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Robot-enhanced Phonological Awareness Intervention for a Child with Cerebral Palsy

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Introduction

Robots have been shown to be an effective means of increasing non-disabled children's interaction with the learning environment for tasks such as drawing [8], learning spatial concepts [5] and other classroom tasks [7]. This study sought to evaluate the use of robot-enhanced instruction for the development of phonological awareness skills by a child with complex communication needs. As far as the current researchers are aware, no studies to date have used robot technology to target phonological awareness skills, though robots are being used more often in classroom research, to investigate their viability as an interactive learning tool for both disabled and non-disabled children.
The research questions were:

1. Will phonological awareness abilities be improved through the use of robot-based instruction?
2. Can a robot-based phonological awareness program be delivered by an educational assistant as part of a student's daily routine.
3. Will specific instruction in phonological awareness skills affect later reading ability?

Participant

The participant was a ten-year-old grade 5 female with spastic athetoid cerebral palsy. She used a Vantage[1] speech generating communication device. Other adaptive

[1] Pretnke Romich, http://www.prentrom.com/

technology included specialized computer software at school, manual and electric wheelchairs, and a walker. She had developed skill in controlling a robot through a previous project.

Materials

To ensure that no verbal responses were required, communication boards for picture stimuli, number choices, and yes/no were developed and used as initial and final probes. There were twelve types of tasks with six sets of 10 probes each: sound and word recognition, initial phoneme recognition , final phoneme recognition, rhyming recognition, rhyming choice, sentence-word segmentation, word-syllable segmentation, word-phoneme segmentation, deletion – word and sound level, manipulation – word and phoneme level and blending – word and phoneme level. Intervention tasks were performed using the Lego Mindstorms™ Roverbot controlled by two hand-activated switches for stop and go and two head-activated switches for left and right turns. The switch signals were transmitted to the robot using an infrared remote control (Figure 1).

Figure 1: Participant controlling the robot.

Procedure

The study followed a single-subject ABA design. Initial Probe Testing sessions took place over a three week period. For the tasks involving picture stimuli (e.g., rhyming, manipulation, blending), a word was spoken while pointing to the corresponding picture choices. This procedure was completed twice with the participant indicating her choice of correct answer using eye gaze or arm gesture. For yes/no tasks two words were spoken and the participant was asked if they contained the same beginning/ending sound, or if they rhymed. For the segmentation tasks a word or sentence was read and the participant was asked to indicate how many words, syllables or sounds it contained by placing her fist on the number of her choice.

Based on results of the pre-treatment probes (Table 1) three phonological awareness skills were targeted for treatment: (1) segmentation of words into phonemes, (2) manipulation of phonemes in words, and (3) phoneme discrimination.

Sessions took place over a period of 8 weeks in the participant's school. One phonological area was targeted during each session using a variety of robot tasks such as rolling the robot over an obstacle (to indicate a segmentation) or driving it to an object to indicate an answer to a question (e.g., carrying *tree* to the location of the number three to indicate the change in initial phoneme (from /th/ to /t/). Most sessions were videotaped and the EA made general written comments about the session. Post intervention probes took at the end of treatment and three months later.

RESULTS

The participant's performance on the pre- and post- treatment probes is summarized in table 1. Bolded items are those targeted in the intervention.

Table 1: Performance on pre- and post-treatment probes

	1 S&WR	2 IPR	3 FPR	4 RR	5 RC	6 SSW	7 SWS	8 SWP	9 DW	10 DP	11 MP	12 BL
Pre	88	**85**	**78**	95	95	60	72	**25**	85	78	**70**	100
Post	90	**85**	**85**	90	100	60	60	**35**	100	85	**90**	95

(S&WR = sound and word recognition; IPR = initial phoneme recognition; FPR = final phoneme recognition; RR = rhyming recognition; RC = rhyming choice; SSW = segmenting sentences into words; SWS = segmenting words into syllables; SWP = segmenting words into phonemes; DW = deletion at word level; DP = deletion at phoneme level; MP = manipulation of phonemes at the beginning, end, and middle of words; BL = blending of words, syllables and phonemes)

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DISCUSSION

The participant improved in her ability to segment words into their individual sounds (phonemes) from 25%t to 35% following treatment. While this gain did not show mastery of the concept of segmentation, it did indicate that the child's skills in this area responded positively to treatment. Although the robot segmentation task allowed for a more tangible experience, this task remained difficult for the participant. A sequential segmentation task awarded points based on whether the student can identify both the sounds in a given word and their sequence [10]. The robot intervention task required driving the robot over one 'speed bump' per speech sound, which is comparable to a child tapping out the sounds as she heard them spoken by a teacher. One difference in these tasks is that a typical child might also rehearse the sounds as she heard them. This 'subvocal rehearsal' may or may not be necessary for phonological awareness skill acquisition. Dahlgren Sandberg and Hjelmquist [3] suggested that subvocal rehearsal was necessary for a nonspeaking child to utilize existing phonological awareness skills, whereas Bishop and Robson [1] proposed that though their literacy skills were often not the same as their peers, subvocal rehearsal was not necessary for children with no speech to be able to spell non-words.

The participant increased her ability to manipulate a phoneme within a word from 70% to 90%. The post- treatment manipulation tasks also contained more challenging items than the pre- treatment probes. The participant gained both in her ability to recognize a new word based on a changed consonant recognition of different vowel sound manipulations. This was remarkable because vowels are inherently more difficult to detect than consonants.

The participant's initial and final phoneme discrimination remained relatively unchanged (Table 1). We targeted an apparently adequately developed skill because certain sounds were more difficult than others for the participant to discriminate (i.e., /l/, /s/ and /sh/), and we wanted to challenge her to develop a more complete sound discrimination repertoire. Discrimination of initial and final sounds has been identified as the most important phonological awareness skill [10]. Thus, the intervention delivered by the EA in the classroom did result in improvement in some phonological skills, answering the first two research questions.

Two studies have indicated that phonological awareness abilities alone are not sufficient for children to achieve acceptable levels of literacy [3,4]. Based on these studies, there may be some as of yet undetermined quality or aspect of phonological awareness that is crucial in helping those who have limited ability to speak achieve high levels of literacy. It has been posited that because people who do not speak do not or cannot articulate the sounds using speech musculature, and that this puts them at a disadvantage for sounding out unfamiliar words when reading [5]. Others suggested that sounding out words using speech muscles is not necessary in developing adequate literacy skills, but consistently lower literacy skills are achieved by children with little or no ability to speak as compared to typically developing children [1].

Research focusing on the assessment of phonological awareness abilities, literacy abilities, and their relationship has established a pattern of low literacy abilities in children who have little ability to speak (often with limited motor skills). Few studies have investigated different methods of *treatment* targeting phonological awareness abilities in this population. Direct instruction in the phoneme to grapheme correspondence followed by phonological awareness instruction for non-speaking children showed a steady improvement in ability to encode (i.e. , spell) words and non-words [2]. This result is supportive of the direct method of phonological awareness instruction in the present study.

The participant's reading comprehension was tested periodically during the school year to determine grade level correspondence. The EA noted that before the robot intervention, the participant was reading books aimed at 'grade 1, 2 months' level, and following intervention she was reading books aimed at children at the 'grade 1, 6 months' level. Since 4.5 months had passed between the start of treatment and the final follow up probe, there is some indication that the third research question was also answered in the affirmative.

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