Improving the Language Ability of Deaf Signing Children through an Interactive American Sign Language-Based Video Game

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Abstract: We present the design of an interactive computer game-based intervention, CopyCat, in which deaf children use sign language to direct the actions of a character in the game. We conducted a study to quantify the game's impact on expressive language development using twelve participants from a local school for the deaf. Learners in the experimental group improved significantly in their receptive, expressive, and sentence repetition abilities as opposed to those in the control group.

Motivation

Ninety percent of deaf children are born to hearing parents (Gallaudet, 2001). These parents may not know sign language, or have low levels of proficiency. Deaf children of hearing parents develop language in the same sequence as deaf children of deaf parents and hearing children of hearing parents, but at a much slower pace. The slow language development for these children has been attributed to incomplete language models and a lack of linguistic interaction (Spencer & Lederberg, 1997). CopyCat seeks to create an interactive, entertaining way to provide additional language exposure and practice for deaf children.

Game Design and Interaction Model

CopyCat includes six language learning games for children ages six to eleven. We used computer-assisted language learning practices (Warschauer, 1996) and research on child-adult interactions (Spencer & Lederberg, 1997; Schiefulbusch & Bricker, 1981) to help design these games. Each game entails a quest by the main character to collect items to remedy a problem, such as rescuing kittens from a villain. Children tell the main character what to do via sign language. Figure 1 shows the CopyCat interface. The main game screen is indicated by the letter A. The obstacle the child must help the main character overcome (the phrase that the child must sign) is indicated by B. In this case, the child must sign, SNAKE-UNDER-CHAIR. Before signing, the children must push a "talk" button (C) to "attract the hero's attention" and to activate the automatic sign language recognition system. The children can view themselves directly on the computer as they are signing (D). When they are finished, they push the "talk" button (C) again, stopping the automatic recognition system. If the children are uncertain what to sign, they can click a "help" button (E) to see the "tutor" (F) demonstrate the required phrase. Our tutor performs the role of the good adult language model (Schiefulbusch & Bricker, 1981). The tutor is always available and responds in an appropriate linguistic manner. The tutor is also extremely patient as the children can ask for help as many times as they like, and the tutor never becomes tired or frustrated.

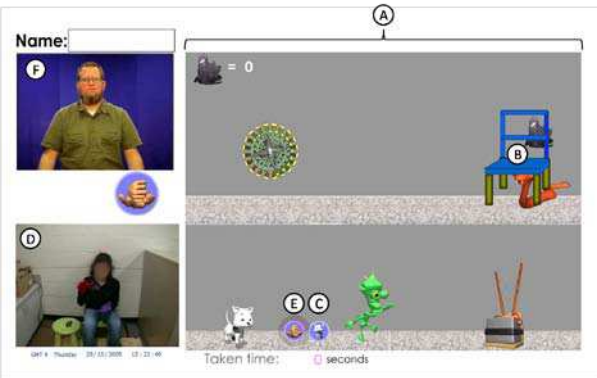

Figure 1. The CopyCat Interface (see text for description).

After the child signs a phrase, the sign language recognition system evaluates the child's utterance to determine its accuracy. Features derived from computer vision, and motion sensors embedded in gloves worn by the child, supply the recognizer with information of the child's signed phrase, similar to (Brashear et al., 2006). If the child's utterance is incorrect, a question mark appears above the character's head, indicating that

the he did not understand the child's sign. The child must try again to communicate until the computer recognition system judges the sign to be of sufficient clarity, but is limited to five attempts to prevent the child from becoming frustrated. All game sentences are of the structure Subject-Preposition-Object. There were twenty 3-sign sentences, twenty 4-sign sentences, and twenty 5-sign sentences.

Study

Twelve participants between the ages of six and eleven were recruited at a local residential school for the deaf. Participants were asked to configure toys based on signed instruction (receptive); express an event depicted in a stop-motion animation (expressive); and repeat a signed phrase (sentence repetition), at both the beginning and end of the study. Most vocabulary used in the pre and post tests was not used within CopyCat. A one-tailed, one-way between-groups analysis of covariance was conducted to compare the effect of using CopyCat on the learners' receptive, expressive and repetition test scores. After adjusting for pre-intervention scores, there was a significant difference between the control and experimental groups on post-intervention scores for all three tests: the receptive language test $F(1, 9) = 11.83$, $p < 0.05$, partial eta squared = 0.57, expressive language test $F(1, 9) = 8.29$, $p < 0.05$, partial eta squared = 0.48, and the sentence repetition test $F(1, 9) = 3.6$, $p < 0.05$, partial eta squared = 0.29. There was a strong relationship between the pre-intervention and post-intervention scores on all three tests. The learners who played CopyCat improved their test scores on all three measures significantly more than the learners who did not. Table 1 shows the mean scores on each of the three tests for both groups at the beginning and end of the study.

Table 1. Table of Means for Pre and Post Intervention Scores

Test	*Group*	*N*	*Pretest M (SD)*	*Post-test M (SD)*
Receptive Language	Control	6	4.00 (4.69)	4.50 (5.21)
	Experimental	6	5.17 (3.66)	8.83 (5.04)
Expressive Language	Control	6	5.50 (6.32)	7.33 (5.05)
	Experimental	6	4.50 (3.39)	10.33 (4.37)
Sentence Repetition	Control	6	6.67 (4.84)	7.33 (5.05)
	Experimental	6	5.17 (2.79)	7.83 (3.37)

Conclusion

CopyCat demonstrates that automatic sign language recognition is of sufficient quality to be used in interactive games with positive educational effects. While CopyCat is intended to supplement, not replace, high-quality adult-child sign language interaction, its interaction method provides a useful computer-based method for rehearsing language skills.

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