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Interface design with integrated communication and robotic manipulation to encourage play

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Introduction

Play is one of the most important means through which children learn about the world, and show and develop their physical, language, cognitive, social and creative abilities [1]. Children typically develop these skills in an integrated natural way, but children who have complex communication needs and severe physical disabilities often rely on the use of assistive technologies to augment their functional limitations. For example children may use augmentative and alternative communication (AAC) methods for communication. Play has been established as a motivating context for children who use AAC to build language and social skills while they direct play activities and make comments [2]. However, rather than only directing others to perform the manipulative portions of the play activity, children with severe disabilities could use assistive robots to independently do the manipulation. Robotic systems have been developed for children with disabilities (for a summary see [3]). Some have panels for direct selection for choosing robot control functions and others use switches and scanning. Some robots could be controlled by playing back a pre-stored program with one "press of a button" or directly controlling each degree of freedom of the robot. However, with all of these systems, the AAC device would have to be removed in order to access the robot controls. A desirable alternative is to be able to control the robot through the AAC device, using the same access method (head pointing, scanning, touch). This option is possible with some robots, like the Lego Mindstorms(TM) robots, due to the infrared and Bluetooth output capabilities of some AAC devices.

Having access to both communication and manipulation in play has the potential to enhance the play experience of children with disabilities, but there are several questions that arise due to the addition of manipulation:

1 - Will children prefer to do things themselves with the robot instead of directing others to do it?

2 - Which robot control mode (playback or direct control) supports children to make AAC voice output?

3 - What navigation system (having all of the robot commands and language symbols on one page, or linked to different pages) will support children to make AAC voice output?

Methods

Participants in this study included three males and three females aged 3, 5 and 7 respectively. (Participants 1-6). Additionally, three five year old children (two males, one female) with severe communicative and mild physical disabilities participated (Participants 7-9). All of the children directly accessed the interface buttons with their fingers. The children with disabilities used a key guard.

To examine the research questions, a play scenario was devised where a zookeeper talks to some animals while he gives them food and water. This scenario was based on Taylor and Iacono [4] who examined whether using scripts would increase communication output of a child with a developmental delay. Materials included "food" (apple slices) and "water" (blue marbles), plastic dishes for apple slices, glasses for water pellets (marbles), and a small hippo, giraffe and zookeeper dolls.

To examine Question 1, two ways of moving the zoo keeper to the hippo/giraffe or the food/ water were devised: A car-like **robot** was built from a Lego Mindstorms kit for the children to do tasks themselves and a toy **truck** about the same size of the robot was pushed by a research assistant (RA) as directed by the children.

To examine Question 2, two movement control modes were implemented: robot control by **playback** of one of two stored sequence of movements (i.e., go get food, go get water) or by **direct** commands to individual motors (e.g., forward, backward, left, and right). The RA simulated these same functions with the truck by pushing it through the "program" sequence or the direct commands.

To examine Question 3, either all buttons for the movement and communication symbols were available on one page (**AIO**) or communication symbols were on one page and the movement symbols were on another page and linked through a page selection button (**Linked**).

Four interfaces were developed to incorporate these conditions (all interfaces had both robot and truck control commands). The robot and communication symbols were implemented in the prototype software program called ATCreator(TM), installed on a Sahara(TM) tablet computer with a resistive touch screen. Infrared output was obtained using a RedRat(TM) two-way infrared controller connected via the USB port. Photographs of the actual items were used as symbols for robot/truck programs and direct control and communication symbols. Communication symbols included the words: “HELLO”, “GOODBYE,” “HIPPO,” “GIRAFFE,” “HUNGRY,” “THIRSTY,” “YES,” “NO” and “FINISHED.”

Sessions were approximately 60 minutes long with breaks. The investigator first demonstrated the script and moving the robot and truck using communication symbols "**HELLO HIPPO** are you **HUNGRY**?", "**YES?** okay" and using movement symbols "Go get food". Then the children used each interface in the order shown in Table 1.

A video camera was positioned for input directly into Morae Usability Testing Software(TM). Morae automatically stores and synchronizes a video image and a recording of on-screen computer actions along a single timeline. The video was coded for occurrences of movements with the robot or truck as well as the occurrences when the participant used a communication symbol. Inter-rater reliability was examined for 20% of the sessions, with specific time frames of videos chosen at random. Inter-rater reliability of the movements was 92% and that of the communication events was 99% (calculated as the frequency ratio = smaller total divided by the larger total [5]). The rates of occurrences were used in the data analysis.

Results

Table 1 shows the proportion of movements done with the robot rather than the truck (robot/(robot+truck)*100%). During the playback mode, the range in rate of movement symbol presses was 0.1 to 1.5 with a median of 0.6. During the direct control mode, the range was 0.2 to 43.3 with a median of 8.2. The table also shows the rate of communication symbol uses.

Table 1. Proportion of robot movements (%) and rate of communication symbol (symbols/minute) use in each condition

			Proportion robot movements		Communication	
	Part.	Age	Playback	Direct	Playback	Direct
All in One (AIO)	P1	7	(1st) 25%	(3rd) 82%	6.0	4.1
	P2	7	64%	89%	3.8	4.3
	P3	5	78%	99%	2.0	0.9
	P4	5	86%	46%	2.0	2.2
	P5	3	67%	96%	2.1	0.7
	P6	3	55%	No attempt	2.2	No attempt
	P7	5	70%	99%	3.3	2.0
	P8	5	64%	98%	2.6	1.6
	P9	5	50%	97%	4.1	1.2
Linked	P1	7	(2nd) 92%	(4th) 67%	7.8	3.7
	P2	7	100%	100%	6.7	1.9
	P3	5	100%	100%	1.9	0.8
	P4	5	No movements	No attempt	2.1	No attempt
	P5	3	100%	No attempt	1.8	No attempt
	P6	3	88%	No attempt	3.3	No attempt
	P7	5	56%	0%	3.0	1.9
	P8	5	88%	98%	1.5	1.7
	P9	5	80%	99%	2.1	0.8

Discussion and Conclusion

In this study, children clearly preferred to directly move the robot to accomplish the tasks rather than using the AAC to direct the RA to move the truck (only three entries under proportion of robot movement were not ≥ 50%). The three year old children could do the playback mode, but had a difficult time with direct control of the robot (shown with "No attempt"). When the children used the playback mode the amount of communication output was higher than when they directly controlled the robot/truck for almost all participants in both the All-in-One and Linked pages modes. This result shows that there is cognitive overhead to using the direct control commands. Children will concentrate on moving the robot, and thus, spend less time talking. The results regarding having the communication commands all in one page or on linked pages were less clear. The children with disabilities seemed to make more communication output with the All in One page. Participants 1, 2, and 6 spoke more with the linked pages (which was the second condition), but they already had practice with the script.

In summary, children will likely prefer to do things themselves if they have the opportunity. They may need the robot to operate with playback commands if they are less than 5 years old. Putting the communication and movement symbols on one page may also be beneficial for young children. Taken together, these results have implications not only for designing AAC device interfaces for controlling robots from AAC devices for play, but also controlling toys, and TVs, etc. Though this study has limitations, it addresses the call to the AAC community to investigate the impact of integration of functions so that children can engage in play and communication seamlessly rather than having to choose between them [6].

The authors disclose they have no financial or other interest in objects or entities mentioned in this paper.

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