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ABSTRACT

The purpose of this study was to examine the impact of visual and auditory presentational features on young children's selection and memory for verbally presented content. Assessed as a function of action and sound were preschool children's preferential selection and recall of words presented in a computer microworld. A computer microworld consists of scenarios providing options to move various objects on a static but vivid pictorial background. The objects, called "sprites," are programmed to have particular shapes, colors, movements, and sounds. In this study, 40 preschoolers, equally distributed by sex, were randomly assigned to one of four versions of a microworld. Within each version, 24 sprites were randomly assigned action and sound properties. The experimental design was counterbalanced so that in each version every sprite assumed all possible factorial combinations of action and sound. Children preferentially selected and recalled more words presented with action than words presented without action. Although children selected sounds, sounds interfered with children's recall of linguistic information. Results supported an action superiority hypothesis and an auditory interference hypothesis. These results suggest that action should be an integral component of educational computer software designed for young children. Cited are 25 references. (RH)

# Computer Presentational Features for Young Children's Preferential Selection and Recall of Information

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RUNNING HEAD: Computer Presentational Features



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## Abstract

Preschool children's preferential selection and recall of words presented in a computer microworld was assessed as a function of action and sound. Forty preschoolers, equally distributed by sex, were randomly assigned to one of four versions of a microworld. Within each version, 24 sprite objects were randomly assigned properties of action and sound. The design was counterbalanced so that across the four versions, each sprite assumed all possible factorial combinations of action and sound. As expected, children preferentially selected and later recalled more words presented with action than words presented without action. Although children selected sounds, sounds interfered with children's recall of linguistic information. Results support an action superiority hypothesis and an auditory interference hypothesis. The practical application is to use action as an integral component of educational computer software designed for young children.

# Computer Presentational Features for Young Children's Preferential Selection and Recall of Information

One of the central debates in the television literature is the role of visual presentation in children's comprehension of verbally presented content. The debate began when Hayes and Birnbaum (1980) argued that visual presentation interfered with children's processing of verbal linguistic information. No one, however, has examined the possibility that nonlinguistic auditory features might inhibit processing of verbal linguistic content, even though both types of sound must be processed through the same auditory channel.

Like television, microcomputers can also present information through visual and auditory symbol systems. Microcomputer software can also be programmed to exert tight control over information presentation, allowing systematic examination of the attractiveness and memorability of features (Lepper & Milojkovic, 1986). The purpose of this study was to examine the impact of visual and auditory presentational features on young children's selection and memory for verbally presented content. Because of the difficulty in exerting tight control over features in televised presentations and the potential to create software that is both apppealing and educational for children, we extend the visual superiority debate from television content to computer software. In addition, we examine the possibilty of an auditory superiority effect.

## The Visual Superiority Hypothesis

Visual presentation has been shown to increase and to decrease children's comprehension of verbally presented content. Hayes and Birnbaum

(1980), for example, demonstrated that when the audio track of one television program was paired with the video track of another television program, preschoolers recalled the visually presented content better than the verbally presented content. Visual superiority effects were most pronounced at young ages. Visual superiority effects are also apparent when children are instructed to watch a television program which they will be tested on later (Field & Anderson, 1985; Hayes, Chemelski & Birnbaum, 1981). Presumably, verbally presented television content is difficult to understand; therefore, children concentrate on processing the comparatively concrete visual track at the expense of the abstract, and potentially informative, auditory track.

The visual superiority debate has shifted emphases from questions about the memorability of visual presentation per se to questions about the memorability of action (Calvert, Huston, Watkins & Wright, 1982; Gibbons, Anderson, Smith, Field & Fisher, 1986; Pezdek & Stevens, 1984). More importantly, in certain instances, action has enhanced, rather than disrupted, children's comprehension of verbally presented content. For example, Gibbons et al. (1986) found that young children recalled dialogue better when a story was presented in audiovisual modes rather than an audio only mode. Children who viewed television actions which supported the verbal linguistic program messages recognized more central story content than did children who saw low action sequences paired with verbally presented messages (Calvert et al., 1982). Action may facilitate comprehension because it provides a visual, iconic form to represent content, which is developmentally appropriate for young children (Bruner, Olver, & Greenfield, 1968). When paired with language, dual modes are provided which children can use to represent content.

The discrepancy in findings regarding visual superiority involves at least two variables. First, the degree to which the visual and auditory tracks supplement versus contradict one another is central. If the tracks are congruent, then the visual superiority effect seems to facilitate children's comprehension. If the tracks are inconsistent then children remember the visual track better than the auditory track (Hayes & Birnbaum, 1980; Pezdek & Stevens, 1984). Secondly, information processing may be modality specific (Beagles-Roos & Gat, 1983; Calvert, Huston, & Wright, in press). That is, visual presentation may be recalled in a visual form whereas verbal information may be recalled in an auditory form.

A major problem in studying visual superiority in television presentations is the production cost which typically forces examination of already existing programs. Therefore, many designs are correlational and lack tight control of information presentation. By contrast, computer software can tightly control the presentation of action, thereby allowing clear empirical investigation of the role of action for children's memory of verbal linguistic information. Although informal observations suggest that children find action an appealing feature in computer arcade games, empirical work has not yet documented the systematic appeal or the potential memorability of action for either computer games or for educational software.

Auditory Superiority Hypothesis

Whereas visual presentation can supplement auditory presentation, interference effects may be more apparent when there is competing information on the auditory track of a presentation More specifically, interesting sounds may be processed and rehearsed at the expense of verbal linguistic information. In contrast, interesting sounds may also call attention to important verbal content.

In the television area, sound effects have been used to highlight certain content for further processing, just as a spotlight can call attention to certain information in a play (Wright & Huston, 1983). When interesting sounds were presented immediately before key information, children were more likely to orient and attend to targeted content. More importantly, selective attention at these key televised events has increased children's comprehension of both abstract, linguistic content (Calvert & Gersh, in press) and of visual integration of the key scenes of a television program (Calvert & Scott, 1987). Beneficial effects of sound were greatest at young ages, particularly for boys.

Sounds may also increase children's interest in computer software. Presumably, the curiosity that children experience when they hear unusual sounds motivates them to attend to the software, or unusual sounds can reinforce children who are performing well (Malone, 1981). Orienting functions that sound can serve in the computer area, however, are limited. Specifically, children are likely to look at a computer most of the time since responses by the child are required for the software to operate whereas children only attend to about 50% of a television program since the program continues to play regardless of children's responses.

While sound can increase children's comprehension in certain instances, interesting sounds may also interfere with young children's processing of verbal linguistic information. For example, kindergarten and first graders did not preferentially listen to a meaningful story presented with a dull soundtrack over a nonmeaningful story presented with a lively soundtrack, but second graders did demonstrate preferences for meaning (Bohannon & Friedlander, 1973). Because sound effects and language are both processed through the auditory channel, children may rehearse the interesting sounds rather than the verbal labels.

Computer Microworlds

Papert (1980) defined a computer microworld as scenarios with options to move different objects on a static but vivid pictorial background. The objects, called sprites, are programmed to have certain shapes, colors, movements, and sounds. Lawler (1982) created a microworld called "beach world" to teach his young daughter to read a set of words. Once the name of the sprite was typed on the computer, the sprite appeared on her beach.

Although children have been shown to learn from interactions with microworlds (Lawler, 1982; Papert, 1980; Shade & Watson, 1987), the specific features of sprites that may lead to optimal interest and learning have not been extensively explored. Because children's sensory curiosity may be increased by certain audio and visual microcomputer effects (Lepper & Milojkovic, 1986), children may use perceptual salience as a way to select and recall content. Specifically, computer features that embody perceptually salient characteristics like movement and novelty are likely to attract children's attention. As in the television area, salient perceptual features may be memorable to children (Wright & Huston, 1983), or salient computer features may distract children from remembering the most important information.

## The Present Study

The purpose of this study was to examine the impact of action and sound on young children's preferential selection and recall of verbal cont ,nt presented in a computer microworld. An analysis of content presented via moderate versus no action in a computer-simulated environment sheds light on the visual superiority ,thesis because content can re..ain constant while objects are programmed to move or not move. Sounds will allow the examination of the role of perceptually salient auditory features on children's recall of verbally presented content. Such information extends the debate about the role of visually and auditorily presented content to new technologies, potentially shaping their development. We ex.mine preschoolers because feature effects in the television area are most pronounced at young ages. Sex differences are included to examine if boys are more responsive to computer features than are girls.

## Method

### Subjects

The sample consisted of 40 preschoolers ($\underline{M}$ = 5 years, 1 month), equally distributed by sex, who attended either day care or nursery school programs in a moderately-sized Southeastern city. Within sex groups, children were randomly assigned to one of four versions of a computer microworld.

Microworld Treatment Conditions

The microworld was the same "parkworld" across all treatment conditions. On the color monitor, a computer screen depicted a park scene which had a green grassy area, a blue lake, a blue sky, a black train track, and a brown road. Twenty-four sprites, i.e., programmable cursor points depicted as objects, could appear in parkworld by keying in (typing) the word for the sprite object. The sprite objects belonged to one of six categories: people (mom, dad, girl, boy); water animals (duck, fish, frog, turtle); land animals (cat, dog, horse, bird); vehicles (car, train, truck, plane); nature (cloud, sun, tree, flower); and toys (ball, kite, wagon, boat).

Within each version of the microworld, the 24 sprite objects were randomly assigned properties of action and sound. The design was counterbalanced so that across the four versions, each sprite object assumed all possible combinations of action and sound. This allowed assessment of the properties of sprites, independent of the attractiveness of a particular sprite. Properties of the sprites within each of the four versions are presented in Table 1.

Insert Table 1 about here

After each word was typed, a sound either occurred or did not occur as the sprite objects either appeared with action (motion) or with no action (in still frame). The sounds were nonmeaningful but distinctive noises that could be generated on an Apple IIe microcomputer. For example, the airplane made a beeping noise. Movement was always moderate, approximating the speed of a walk. Objects performed the actions appropriate for the designated sprites. For example, the train moved along the railroad track, and the fish swam in the pond. Parkworld, programmed in Sprite LOGO, requires a Sprite Logo board. Specific documentation is reported elsewhere (Watson, Calvert, & Popkin, 1987).

Procedure

For four consecutive days, children individually came to a room where they interacted 15 to 20 minutes with their microworld on an Apple IIe microcomputer. In order to familiarize children with the sprite properties of objects within their particular parkworld, the sprites were presented each day by an experimenter who keyed in each word as she read the following story called "An afternoon in the park."

> The Blue family decided to have a picnic in the park. They followed an old **truck** to the parking lot and found a place to leave the **car**. They watched a **plane** fly over the park. The family decided they would wait until another afternoon to ride the park **train**. **Mom, Dad,** the **boy** named Jimmy, and the **girl** named Susie got the picnic bas t and blanket.
>
> They found a clear grassy area for their picnic across from the playground. Lots of people were playing **ball**. Jimmy and Susie saw a **kite** flying. Jimmy watched a toy **boat** sailing in the pond. Susie saw a **wagon** near the pond.
>
> During lunch, Jimmy and Susie saw a **duck** waddle into the pond. Jimmy watched a **frog** jump and wondered if he could catch one. Susie saw a **turtle** crawl out on the grass and thought it would be more fun to catch than a frog. They even saw a big **fish** splash in the pond.

Across from the pond, a baby **horse** raced through the park. A **dog** chased a **cat**. Jimmy and Susie saw a new kind of **bird** fly overhead.

There was only one small **cloud** in the sky so the **sun** seemed really bright. They walked past a **flower** on their way to an oak **tree**.

By late afternoon, everyone was tired. As they walked back to the car, Jimmy and Susie planned the toys that they would bring on their next trip to the park.

Comprehension

Preferential Selection Scores. Next children selected one of four words from pictures of sprites that represented the four factorial combinations of action and sound. For this task, the four sets of six pictures had been drawn and placed in a notebook. The child was asked to choose one picture from each of the six pages to put in their parkworld.

Ea h time a selection was made, the experimenter circled the child's response on an answer sheet. Then the child was given a 5" x 7" index card of the particular sprite selected. The index card had the word, a picture of the sprite, and a drawing of the computer keyboard with relevant letters of that word highlighted in yellow. The child was asked to type the word that was on the index card. The experimenter helped the child key in the word as needed. After each word was correctly typed, the sprite appeared in parkworld. If the word was typed incorrectly, the computer program printed "I don't know that" on the screen, and the child retyped the word. This process was repeated for the six sets of four words for each of the four daily sessions. At the end of each session, a printout was made of the words selected by the child.

Preferential selection scores were computed by summing the number of sprite objects in the 2 x 2 factorial cells which children selected for each of the four sessions. There were 6 scores for each child each day. The maximum possible number of words in the 2 x 2 within-subject cells was 6.

Free Recall Scores. On the fifth day, children individually participated in a thirty minute posttest. First, the experimenter said, "Tell me the names of all the objects you can remember from parkworld." The experimenter recorded their responses in consecutive order from the first to last response. Then the experimenter said, "That's good. Can you think of any other objects?" If children named any other objects, those objects were then recorded by the experimenter in consecutive order beginning with the last number previously recorded.

Next children were asked to type in the words, beginning with the first word that they had recalled. Children keyed in each word, aided by the index cards and teacher as needed, and the sprite objects appeared in parkworld.

Free recall scores were computed for each child by summing all sprite objects that were remembered representing each of the 2 x 2 factorial cells of action and sound and for the total number of words recalled. Six was the maximum possible score for each of the four within-subject cells. Twenty-four was the maximum total possible score.

## Results

### Comprehension

Preferential Selection Scores. Each child received four preferential selection scores, representing words presented by action vs. no action and sound vs. no sound. Children's preferential selection scores, ranging from 0-6, were submitted to a 2 (action) x 2 (sound) x 2 (sex) x 4 (days) mixed analysis of variance. Sex was a between-subjects factor; action, sound, and days were within-subjects factors. Duncan's multiple-range test was used for follow-up contrasts.

The four factor ANOVA computed on the preferential selection scores yielded a main effect of action, $F(1,38) = 5.45$, $p < .05$, a sex by action interaction, $F(1,38) = 4.30$, $p < .05$, and a sound by day interaction, $F(3,307) = 2.97$, $p < .05$. As predicted, children preferentially selected more words that were presented with action ($M = 1.61$) than words that were presented without action ($M = 1.39$). As seen in Table 2, boys preferred action over nonaction presentation, but girls did not.

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Insert Table 2 about here

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As seen in Figure 1, a sound by day interaction revealed that on the

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Insert Figure 1 about here

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fourth day, children tended to select more words that had been presented with, rather than without, sound (Duncan's; $p = .06$).

Systematic preferences for action vs. nonaction presentation were examined by comparing children who selected action or nonaction presentation at a greater than chance level (approximately 60% or greater). Children who selected action/nonaction presentation at a chance level were eliminated from this comparison. Of the 25 children who demonstrated a clear preference for presentation mode across the four sessions, 19 children (boys = 11; girls = 8) selected sprite objects presented with action whereas only 6 children (boys = 1; girls = 5) selected words presented without action. Put another way, children who demonstrated a preference for presentation mode selected action three times as often as those who selected no action. Preferences for action were most pronounced for boys.

Free Recall Scores. Four free recall scores were computed for each child, again representing the 2 x 2 factorial combination of action and sound. Free recall scores, ranging from 0-6 within cells, were submitted to a 2 (action) x 2 (sound) x 2 (sex) mixed analysis of covariance with children's preferential selection scores as the covariate. Sex was a between-subjects factor; action and sound were within-subjects factors.

The three factor ANACOVA on children's free recall scores yielded a main effect of action, $F(1,38) = 5.78$, $p < .05$, and a main effect of sound, $F(1,38) = 4.25$, $p < .05$. As expected, children recalled more words that had been presented with action ($M = 4.40$) than words presented without action ($M = 4.00$). Children also recalled more words presented without sound ($M = 4.34$) than words presented with sound ($M = 4.06$). Preferential selection scores were not significantly related to free recall scores.

The total mean number of words recalled by each subject, summed across the four within-subject cells, was 16.80. Scores ranged from 4-22 from a total possible score of 24. As is typical for a preschool age group, children did not cluster words by category or by presentational features during free recall.

Discussion

The purpose of this study was to examine the effects of presentational features on children's preferential selection and memory for information presented in a computer microworld. As expected, preschoolers preferentially selected and recalled words that had been presented with moderate levels of action better than words that had been presented with no action. Action was both inherently interesting to children, as demonstrated by their preferential selection scores, and memorable to children, as demonstrated by their free recall scores. The initial appeal of action may have been due to its salient perceptual qualities (Berlyne, 1960; Huston & Wright, 1983; Lepper & Milojkovic, 1986). Specifically, children may find moving objects to be more inherently interesting than are stationary objects.

The recall findings shed light on the visual superiority hypothesis (Hayes & Birnbaum, 1980) in two ways. First, action rather than visual presentation per se, may well be the critical component for children's superior recall of visually presented content. Consistent with the television area (Huston & Wright, 1983), computer content presented with functionally relevant actions was better recalled than was content presented without action. As suggested by Gibbons et al. (1986), visual superiority may really be action superiority. Secondly, verbal labels which were supplemented by visual actions were well recalled by young children, supporting the thesis that congruent actions facilitate, rather than hinder, children's memory for language (Calvert et al., 1982). The present findings suggest that action superiority is a topic which is relevant to the computer as well as the television area. Future computer research should examine developmental implications of the action superiority hypothesis for older children.

The findings for auditory effects were less clear than were those for visual presentation. Although sound effects tended to be selected on the fourth day, objects presented without sounds were better recalled. One interpretation of these findings is that there was an auditory interference effect. That is, children may have rehearsed the nonmeaningful sounds rather than the meaningful verbal labels. Because there was not a direct echoic relation between the sounds and the words they represented, the sounds may have interfered with rehearsal of the verbal labels which were later necessary for recall.

Limitations of the sprite LOGO board forced the use of nonmeaningful sounds. Ideally, the dog should bark and the cat should meow. Charr (1985), for instance, found that meaningful sounds increased children's understanding of a story presented via radio. Future research should further examine potential interference vs. facilitative effects of sound, perhaps by pairing meaningful vs. nonmeaningful sounds with the objects.

Because preferential selection scores were unrelated to free recall scores, the results suggest that features had independent effects on children's choices for, and memory of, content. Action, in particular, had positive effects on both selection and recall. However, because preferential selection for sound varied over the four days, a summary score may have wiped out a potential relation between preference and recall for sound. The relation between preference and recall for linguistic information as a function of nonlinguistic sounds, therefore, requires further clarification.

Sex differences in children's preferential selection scores suggested that action is more inherently interesting to boys than to girls. In the television area, boys choose to watch action-oriented programs more often than do girls (Huston, Wright, Kerkman, & St. Peters, 1986). In contrast to the television area (e.g., Calvert & Gersh, in press), sound was not more appealing and helpful for boys' than for girls' comprehension. Nonetheless, the results suggest that the attractiveness and memorability of both television and computer content is partly dependent on how the information is presented (Lepper, 1985; Wright & Huston, 1983), and boys, in general, seem more responsive to perceptually salient features than are girls.

In conclusion, the findings of this study clearly support an action superiority hypothesis, and suggest a possible nonlinguistic auditory interference effect for young children's preference for, and memory of, verbal content presented via computers. Features, therefore, play an important role in children's interactions with both television and computer content. As found in the television area (Huston & Wright, 1983), the way that information is presented may well affect how children select and recall computer content.

As our culture increasingly moves into the information age, the ways by which children learn from information technologies become increasingly important (Watson, Chadwick, & Brinkley, 1986). Presentational features, such as action, can enhance young children's preferential selection and recall of information presented in computer microworlds. Action seems a promising feature for children's learning from various information technologies. Research which examines the interface between information technologies and children's learning provides basic information about how children think as well as applied information which can be used to increase what children learn.

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Table 1. Counterbalancing of Sprite Object Characteristics in the Four Versions

| | NO ACTION NO SOUND | ACTION NO SOUND | NO ACTION SOUND | ACTION SOUND |
|---|---|---|---|---|
| | Dog | Horse | Bird | Cat |
| | Fish | Duck | Turtle | Frog |
| VERSION 1 | Mom | Boy | Dad | Girl |
| | Wagon | Boat | Kite | Ball |
| | Cloud | Tree | Sun | Flower |
| | Train | Truck | Plane | Car |
| | Cat | Dog | Horse | Bird |
| | Frog | Fish | Duck | Turtle |
| VERSION 2 | Girl | Mom | Boy | Dad |
| | Ball | Wagon | Boat | Kite |
| | Flower | Cloud | Tree | Sun |
| | Car | Train | Truck | Plane |
| | Bird | Cat | Dog | Horse |
| | Turtle | Frog | Fish | Duck |
| VERSION 3 | Dad | Girl | Mom | Boy |
| | Kite | Ball | Wagon | Boat |
| | Sun | Flower | Cloud | Tree |
| | Plane | Car | Train | Truck |
| | Horse | Bird | Cat | Dog |
| | Duck | Turtle | Frog | Fish |
| VERSION 4 | Boy | Dad | Girl | Mom |
| | Boat | Kite | Ball | Wagon |
| | Tree | Sun | Flower | Cloud |
| | Truck | Plane | Car | Train |

Table 2.

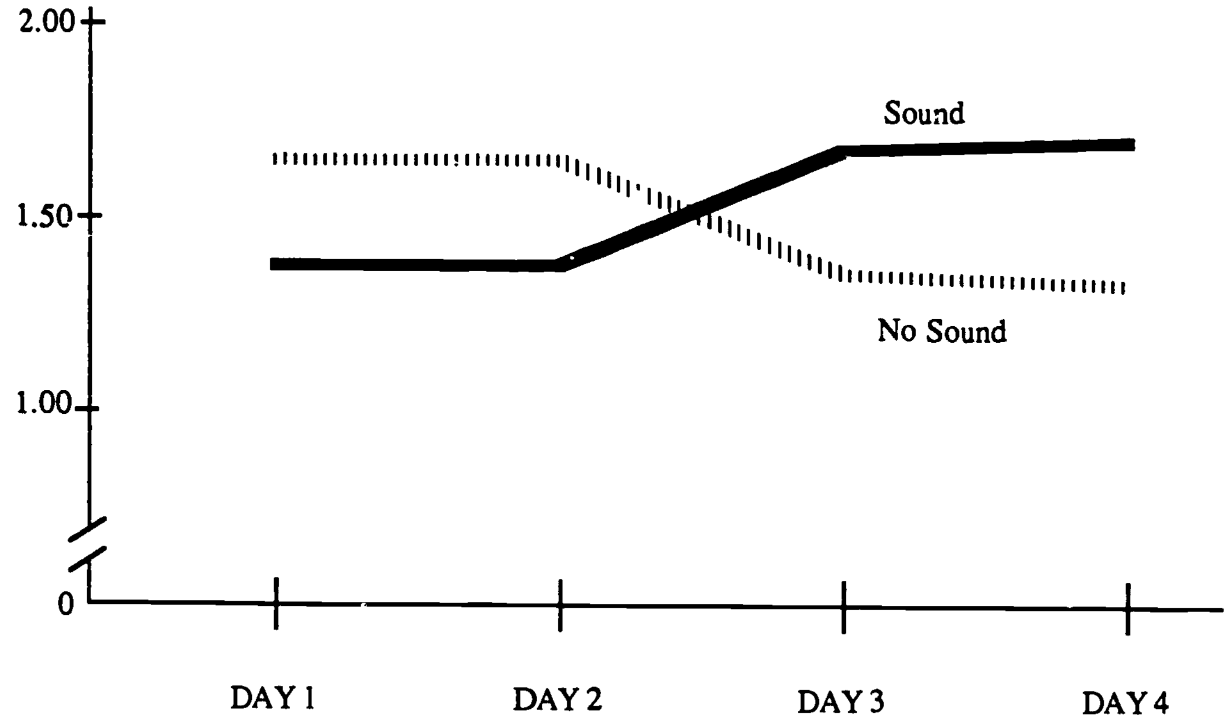
Sex differences in mean number of times that children selected action versus nonaction presentation

| | | PRESENTATION MODE | |
|---|---|---|---|
| | | No Action | Action |
| SEX | Boys | 1.29[a] | 1.71[b] |
| | Girls | 1.49 | 1.52 |

Scores with different letter superscripts are significantly different at $p < .05$.

Figure 1.

Mean number of sound vs. no sound words selected for the four sessions




Cell means are based on 80 subjects.