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Robot Assisted Play for Children with Disabilities

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ABSTRACT

Children learn through interacting with their environment. Most children develop their cognitive and linguistic abilities though play interactions. The Lego Mindstorms Robotic Invention SystemT is a tool that children with physical disabilities can use to facilitate play interactions. Over a four week period, a single participant learned how to use two Lego Mindstorms robots in play activities. The participant was able to achieve planned control over the robots by using head-mounted switches and a switch-adapted remote control. He demonstrated quick learning with various types of interactive play activities. The Lego Mindstorms Robotic Invention System was found to be a valuable tool for observing how children with physical disabilities can learn through play interactions.

KEY WORDS

Robotics, Play, Physical Disabilities, Children, Cognitive Development

BACKGROUND

Children who are unable to independently manipulate objects due to physical disabilities often cannot engage in the same play activities as their able-bodied peers. As a result, children with disabilities may have difficulty developing the cognitive and linguistic skills that typically developing children learn through play. Assistive technology for computer access, augmentative communication, and environmental control can be used to modify, or provide alternatives to, traditional object manipulation play activities. Robots have been used with very young (7 to 9 month) children (1), with children who have severe disabilities for self care tasks (2), and for science instruction at the elementary school level (3). We have also demonstrated that robotic systems can allow children with severe disabilities to develop and demonstrate cognitive skills that are typically learned through activities involving direct

object manipulation (4). However, these studies were conducted with an expensive robotic manipulator that makes wide spread replication difficult. The purpose of this study was to explore the feasibility of using the widely-available and inexpensive Lego Mindstorms Robots for robot-enabled play activities.

RESEARCH QUESTION

Can the Lego Mindstorms Robotic Invention System be used to facilitate play activities for children who have physical disabilities?

METHOD

The investigative team used Lego MindStorms components to construct two robots; the roverbot (see figure 1) and a robotic arm (see figure 2). The initial design for the robotic arm included two motors; one motor for base rotation and one that controlled arm elevation and hand opening and closing. The robotic arm was redesigned so that hand closure was separated from arm elevation and powered by a third motor. The Lego MindStorms system includes a remote control that can activate a programmed sequence of movement or can control the robots' individual motors. The remote control was adapted to allow switches to be used in place of each remote button.


Figure 1. The roverbot (Click image for larger view)

The participant was an eight-year old with severe physical disabilities who used his head to activate the switches. Prior to beginning the study, he had only used one switch, mounted to the right of his head for controlling battery-powered toys. During the study, the child was seen 2 times per week, for approximately 15-20 minutes, for a total of 8 sessions. The sessions were conducted in the child's school facility. Five of these sessions were videotaped. Before each session, the investigators downloaded play-based programs into the robot for the child to use during the session. Initially, the investigators modeled the task for the child. If the child did not engage in the play task, a prompt hierarchy was followed: (1) full physical prompt + verbal (ie. investigator hand over child's hand), (2) partial physical prompt + verbal (ie. investigator's finger tip touching child's hand), (3) verbal prompt, and (4) visual (gesture) prompt.


Figure 2. The robotic arm (Click image for larger view)

The child completed a variety of tasks each day. The participant's teacher was interviewed prior to

beginning the study to identify appropriately engaging and motivating tasks for the child. Roverbot tasks included: (1) hitting a switch to activate a song and dance program, and (2) holding down a switch to move the roverbot forward in order to knock over a tower of blocks. Robotic arm tasks were: (1) hitting a switch to drop a variety of toys, (2) hitting a switch to lift a toy into sight (3) holding one switch to rotate the arm closer to the participant, followed by hitting a second switch to open the hand and release a toy, and (4) using one switch to lift a toy into sight, and a second switch to open the hand and release the toy.

RESULTS

The child quickly mastered the single-switch roverbot tasks. At this point the child progressed to the robotic arm tasks. He used a single switch on his right side to carry out robotic arm tasks 1 and 2, but after he had mastered them he began to display off-task behavior. Therefore, a second switch was introduced on his left side to perform robotic arm tasks 3 and 4. When the second (left) switch was introduced, the child seemed to display more goal-directed behavior. The child also progressed through the robotic arm play tasks rapidly and was able to easily complete them after a few trials.

The child's affect and attention changed throughout the course of the study. Initially, the child displayed flat affect and little attention towards the investigative team, robots, and play tasks. As the study progressed, the child smiled and vocalized more frequently.

From the video, the number of prompts, location of eye gaze, number of switch errors, time to hit the switches, and non-verbal communication behaviors were measured. As the study progressed, the child required fewer prompts, made fewer errors, and carried out the tasks more quickly. The child shifted his gaze between the investigative team, the robots, and the play tasks. In most cases he was able to complete a task he had learned the previous session with no prompting. His attention span lengthened and he attempted more trials of the play tasks.

At the end of the study, the participant's teacher was interviewed to determine if she had noticed any changes in the child's behavior, social skills, language, and/or academic skills during the robot study. She commented that prior to beginning the study the child had never used two switches. This is now a school goal for him. The teacher also noted that the child had started to remember concepts from the beginning of the year during the course of the robot study. She was not sure if using the robot had helped improve the child's memory, but thought that these events might have been related. The teacher commented that she saw a difference in the child's behavior towards the investigators, but did not notice changes with others. Specifically, the teacher noted that the participant smiled when he heard that the investigators were coming, and that he became more willing to do what the investigators asked of him throughout the course of the study. The teacher also observed that the child had become more vocal but she was not sure whether that was an effect of the study. She also commented that it was nice to see him being able to play independently as this was previously not a regular occurrence for him, and that she thought he enjoyed playing with the robots.

DISCUSSION

The results obtained from this study showed that the child learned the play tasks with ease and enjoyment, leading the investigators to conclude that the Lego Mindstorms robotic system was an excellent tool to facilitate play and learning activities for children with physical disabilities. The participant displayed rapid and active learning, which was a change from the more common passive play activities that were previously available to him. He also displayed strong memory skills by

demonstrating knowledge of input required on tasks that had been previously done. The participant showed his understanding of the tasks to be carried out by pressing the switches in the correct order and for the correct length of time. The participant also displayed joint attention, as he would consistently shift his gaze between the task and investigators. Since joint attention is a precursor to language development, this suggests that this type of robot play would facilitate language development.

The participant was very successful using the first switch. His ability to progress through the play tasks with the single switch and the roverbot at such a rapid rate was precursor to the investigator's decision to introduce the robotic arm and the second switch. The child was able to use the second switch very well and almost appeared to welcome the challenges that were presented to him. This is consistent with the teacher's report that the child appeared to enjoy playing with the investigators and robots and was previously more passive in play activities. The child displayed behavior consistent with learning and memory throughout the study and this was verified by the teacher's comments.

Overall, the Lego Mindstorms robots were an excellent way to facilitate play activities for the participant in this pilot study. The child enjoyed himself, learned new play skills, and displayed increased memory abilities.

REFERENCES

1. Cook, A. M., Liu, K. M., & Hosit, P. (1990). Robotic arm use by very young motorically disabled children. Assistive. Technology, 2, 51-57.
2. Kwee, H., & Quaedackers, J. (1999). Pocus project adapting the control of the Manus manipulator for persons with cerebral palsy. Proceedings, ICORR: International Conference on Rehabilitation Robotics, Stanford, CA: pp. 106-114.
3. Howell, R. D., Mayton, G., & Baker, P. (1989). Education and research issues in designing robotically-aided science education environments. Proceedings 12th RESNA Conference: pp.109-110.
4. Cook, A. M., Meng, M. Q. H., Gu, J.J, & Howery, K (2002). Development of a robotic device for facilitating learning by children who have severe disabilities. IEEE Transactions on Neural systems and Rehabilitation Engineering, 10(3), 178-187.

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