underestimated, reducing parents', teachers, and caregivers expectations. Robots can give children the power to control play activities that are motivating to them and that also reveal certain cognitive skills. By comparing performance of children with disabilities with that of typically developing children one can obtain a proxy measure of their cognitive age.

Lego robot activities have successfully been used to these ends. Lego robots can be controlled using an adapted interface (e.g. single switches), are appealing to children, are safe, and relatively inexpensive. They can be programmed to execute different tasks with various degrees of autonomy to match children's capabilities. Using different props, robots can be placed in motivating scenarios for children, and play activities may be designed to reveal cognitive skills.

Lego robots are still too expensive to be widely used in under resourced countries. They require assembly, programming and adaptation for children with disabilities. They are not as reliable as an industrial robot, compromising their performance (e.g. turning less than a programmed amount and failing to complete a task when a switch is hit, causing confusion). It is not easy to build robots that resemble cartoon or movie characters out of Lego parts to keep the child engaged, and usually the robots assume car shapes with some kind of gripper for manipulation.

To overcome these limitations, virtual robots in a virtual environment on a computer screen can be used. Instead of controlling a physical robot, children would be controlling a virtual robot that wouldn't have any of technical limitations of the physical one. It could assume different shapes to match the child's preferences. Software packages could be developed and widely deployed for home use at a lesser price than physical robots. This approach is similar to computer games.

The study reported here aims at comparing the performance of children with and without disabilities in play activities with a physical and matching virtual robot.

Methods

Twenty typically developing children from 3 to 5 years old and ten with cerebral palsy participated in the study. The cognitive age was accessed using the Pictorial Test of Intelligence [2] and participants were grouped into three cognitive age brackets: 33-39, 45-51 and 57-63 months. All children were able to access three different single switches to control the two robots. Children were seen in two sessions, approximately one week apart, at their schools or a rehabilitation centre. The scenario in which the virtual robot operated was made similar to the physical scenario (a table with the robot and blocks on top, inside a school room), and the virtual environment simulated physical properties (e.g. the robot had to hit the stack of blocks hard enough in order to knock it over). Participants were requested to perform three activities with both the physical and virtual robots. The three activities from a previous study involved knocking over stacks of blocks with the robot, requiring increasingly more complex cognitive skills to accomplish them [3]. Success rates in executing each activity were used as the performance measure to compare children's use of the two robots.

Results and discussion

Success rates in each activity varied across ages. Participants of all ages had no problems executing activity one (making the robot move forward). Children in the 3 and 4 years cognitive age brackets had more difficulties with activities 2 (stopping the robot) and 3A (turning in the appropriate direction) when compared to 5 year olds. The majority of the 3 year olds were not able to complete the sequencing activity 3B (after turning, move forward). The success rates in this activity were higher in average in the 4 year olds group, and even higher in the 5 years old group. The results across cognitive ages were in general similar for participants with and without disabilities, are in line with developmental psychology theories, and shows that the designed activities are able to discriminate children within cognitive age groups.

ANOVA tests, assuming its assumptions are met, show that for both groups (children with and without disabilities) the participants' performance was not influenced by the robot type, independently of the task that was being done. Video analysis is now underway to assess the cognitive strategies employed by the children when executing the different activities. This will provide a more comprehensive picture of how children view the two robots.

Conclusions

The study results encourage the development of virtual robots as augmentative manipulation tools for children with disabilities. The use of virtual robots instead of physical ones facilitates the distribution and use of such technologies. Different scenarios for cognitively equivalent activities may be incorporated into a single software package, and scenarios can be switched in order to maintain a child's motivation. The cognitive skills involved in using the robot as a tool to perform different activities are also required for using other assistive technologies (e.g., speech generating devices), and the scenarios can emphasize skills associated with AAC. Further research is needed to evaluate the use of virtual robots in school settings. Previous studies have shown that physical robots contribute to the integration of children with disabilities, because they move from passive observer to the role of main actor. Will that also be the case with virtual robots, where all the action takes place on a computer screen?

References

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