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The importance of play: AT for children with disabilities

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ABSTRACT

The potential of robots as assistive tools for play activities has been demonstrated through a number of studies. Children with motor impairments can use robots to manipulate objects and engage in play in activities that parallel those of their typically developing peers. This participation creates opportunities to learn cognitive, social, motor and linguistic skills. By comparing disabled children's performance with that of typically developing children, robot use can also provide a proxy measure of cognitive abilities.

BACKGROUND

During typical development, play activities provide an opportunity for children to learn cognitive, social, motor and linguistic skills through the manipulation of objects. Physical impairments make it difficult for a child who has disabilities to independently manipulate objects in a play context (Musselwhite, Wagner, & Cervantes, 2008).

Assistive technologies have been used to enable play by adapting battery powered toys to be controlled by a single switch activated by a gross motor movement. This engages children and provides a sense of control, but the repetitive action of the toy causes the child to lose interest.

There are also simple electronic aids to daily living (EADLs) that allow an appliance such as a food mixer to be plugged in and controlled with a single gross movement on one switch. This allows a child to participate in activities with other children. For example a child with fair fine motor control could open a package of pudding, pour it in to a blender. Another child might add milk and a child with very limited motor control could mix the ingredients using the EADL.

One challenge with many EADL or switch controlled toy situations is that a child who is using augmentative communication must choose between controlling the toy or EADL or controlling her communication device. Anderson [5] overcame this choice problem by having children control infrared toys from their communication device and reported that this approach offers "highly motivating activities for use in the development of language" (p. 7). Although this approach solves the problem of integrating play and communication, infrared toys will always perform the same function, becoming boring after a while.

Robot applications for children

Robots have a potential learning advantage over toys or appliances since robots can be reprogrammed to perform a variety of functions and thus keep the interest of the child. They can also present increasing challenges. Young children with disabilities can control robots for manipulation of three-dimensional objects in play and school activities. Children with disabilities may also be able to carry out the robot programming on a computer to engage in problem solving.

Robots have been used successfully in a number of studies to allow children with disabilities to participate in play and engage in school-based activities. School activities aided by robots include manipulative tasks using a robot [13], pick and place academic activities [15, 16], drawing [23], science lab activities [12], science and art [10,18]. Robots have also been used to facilitate play [4, 14]. In many of these projects the focus is on the importance of play in child development and the role that robotics can play in enabling play by children who have disabilities. The IROMEC project team has developed a set of play scenarios that serve to set the context for users to be involved in the design process of appropriate robotics activities and hardware. They have identified four types of play: sensory motor play, symbolic play, constructive play and games with rules [22] and have developed a flexible modular mobile to accommodate multiple users and play scenarios [19].

Robots and cognitive development in children

Many standardized tests of cognitive ability require speech or fine motor control. This can make it difficult to ascertain the developmental level of children who have motor disorders or complex communication needs. Due to these limitations, children with severe disabilities may be perceived as being more developmentally delayed than they actually are. Robots give the child an opportunity to manipulate items and choose how to interact with their environment. Because these tasks often require problem solving, they can also provide a method for children to demonstrate their understanding of cognitive concepts.

Robots have been used to demonstrate previously unmeasured cognitive skills. Robot-based tool use was demonstrated by disabled and typically-developing children greater than 8 months in mental age by using a robot to bring an object closer to them [6]. Children aged 6-14 who had severe cerebral palsy performed a structured play task to uncover a hidden toy by activating one or more switches [7]. The majority of the participants could not be evaluated through standard cognitive measures, but teachers noticed differences in overall responsiveness, amount of vocalization and interest (i.e., increased attention to tasks) for children who used the robotic arm.

Ten children with varying physical and cognitive disabilities participated in a study using the Lego MindStorms robot [8]. Two robots were built and used in this project (Figure 1). The robot arm (left in the figure) and the roverbot (centre) car. Each robot could be programmed to perform different actions. The child used from one to four switches connected to a modified remote control (right) designed and built for this project. The child could play back a movement (e.g. a dancing robot) with one switch press or control the robot to move in four directions (left, right, forward, back) using four switches.

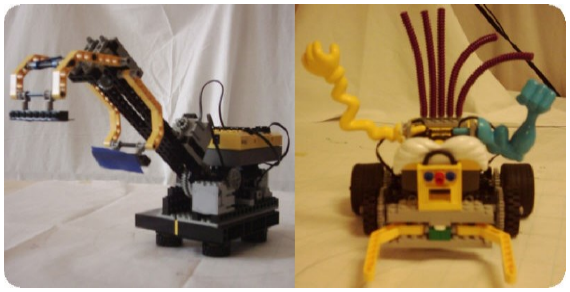

Figure 1: Lego robots and adapted controller.

The hypothesis was that children with cognitive disabilities will use a robot to interact with objects in a manner that is consistent with typical developmental levels for non-disabled children.

The children fell into three groups with respect to their cognitive level and skills attained with the robots:

1) Severe physical and cognitive disabilities: These children had limited control or understanding of the robot. They controlled the robot with a single switch to bring toys to them, or to move it across their field of vision.
2) Multiple physical and cognitive disabilities: This group had greater, but still limited, control over their surrounding environment. They were able to use one switch to control the robot in tasks such as fetching a toy or taking toys to play partners. They took turns with the researcher. This group's verbal skills improved, their willingness to interact with others increased, and their ability to concentrate on new tasks was apparent throughout the sessions.
3) Greater physical and cognitive abilities: These children controlled the robots using multiple switches. This group could drive the robot through an obstacle course, create stories, use the robot to take specific items to others, use the arm to sort and play games with other students. Their socialization skills increased, and they became more outgoing, and vocal. Their parents were pleased as they noticed changes in the home environment.

Children in groups 2 and 3 demonstrated discovery using the robots in symbolic and imaginative play. All of the children were able to demonstrate a range of cognitive skills, even though many of them were judged "non-testable" on standardized tests. The hypothesis was proven true, and a hierarchy of cognitive skills represented by robot task was developed.

Robot use by very young typically developing children

If robot-based tasks are to be used as a proxy measure of cognitive development, it is important to know how typically developing young children are able to use the robot. Few studies have address robot use with very young children. A recent study involved typically developing children aged three, four and five years [21]. They used a Lego robot to complete tasks based on the cognitive concepts of causality, negation, binary logic and sequencing. All of these tasks are related to the use of electronic assistive technologies and the use of robots for exploration and discovery.

Of the cognitive skills, causality was understood by all of the participants, negation (the concept that releasing a switch was an action) and binary logic (left and right) task were understood by the four and five years olds. The three years olds had more difficulty with negation and none were able to consistently use a two step sequence to accomplish a task. Most of the four and five year olds accomplished the two step sequence successfully. This study confirmed that robot-related tasks were dependent on developmental level. This provides the basis for using simple robot tasks to probe cognitive understanding and developmental level in children who have disabilities.

Integrating Communication and Robotic Manipulation

As described above, children who use augmentative communication devices (often called speech generating devices or SGDs) may have difficulty in integrating the control of play objects with the control of the SGD. Just as Anderson [5] integrated SGDs and infrared controlled toys, infrared robots like the Lego roverbot can be controlled via the SGD [1]. Many SGDs have the capability to learn infrared commands. Robotic control is important because much of play and selected portions of the academic curriculum involve manipulation of real objects. Controlling robots through SGDs allows children to talk while they play, similar to how typically developing children do it.

Professional experts [9] and children with and without disabilities (in preparation) performed usability testing with an integrated communication and robotic play testing platform. The robot could be used in either play back mode of stored programs or direct teloperated mode. Teleoperation was possible for the experts and older children (5 years old). Younger children (3 years old) relied on the playback of pre-programmed movement using a single switch. Children were also given the option of directing another person to do the manipulation in a play task or to do it directly with the robot. Children preferred to do activities using the robot rather than directing another person. All children used the built-in communication functions to spontaneously talk using the system during play.

A commercially available communication device was used by a 12 year old girl who has Cerebral Palsy to control Lego robots for academic activities [1,2,3]. This study established the feasibility of controlling Lego robots via an SGD for social studies, math and robot programming activities. With systems such as these, children can demonstrate and develop manipulative, communicative and cognitive skills in an integrated way.

Summary

Small robots can provide interesting and engaging opportunities for children with disabilities to engage in play. They can also allow access to learning activities involving manipulation. The ways in which children use robots reveals a great deal about their cognitive skills and problem solving abilities. When combined with augmentative communication device use, robots provide a powerful active component to play and academic activities that is not possible with the communication device alone.

References

[1] K. Adams, J. Yantha, and A.M. Cook, Lego Robot Control via a Speech Generating Communication Device for Play and Educational Activities, *RESNA Annual Conference*, 2008, Washington, DC.

[2] K. Adams, J. Yantha, and A.M. Cook, Lego Robot Control via a Speech Generating Communication Device for Operational and Communicative Goals, *International Society for Augmentative and Alternative Communication - 13th Biennial ISAAC Conference*, 2008, Montreal, QC.

[3] K. Adams and A.M. Cook, Using an Augmentative and Alternative Communication Device to Program and Control Lego Robots, *RESNA Annual Conference*, 2009, New Orleans, LA.

[4] A. Andreopoulos and J.K. Tsotsos, A framework for door localization and door opening using a robotic wheelchair for people living with mobility impairments, *Proceedings of the Robotics Science and Systems (RSS) 2007 Manipulation Workshop: Sensing and Adapting to the Real World*, June 30, 2007, Atlanta.

[5] Anderson, A. (2002, October 3-5). *Learning Language Using Infrared Toys.* Paper presented at the 23rd Annual Southeast Augmentative Communication, Birmingham, Alabama.

[6] A.M. Cook, P. Hoseit, M.L. Ka, R.Y. Lee, and C.M. Zenteno-Sanchez, Using a robotic arm system to facilitate learning in very young disabled children, *IEEE Transactions on Biomedical Engineering* **35**(2) (1988), 132-7.

[7] A.M. Cook, B. Bentz, N. Harbottle, C. Lynch, and B. Miller, School-based use of a robotic arm system by children with disabilities, *IEEE Transactions on Neural Systems and Rehabilitation Engineering* **13**(4) (2005), 452-460..

[8] A.M. Cook, K. Adams, J. Volden, N. Harbottle, and C. Harbottle, Using Lego robots to estimate cognitive ability in children who have severe physical disabilities, *Disability and Rehabilitation: Assistive Technology* (in press).

[9] M. Corrigan, K. Adams, and A.M. Cook, Development of an Interface for Integration of Communication and Robotic Play, *RESNA Annual Conference*, 2007, Pheonix, AZ.

[10] S.P. Eberhardt, J. Osborne, and T. Rahman, Classroom evaluation of the Arlyn Arm Robotic Workstation, *Assistive Technology* **12**(2) (2000), 132-43.

[11] W.S. Harwin, A. Ginige, and R.D. Jackson, A robot workstation for use in education of the physically handicapped, *IEEE Transactions on Biomedical Engineering* **35**(2) (1988), 127-131.

[12] R. Howell and K. Hay, Software-based access and control of robotic manipulators for severely physically disabled students, *Journal of Artificial Intelligence in Education* **1**(1) (1989), 53-72.

[13] G. Karlan, S. Nof, N. Widmer, I. McEwen, and B. Nail, eds., Preliminary clinical evaluation of a prototype Interactive Robotic Device (IRD-1), *Proceedings of the ICAART 88*, 1988, Montreal, Quebec.

[14] G. Kronreif, M. Kornfeld, B. Prazak, S. Mina, and M. Fürst, Robot assistance in playful environment – user trials and results, *Proceedings of the IEEE International Conference on Robotics and Automation*, April 10-14, 2007, Rome, Italy.

[15] H. Kwee, J. Quaedackers, E. van de Bool, L. Theeuwen, and L. Speth, Adapting the control of the MANUS manipulator for persons with cerebral palsy: an exploratory study, *Technology & Disability* **14**(1) (2002), 31-42.

[16] H. Kwee, J. Quaedackers, E. van de Bool, L. Theeuwen, and L. Speth, eds., POCUS project: adapting the control of the MANUS manipulator for persons with cerebral palsy, *Proceedings of the International Conference on Rehabilitation Robotics (ICORR)*, July 1-2, 1999, Palo Alto, CA.

[17] Musselwhite, C., Wagner, D., & Cervantes, O. (2008). *AAC Authors: Writing Beginning Books for Young Readers.* Paper presented at the 13th Biennial Conference of International Society for Augmentative and Alternative Communication (ISAAC) Montreal, QC.

[18] S. Nof, G. Karlan, and N. Widmer, Development of a prototype Interactive Robotic Device for use by multiply handicapped children, *Proceedings of the ICAART 88*, 1988, Montreal, Quebec.

[19] M. Patrizia, M. Claudio, G. Leonardo, and P. Alessandro, A robotic toy for children with

special needs: from requirement to design, *Proceedings of the 11th International IEEE Conference on Rehabilitation Robotics*, 2009, pp. 918-923.

[20] Plaisant, C., Druin, A., Lathan, C., Dakhane, K., Edward, K., Vice, J. M., et al. (2000). *A Storytelling Robot for Pediatric Rehabilitation.* Paper presented at the ASSETS'00, Arlington, Virginia.

[21] L. Poletz, P. Encarnação, K. Adams, and A.M. Cook, Robot Skills of Preschool Children, *RESNA Annual Conference*, 2009, New Orleans, LA.

[22] B. Robins, E. Ferrari E, and K. Dautenhaun, Developing scenarios for robot assisted play, *Proceedings of the 17th Annual International Symposium on Robot and Human Interactive Communication,* 2008, pp. 180-186.

[23] J. Smith and M. Topping, The introduction of a robotic aid to drawing into a school for physically handicapped children: a case study, *British Journal of Occupational Therapy* **59**(12) (1996), 565–569.