# *Behavior Analysis & Technology*

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# Overselective Attention to Words in Young Children: Utilizing Multiple Assessments

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## Abstract

Computer touch-screen technology was employed to determine if overselective attention occurred in young children when word discriminations were presented. Multiple stimulus-control tests were automatically administered. One test assessed how many letters of word discriminations were attended to by recording response choice when the letters comprising the S+ and S- words were presented separately. In a second test, word choice was determined when the S+ word appeared with three similar comparison words that differed from the S+ word by only one letter. Another stimulus-control test measured the response topographies of the children by using a touch screen attached to a computer monitor screen that automatically recorded which of the individual letters the children touched when words were presented. In addition, both nondifferential and differential-reinforcement contingencies were employed during the stimulus-control tests. Assessing visual attention to words under a variety of test conditions can reveal the intensity of overselective attention and not merely the presence of overselective attention as previous investigations have done. Individual differences were found in how the young children attended to words. Although three of the four children demonstrated overselective attention when word discriminations were presented, they differed in the degree of their overselective attention. In addition, the effect of repeated testing on whether the children learned to attend to all three letters of training words depended on the type of reinforcement contingency utilized during the test trials. If a nondifferential-reinforcement contingency was employed, repeated testing for three children did not result in attention to all three letters of the S+ words. In contrast, although most of the children revealed overselective attention during the differential-reinforcement test trials, repeated testing with a differential-reinforcement contingency employed eliminated their overselective attention. In summary, administering multiple tests provided a fine grain analysis and revealed overselective attention in children when words were presented. This has educational relevance because assessing whether a child can attend to individual letters within whole words is critical for reading instruction.

Key Words: Overselective Visual Attention, Word Discriminations, Stimulus Overselectivity, Young Children

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(Full text follows)

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Children with overselective attention demonstrate restricted attention, as they attend to only a limited number of stimulus elements in a stimulus compound. They might, for example, attend to only color features in a visual compound display and ignore the size and shape elements. Identifying children at a young age with pervasive overselective attention is important since past research has shown it can interfere with many different aspects of a child's development (Burke, 1991; Dunlap, Koegel, & Burke, 1981). Overselective attention has been reported primarily in students with developmental and intellectual disabilities (Bailey, 1981; Dickson, Deutsch, Wang, & Dube, 2006: Dickson, Wang, Lombard, & Dube, 2006; Dube & McIlvane, 1999; Fabio, Giannatiempo, Antonietti, & Budden, 2009; Huguenin, 1997, 2004; Koegel &Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas, Schreibman, Koegel, & Rehm, 1971; Ploog & Kim, 2007; Reed, Broomfield, McHugh, McCausland, & Leader, 2009; Rincover & Ducharme, 1987; Schreibman & Lovaas, 1973; Schreibman, Koegel, & Craig, 1977; Schreibman, Kohlenberg, & Britten, 1986; Stromer, McIlvane, Dube, & Mackay. 1993; Wilhelm & Lovaas, 1976). Restricted attention is especially prevalent in children diagnosed with autism spectrum disorder (Ploog, 2010), and the severity of overselective attention in this population is thought by some to be due to a brain dysfunction involving the prefrontal cortex (Kriete & Noelle, 2006).

Some studies have also reported overselective attention in young children of typical development (Eimas, 1969; Hale & Morgan, 1973; Huguenin, 2006: Smith, 2005). Although overselective attention has been observed in children of typical development younger than six years of age (Eimas, 1969; Hale & Morgan, 1973; Smith, 2005), many studies have not reported overselective attention in children of typical development six years of age or older (e.g., Bailey, 1981; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Leader, Loughnane, McMoreland, & Reed, 2009; Lovaas & Schreibman, 1971: Lovaas et al., 1971; Ploog & Kim, 2007; Wilhelm & Lovaas, 1976). A recent investigation discovered, however, that overselective attention occurred in boys of typical development with an average age of 6.3 years when conditional-discrimination tasks utilizing stimulus compounds composed of a letter and a symbol or two letters were presented (Huguenin, 2006).

This investigation determined if overselective attention occurred in young children of typical development when word discriminations were presented. Although studies have demonstrated overselective attention in children (Eimas, 1969; Hale & Morgan, 1973; Huguenin, 2006; Smith, 2005), none of these investigations examined the occurrence of overselective attention in children when word discriminations were administered. Most studies investigating overselective attention in students with developmental disabilities have also not involved stimuli involving words. Assessing if young children display overselective attention when words are presented has important educational relevance. Determining whether a child can attend to individual letters within whole words, for example, is critical for word recognition. If a child is attending to only a restricted number of individual letters within words, reading instruction and spelling would be significantly impaired (Birnie-Selwyn & Guerin, 1997; Saunders, Johnston, & Brady, 2000).

In order to accurately determine the presence of overselective attention, a fine-grained analysis of the control exhibited by the stimulus elements of compound cues is needed. Many studies have shown the advantage of multiple test conditions for accurately assessing stimulus control (Danforth, Chase, Dolan, & Joyce, 1990; Dickson, Wang, Lombard, & Dube, 2006; Fields, 1985; Huguenin, 1997, 2004; Huguenin & Touchette, 1980; Merrill & Peacock, 1994; Newman & Benefield, 1968; Ploog & Kim, 2007; Sloutsky & Napolitano, 2003; Smeets, Hoogeveen, Striefel, & Lancioni, 1985; Van Laarhoven, Johnson, Repp, Karsh, & Lenz, 2003; Wilkie & Masson, 1976), but equipment limitations in the past have often limited the use of more than one testing procedure. Computer touch-screen technology was employed in this study to automatically administer multiple stimulus-control testing procedures to permit greater precision in identifying the presence and intensity of overselective attention in young children when words were presented.

One stimulus-control test assessed how many letters of word discriminations were attended to by recording response choice when the letters comprising the training words were presented separately. The number of letters of the S+ training word that the child consistently selected when individual letters of the S+ and S- words were presented was used to assess whether or not the child attended to only a restricted portion of the S+ word. In this manner, test performance was used to infer how the child attended to training words.

In a second stimulus-control test, word choice was determined when the S+ training word appeared with three similar comparison words that differed from the S+ word by only one letter. By utilizing this type of test, it was possible to directly determine whether the child was attending to each of the individual letters of the S+ word. If the child consistently selected the S+ word despite appearing with comparison words that differed by only one letter, in each spatial position within the comparison word, attention to each letter of the S+ word would be revealed. Previous investigations found employing similar testing procedures, which directly assessed the presence or absence of simultaneous attention to multiple cues, effective in determining how young children of typical development (Huguenin, 2004, 2006) and students with severe intellectual disabilities (Huguenin, 1985, 2004) attended to visual compounds composed of two elements. By presenting the S+ training word throughout the test with comparison words differing by one letter, it was wondered if this type of stimulus-control test could also directly assess whether or not young children attended simultaneously to individual letters of consonant-vowel-consonant words.

A third stimulus-control test measured the response topographies of the training and test words by using a touch screen attached to a computer monitor screen that automatically recorded which of the individual letters the children touched when words were presented. An advantage of a touch screen is that it can more directly record spatial locations of responses, which can assist in identifying the features of compound visual stimuli that students are attending to. The use of a touch screen also eliminates the potential interfering effects of the added eye-hand coordination associated with using a mouse. Although other investigations utilized touch screens to teach visual discriminations (e.g., Bhatt & Wright, 1992; Dube & McIlvane, 1999; Huguenin, 1987; Lynch & Green, 1991; Markham, Butt, & Dougher, 1996; Saunders, Johnston, & Brady, 2000, Stromer et al., 1993)), only a few studies have employed touch screens to record response topographies in order to identify stimulus elements selectively attended to in visual compounds (Huguenin, 1997, 2000, 2004). In this investigation, it was determined whether recording response topographies with a touch screen might assist in identifying how young children attended to words.

In addition to comparing different testing procedures designed to assess how young children attended to word discriminations, another manipulation was the type of reinforcement contingency utilized during the test trials. Both nondifferential and differential-reinforcement contingencies were employed during the single-letter and word test trials to determine the effect of different reinforcement contingencies on test performance. Assessing stimulus control utilizing more than one type of reinforcement contingency during the test trials is important in confirming which features of compound cues students are attending to. Huguenin and Touchette (1980), for example, demonstrated how easily different reinforcement contingencies can alter test performance. False conclusions can be drawn, therefore, about which elements of compound cues are attended to if only one type of reinforcement contingency is utilized during the test trials.

By assessing the visual attention to words of young children under a variety of test conditions, the intensity of overselective attention can also be assessed and not merely the presence of overselective attention as previous investigations have done. Multiple testing procedures can further discover individual differences in how children attend to words, which might not be revealed if only a single testing procedure was employed. This is especially relevant; as previous research has shown even children of similar age can vary in how they attend to words (Huguenin, 2008). Employing computer technology to administer multiple testing procedures could not only accurately identify overselective attention to words in children but it could also result in more individualized and effective reading programs.

The present investigation, in addition, examined the effect of repeated stimulus-control testing on the visual attention of young children to whole words. Determining the amount of exposure to stimulus-control tests that is necessary before a child attends to multiple letters of training words could be another parameter for assessing a child's attentional skills. This type of assessment can assist in identifying if a child has the prerequisite behaviors for reading instruction. Discovering procedures that eliminate overselective attention in young children would also have potential clinical significance for students with developmental disabilities who have a high prevalence of overselective attention. Indeed, other investigators have emphasized the importance of demonstrating the effectiveness of teaching and behavioral procedures for students of typical development prior to their utilization with students with developmental disabilities. Otherwise, valuable instructional time might be lost for students with developmental disabilities while attempting to find effective assessment and instructional techniques (Broomfield, McHugh, & Reed, 2008a, 2008b).

## Method

### Subjects

Four young boys of typical development, whose ages ranged from approximately six to seven years of age, participated in the study. The children had no known sensory, motor, or cognitive impairments and were enlisted as a result of an ad placed in a local newspaper. The four children came from similar socioeconomic backgrounds and attended schools in the same school district.

### Apparatus

An Apple Power Macintosh 7500/100 desk-top computer with a 125 GB internal hard disk, 128 MB RAM, and System 9.2 automated the experimental sessions. A MicroTouch 14-in monitor was used. The code was generated to be fully System 9.x compatible, using Macintosh-standard graphical user interface dialog boxes to initialize the sessions, fully automated event-driven procedure implementation and data acquisition, and automatic output file generation.

The computer presented stimuli and recorded responses. When stimuli appeared on the display screen, the computer decoded the correct position for each trial. The computer also kept a running account of trials, stimuli presented, the location on the display screen where the student touched during each trial, as well as response choice. A report was provided following each session that supplied this information. A BCI, Inc. token/coin dispenser was located to the left of each student. This device was operated after each correct response, and pennies dropped into a 9.6- by 14- by 9.6-cm receptacle at the base of the dispenser.

### Experimental Design

A within-subject reversal design was utilized to determine the effect of different stimulus-control testing procedures in revealing how young children attended to word discriminations. A within-subject reversal design was also employed to assess the effect of different reinforcement contingencies, utilized during the test trials, on test performance.

### General Procedure

Each child sat in a chair facing a computer display screen, and the author sat beside the student. Sessions consisted of approximately 100 trials in length. A trial began when words or letters, centered on two white illuminated backgrounds, appeared on the computer screen. The trial ended when the student touched either illuminated area. A 3-second intertrial interval followed in which the computer screen was dark, and then the next trial began. Each time the child made the correct choice, he was reinforced with the delivery of a penny, a flashing computer screen, and verbal praise. If the child made an incorrect choice, reinforcement was not provided. At the conclusion of each session, the children traded their accumulated pennies for recreational items. The stimuli were presented in an unpredictable sequence with the restriction that no stimulus appeared more than twice in succession in the same location. The stimuli also occurred an equal number of times on the left and right portions of the computer screen. An individual session consisted of approximately 40 word-discrimination training trials, 30 single-letter test trials, and 30 word-test trials.

Phase One

Each child was initially presented a word discrimination in which the S+ word and the S- word were presented simultaneously. During the word-discrimination task, the children were required to select the S+ word (SAT) to obtain reinforcement. If the S- word (MOP) was selected, reinforcement was not provided (see Fig. 1). The word discrimination was presented until the child achieved 90% accuracy in a block of 20 trials.

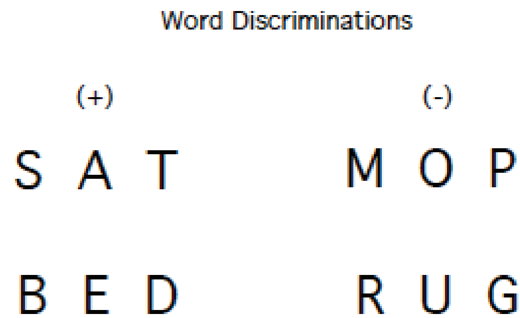



Figure 1. Diagram of the two word-discrimination tasks, which were composed of CVC words. Plus (+) indicates words paired with reinforcement and minus (-) denotes words paired with nonreinforcement. Each word-discrimination task was presented until the child achieved 90% accuracy in a block of 20 trials.

Single-letter test. Following criterion accuracy for the word discrimination, stimulus-control tests were administered to assess how the children attended to the training words. One stimulus-control test consisted of recording response choice when the letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately. Individual letters occupying the same position in the S+ and S- words were presented in pairs (see Fig. 2). During the 30-trial test, each of the three letter pairs appeared alone for ten trials in an unpredictable mixed sequence. A nondifferential-reinforcement contingency was employed during the single-letter test trials. This consisted of providing reinforcement whichever illuminated area the child touched regardless of the letter presented.

The purpose of the single-letter test was to determine how many letters of the S+ word (SAT) each child was attending to when they achieved criterion accuracy for the word discrimination. This was determined by calculating the percentage of single-letter test trials in which the child chose the individual letters comprising the S+ word (SAT). Individual letters that the child chose during the single-letter test at levels of 80% or greater were said to control responding in the word discrimination when criterion accuracy was achieved.

Word test. A second stimulus-control test was administered after criterion accuracy was again achieved for the word discrimination. During the test, three word pairs were presented in which the S+ word (SAT) appeared with three different words (MAT, SOT, and SAP) that differed from the S+ word by only one letter (see Fig. 2). During the 30-trial test, the three word pairs were presented ten trials each in an unpredictable mixed sequence, and a nondifferential-reinforcement contingency was again employed during the word test trials.

The purpose of the word test was also to determine how many individual letters of the S+ word (SAT) each child was attending to when they achieved criterion accuracy for the word discrimination using a different testing procedure. This was accomplished by recording the percentage of trials in which the child chose the S+ word (SAT) when presented with words that differed by only one letter. Individual letters of the S+ word were said to control responding when the child chose the S+ word (SAT) at levels of 80% or higher when each letter of the S+ word (SAT) distinguished it from comparison words (MAT, SOT, and SAP) that had two letters in common.

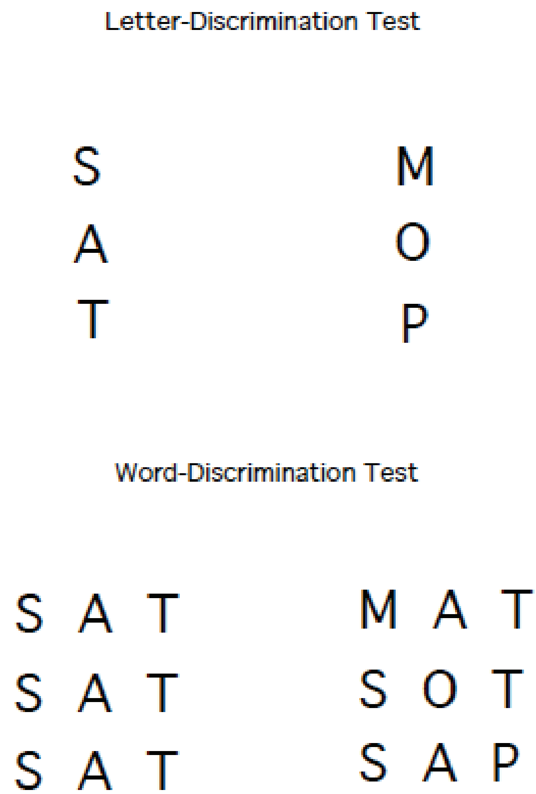



Figure 2. Diagram of two stimulus-control tests administered following criterion accuracy to assess how the children attended to the S+ word (SAT). The single-letter test consisted of recording response choice when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately. The word test consisted of recording response choice when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter.

## Phase Two

The single-letter test and the word test were repeated following criterion accuracy for the word discrimination (SAT+ vs. MOP-) in phase two, but a different reinforcement contingency was utilized during the stimulus-control tests. This was done in order to determine the effect of the type of reinforcement contingency employed during the test trials on the children's test performance.

Single-letter test. During the 30-trial single-letter test, individual letters occupying the same position in the S+ and S- words were again presented in pairs for ten trials each in an unpredictable mixed sequence (see Fig. 2). A differential-reinforcement contingency was employed, however, during the single-letter test trials in phase two. This meant that only the individual letters that comprised the S+ word (SAT) resulted in reinforcement when chosen during the single-letter test in phase two. If the child selected the individual letters that comprised the S- word (MOP), reinforcement was not provided.

Word test. During the 30-trial word test, the three word pairs presented in phase one were repeated in phase two (see Fig. 2). The S+ word (SAT) continued to appear with the three comparison words which differed by only one letter (MAT, SOT, and SAP), but a differential-reinforcement contingency was also in effect during the word test trials in phase two. During the differential-reinforcement test trials, the child was required to choose the S+ word (SAT) to receive reinforcement. If the comparison words were chosen (MAT, SOT, or SAP), reinforcement was not provided.

Phase one and phase two were subsequently repeated to determine the effect of repeated stimulus-control testing on how young children attended to words and whether the effect of extended testing depended on the type of reinforcement contingency (nondifferential vs. differential) utilized during the test trials.

Phase Three

A second word discrimination was next presented to assess generalization effects in which BED was the S+ word and RUG was the S- word (see Fig. 1). The second word discrimination was also presented until the child achieved 90% accuracy in a block of 20 trials.

Single-letter test. Following criterion accuracy for the second word discrimination, stimulus-control tests were administered to assess how the words were attended to. A single-letter test was again administered for 30 trials in phase three, which consisted of recording response choice when individual letters comprising the S+ word (BED) and the S- word (RUG) were presented separately in pairs (see Fig. 3). A nondifferential-reinforcement contingency was employed during the single-letter test trials in phase three. How many letters of the S+ word (BED) each child was attending to was also determined by the number of individual letters of the S+ word that the child chose at levels of 80% or greater.

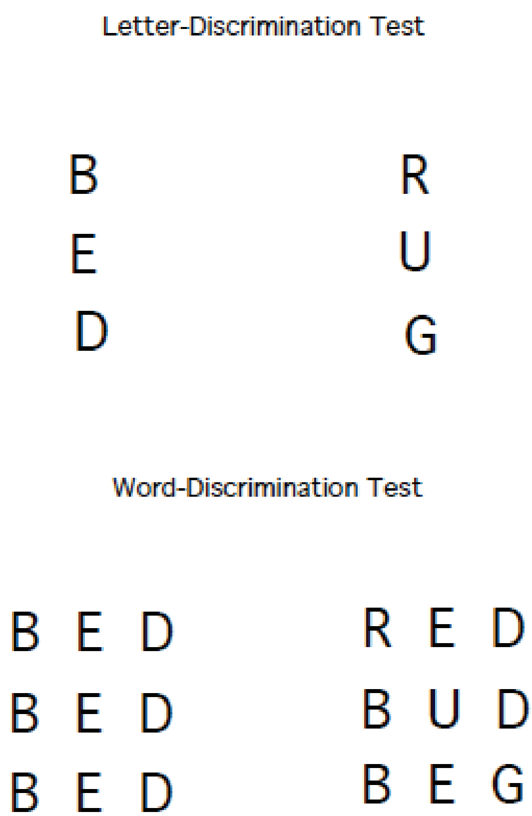



Figure 3. Diagram of two stimulus-control tests administered following criterion accuracy to assess how the children attended to the S+ word (BED). The single-letter test consisted of recording response choice when letters comprising the S+ word (BED) and the S- word (RUG) were presented separately. The word test consisted of recording response choice when the S+ word (BED) appeared with three different words (RED, BUD, and BEG) that differed from the S+ word by only one letter.

Word test. A 30-trial word test was also provided, following criterion accuracy for the second word discrimination, where the S+ word (BED) appeared with three different words (RED, BUD, and BEG) that differed from the S+ word by only one letter (see Fig. 3). A nondifferential-reinforcement contingency was again employed during the word test trials. Individual letters of the S+ word (BED) were said to control responding when the child chose the S+ word at levels of 80% or higher when each letter of the S+ word (BED) distinguished it from comparison words (RED, BUD, and BEG) that had two letters in common.

## Phase Four

After criterion accuracy was again achieved for the word discrimination (BED+ vs. RUG-), the single-letter and word tests described in phase three were repeated in phase four with the exception that the reinforcement contingency was changed during the stimulus-control tests.

Single-letter test. Although individual letters occupying the same position in the S+ and S- words were also presented in pairs for ten trials each (see Fig. 3), a differential-reinforcement contingency was utilized during the single-letter test trials in phase four. During the differential-reinforcement test trials, the child had to choose the individual letters that comprised the S+ word (BED) to obtain reinforcement. Reinforcement was not provided, however, if the child chose the individual letters that comprised the S-word (RUG).

Word test. The three word pairs, presented for ten trials each in phase three, were repeated in phase four (see Fig. 3). The S+ word (BED) again appeared with three comparison words (RED, BUD, and BEG) that differed from the S+ word by only one letter. A differential-reinforcement contingency was employed, however, in phase four. This meant that during the differential-reinforcement test trials, choosing the S+ word (BED) produced reinforcement. If the child chose the comparison words (RED, BUD, or BEG), reinforcement was not provided.

## Data Collection

Data collection during the single-letter tests and word tests consisted of recording response choice when pairs of single letters or pairs of words were presented on the computer screen. Because a touch screen was utilized, it was also recorded where the children touched each time word pairs appeared on the computer screen. This permitted a direct comparison of test-session results with letters touched in the word discriminations when criterion accuracy for the word discriminations was met.

Table 1 lists the sequence of stimuli and procedures provided to each of the four children.

Table 1

Sequence of Stimuli and Procedures

| |
|---|
| Word-Discrimination SAT (+) MOP (-) |
| Single-Letter Test Trials-NDR |
| Word-Discrimination SAT (+) MOP (-) |
| Word Test Trials-NDR |
| Word-Discrimination SAT (+) MOP (-) |
| Single-Letter Test Trials-DR |
| Word-Discrimination SAT (+) MOP (-) |
| Word Test Trials-DR |
| Word-Discrimination SAT (+) MOP (-) |
| Single-Letter Test Trials-NDR |
| Word-Discrimination SAT (+) MOP (-) |
| Word Test Trials-NDR |
| Word-Discrimination SAT (+) MOP (-) |

Table 1 (Continued)

| |
|---|
| Single-Letter Test Trials-DR |
| Word-Discrimination SAT (+) MOP (-) |
| Word Test Trials-DR |
| Word-Discrimination BED (+) RUG (-) |
| Single-Letter Test Trials-NDR |
| Word-Discrimination BED (+) RUG (-) |
| Word Test Trials-NDR |
| Word-Discrimination BED (+) RUG (-) |
| Single-Letter Test Trials-DR |
| Word-Discrimination BED (+) RUG (-) |
| Word Test Trials-DR |

## Results

Utilizing computer touch-screen technology to administer multiple stimulus-control tests revealed individual differences in how young children of typical development attended to words. Although three of the four young boys demonstrated overselective attention when word discriminations were presented, they differed in the degree of their overselective attention. In addition, the effect of repeated testing on whether the children learned to attend to all three letters of the training words depended on the type of reinforcement contingency utilized during the test trials. If a nondifferential-reinforcement contingency was employed, repeated testing for the three children did not result in attention to all three letters of the S+ words. In contrast, although the three children revealed overselective attention during the differential-reinforcement test trials, repeated testing with a differential-reinforcement contingency employed eliminated their overselective attention.

### Nondifferential vs. Differential-Reinforcement (Child 1)

Nondifferential-reinforcement test condition. The single-letter testing procedure did not reveal overselective attention for Child 1 when either word discrimination was presented if a nondifferential-reinforcement contingency was utilized during the test. During the single-letter test trials of the first two nondifferential-reinforcement test sessions, for instance, none of the individual letters composing the S+ word (SAT) exhibited stimulus control (see Fig. 4). Child 1 chose, instead, the letters of the S+ word at levels at or near 50% when the individual letters of the word discrimination were presented separately during the test. After Child 1 achieved criterion accuracy for the second word discrimination (BED+ vs. RUG-), he also failed to display stimulus control for any of the individual letters of the S+ word. He continued to select the letters of the second S+ word (BED) at 50% levels during the single-letter test in the third nondifferential-reinforcement test session (see Fig. 4).

Child 1 also demonstrated during the word test trials a lack of stimulus control for any of the letters of the S+ word (SAT) if a nondifferential-reinforcement contingency was in effect. In the word test of the first two nondifferential-reinforcement test sessions, he chose the S+ word at only 50% levels when each of the individual letters of the S+ word (SAT) differentiated it from comparison words (MAT, SOT, and SAP) differing by only one letter (see Fig. 5). After Child 1 achieved criterion accuracy for the second word discrimination, he also displayed a lack of stimulus control for any of the individual letters of the S+ word (BED) during the word test trials of the third nondifferential-reinforcement test session (see Fig. 5). The word testing procedure also failed to demonstrate overselective attention for either word discrimination with nondifferential reinforcement during the test.

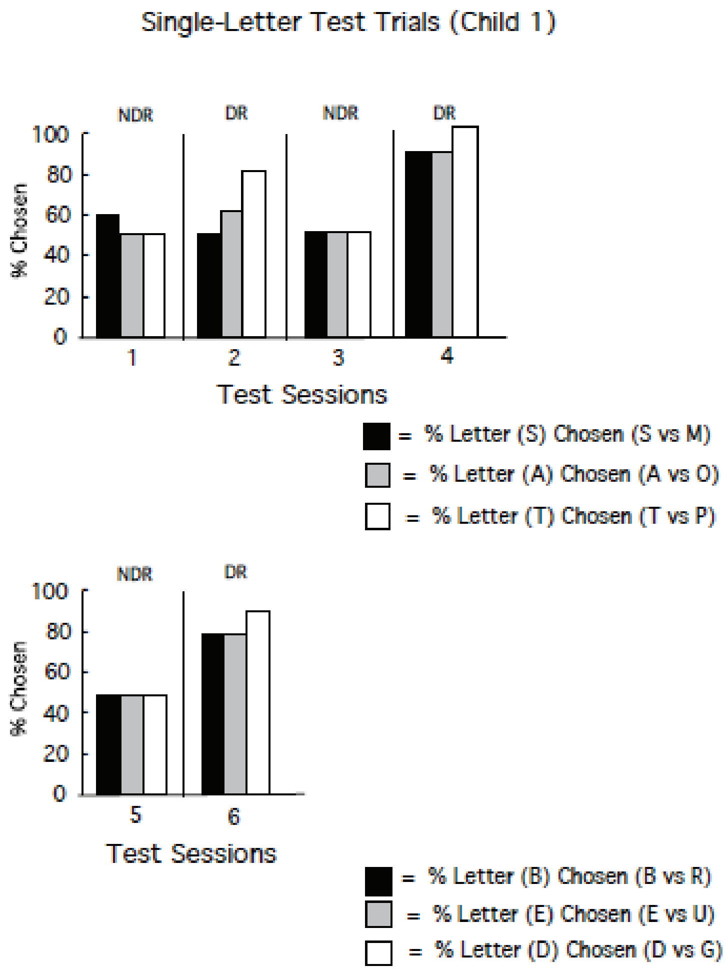



Figure 4. For Child 1, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Differential-reinforcement test condition. During the differential-reinforcement test condition, in contrast, Child 1 did display overselective attention. Child 1 demonstrated overselective attention in the single-letter test trials of the first differential-reinforcement test session, for example, when he exhibited stimulus control for only one of the letters of the S+ word (SAT) (see Fig. 4). Stimulus control was evident, however, for all three letters of the S+ word in the second differential-reinforcement test session when the single-letter test trials were repeated following criterion accuracy for the word discrimination (SAT+ vs. MOP-). Child 1 continued to reveal stimulus control for all of the individual letters of the S+ word (BED) in the third differential-reinforcement test session during the single-letter test trials after the second word discrimination was presented (see Fig. 4). Although Child 1 displayed overselective attention initially during the single-letter test trials, he learned to attend with repeated testing to each letter of the S+ words if a differential-reinforcement contingency was in effect.

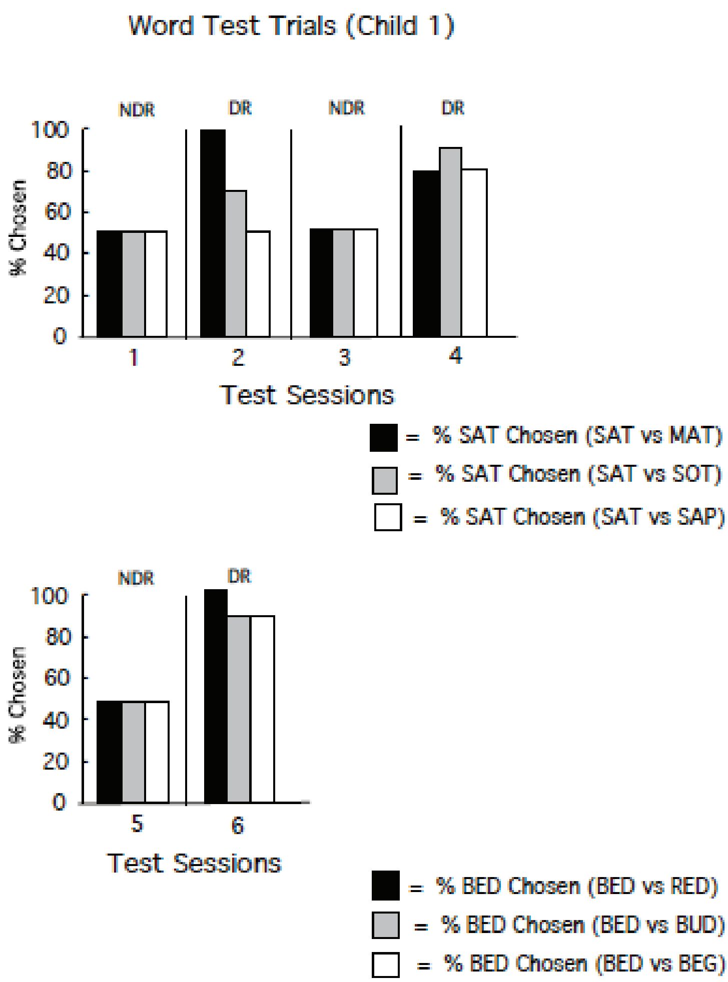



Figure 5. For Child 1, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed from the S+ word by only one letter (bottom graph). During the word test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

The word test trials also revealed overselective attention in the first differential-reinforcement test session, as Child 1 exhibited stimulus control for only one of the letters of the S+ word (SAT) (see Fig. 5). When the word test trials were repeated in the second differential-reinforcement test session, Child 1 displayed stimulus control for all three letters of the S+ word as had also occurred during the single-letter test trials. He persisted in attending to all of the individual letters of the S+ word (BED) in the third differential-reinforcement test session when the word test trials were provided following criterion accuracy for the second word discrimination (see Fig. 5). In summary, the word test trials also demonstrated overselective attention initially, but with repeated testing, Child 1 again learned to attend to each letter of the S+ words when a differential-reinforcement contingency was employed.

Nondifferential vs. Differential-Reinforcement (Child 2)

Nondifferential-reinforcement test condition. Child 2, in opposition to Child 1, displayed overselective attention for both word discriminations when nondifferential-reinforcement test conditions were presented. During all three nondifferential-reinforcement test sessions, which were provided following criterion accuracy for the word discriminations, overselective attention was consistently revealed when the single-letter test was provided (see Fig. 6). The single-letter test trials indicated, for instance, that Child 2 attended to only one of the letters of the S+ word (SAT) in the first two nondifferential-reinforcement test sessions. In the final nondifferential-reinforcement test session, overselective attention was also evident when the single-letter test trials revealed Child 2 attended to just two of the three letters of the S+ word (BED) (see Fig. 6).

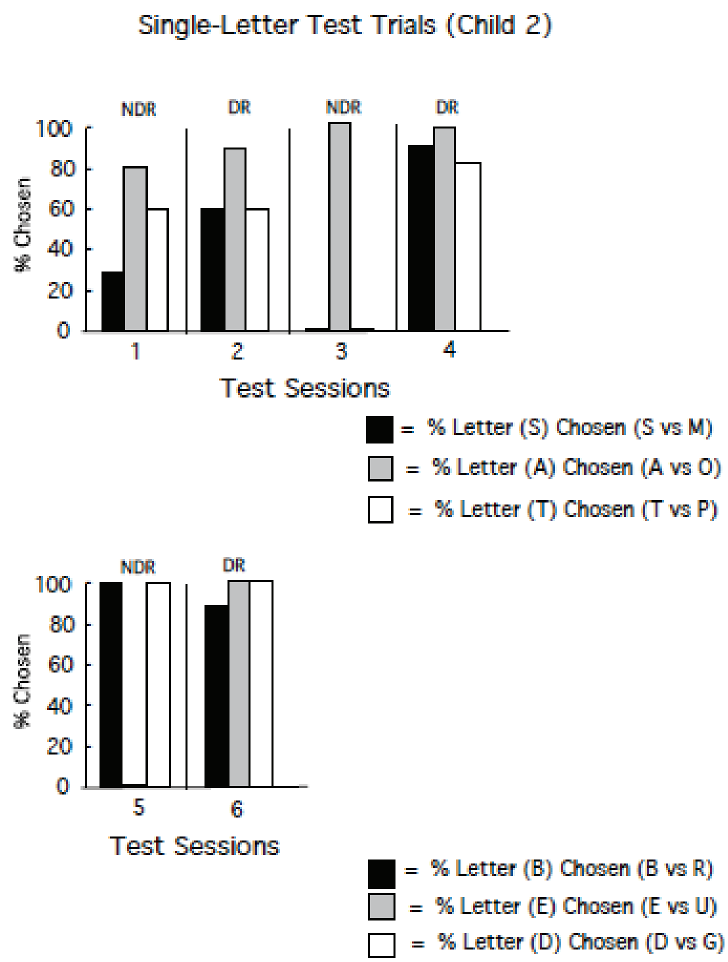
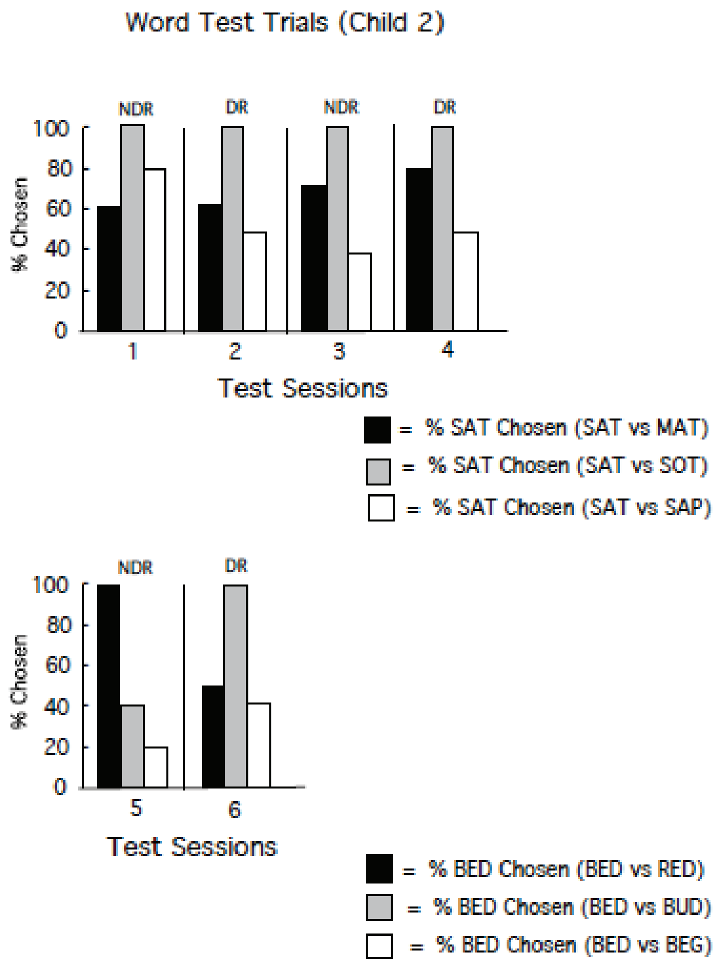



Figure 6. For Child 2, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Child 2 also demonstrated overselective attention during the word test trials in all of the nondifferential-reinforcement test sessions (see Fig. 7). In the first nondifferential-reinforcement test session, overselective attention was observed in the word test trials when Child 2 exhibited stimulus control for only two of the three letters of the S+ word (SAT). He revealed stimulus control for only one letter of the S+ word (SAT) when the word test trials were repeated in the second nondifferential-reinforcement test session (see Fig. 7). Child 2 continued to display overselective attention in the word test trials of the third nondifferential-reinforcement test session when he attended to just one of the letters of the S+ word (BED) (see Fig. 7).

In summary, Child 2 displayed overselective attention during both the single-letter and word tests, and repeated testing failed to eliminate overselective attention for Child 2 when a nondifferential-reinforcement contingency was utilized during the test trials.




<u>Figure 7</u>. For Child 2, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed from the S+ word by only one letter (bottom graph). During the word test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

<u>Differential-reinforcement test condition</u>. Child 2 also displayed overselective attention when the stimulus-control tests were provided with a differential-reinforcement contingency. Child 2 demonstrated overselective attention during the single-letter test trials of the first differential-reinforcement test session, for example, when he chose only one of the letters of the S+ word (SAT) at levels of 80 percent or greater

(see Fig. 6). He chose the remaining two letters of the S+ word, in contrast, at near chance levels. When the single-letter test trials were repeated in the second differential-reinforcement test session, however, Child 2 now exhibited stimulus control for each letter of the S+ word (SAT) (see Fig. 6). Child 2 continued to display stimulus control for all three letters of the S+ word (BED) in the single-letter test trials of the third differential-reinforcement test session (see Fig. 6). Child 2 demonstrated overselective attention initially during the single-letter test trials, but repeated testing with a differential-reinforcement contingency resulted in Child 2 attending to each letter of the S+ words.

Child 2 persisted in exhibiting overselective attention during the word test trials when a differential-reinforcement contingency was employed. In the first differential-reinforcement test session, the word test trials indicated he attended to only one of the letters of the S+ word (SAT) (see Fig. 7). Child 2 continued to display overselective attention when the word test trials were repeated in the second differential-reinforcement test session as he exhibited stimulus control for only two of the three letters of the S+ word (see Fig. 7). In the final differential-reinforcement test session, Child 2 also displayed overselective attention in the word test trial when he exhibited stimulus control for only one of the letters of the S+ word (BED) (see Fig. 7). Repeated testing, with a differential-reinforcement contingency, was not effective in eliminating the overselective attention that Child 2 demonstrated during the word test trials even when overselective attention was no longer evident during the single-letter test trials.

Nondifferential vs. Differential-Reinforcement (Child 3)

Nondifferential-reinforcement test condition. When nondifferential reinforcement was employed during the single-letter test trials, Child 3 displayed overselective attention in all three test sessions following criterion accuracy for the word discriminations (see Fig. 8). Overselective attention was revealed in the single-letter test trials of the first two nondifferential-reinforcement test sessions, for instance, when Child 3 displayed stimulus control for only a single letter of the S+ word (SAT). Child 3 also demonstrated overselective attention in the single-letter test trials of the third nondifferential-reinforcement test session as he displayed stimulus control for only two of the three letters of the S+ word (BED) (see Fig. 8).

Child 3 continued to exhibit overselective attention in the word test trials in the nondifferential-reinforcement test condition (see Fig. 9). In the first two nondifferential-reinforcement test sessions, for instance, Child 3 displayed overselective attention in the word test trials when he exhibited stimulus control for only one of the letters of the S+ word (SAT). His level of response choice for the S+ word (SAT) was at or near chance levels when the remaining two letters of the S+ word differentiated it from comparison words that differed by only one letter (see Fig. 9). Child 3 continued to exhibit overselective attention in the word test trials of the third nondifferential-reinforcement test session when he again displayed stimulus control for only one of the letters of the S+ word (BED).

In summary, repeated testing did not eliminate the overselective attention that Child 3 demonstrated during both the single-letter and word test trials if a nondifferential-reinforcement contingency was utilized, as had also occurred for Child 2.

Differential-reinforcement test condition. Child 3 also displayed overselective attention during the stimulus-control test trials when a differential-reinforcement contingency was in effect. During the single-letter test trials, Child 3 demonstrated overselective attention in the first two differential-reinforcement test sessions when he exhibited stimulus control for only two of the letters of the S+ word (SAT) (see Fig. 8). In the single-letter test trials of the third differential-reinforcement test session, however, Child 3 attended to all three letters of the S+ word (BED) (see Fig. 8). Repeated testing with a differential-reinforcement contingency eliminated the overselective attention that Child 3 initially exhibited during the single-letter test trials.

Child 3, in addition, exhibited overselective attention during the word test trials of the first differential-reinforcement test session when he displayed stimulus control for only one of the letters of the S+ word (SAT) (see Fig. 9). When the word test trials were repeated with a differential-reinforcement contingency in effect, Child 3 now displayed stimulus control for all three letters of the S+ word (SAT) following criterion accuracy for the word discrimination. Child 3 exhibited stimulus control for all three letters of the S+ word (BED) as well during the word test trials of the third differential-reinforcement test session (see Fig. 9). Repeated testing with a differential-reinforcement contingency also eliminated the overselective attention that Child 3 initially displayed during the word test trials.

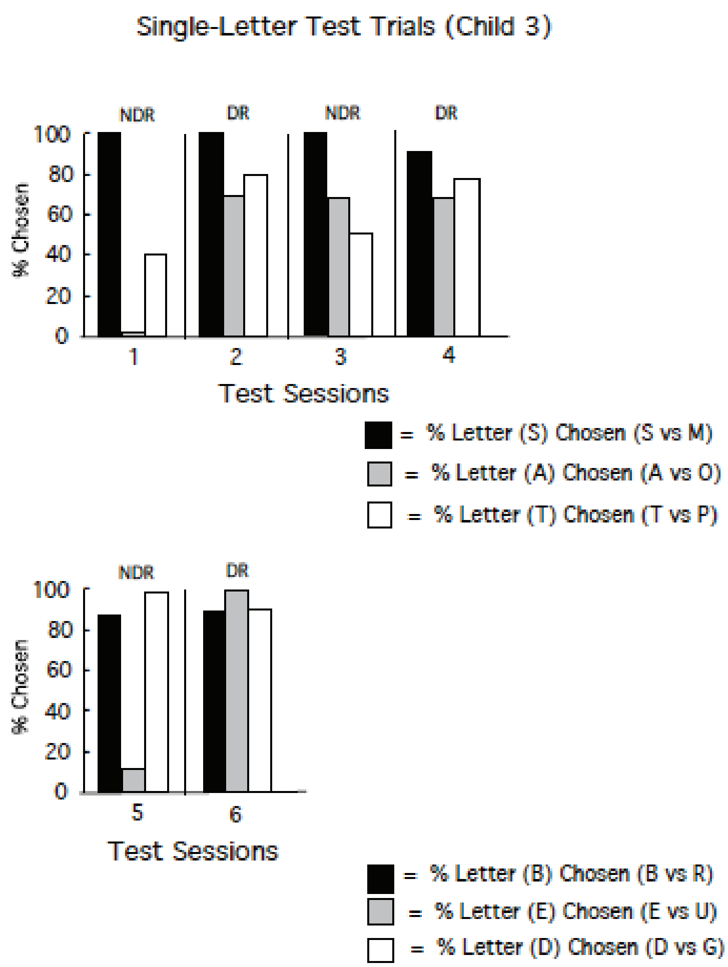



Figure 8. For Child 3, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

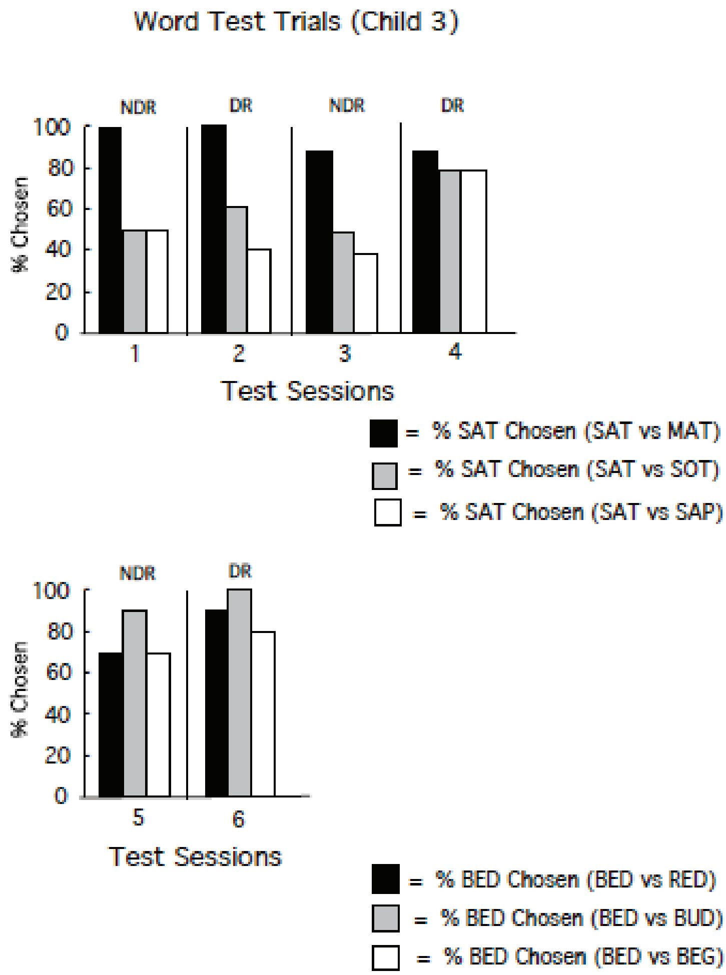



Figure 9. For Child 3, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed from the S+ word by only one letter (bottom graph). During the word test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Nondifferential vs. Differential-Reinforcement (Child 4)

Nondifferential-reinforcement test condition. When a nondifferential-reinforcement contingency was employed, Child 4 did not reveal overselective attention during the single-letter test trials in any of the test sessions (see Fig. 10). He chose, instead, all three letters of the S+ words at levels of 80% or higher in the single-letter test trials of all three nondifferential-reinforcement test sessions.

Child 4 did not display overselective attention as well during the word test trials of the nondifferential-reinforcement test sessions. In the three nondifferential-reinforcement test sessions, Child 4 selected the S+ word at levels of 80% or higher when each of the letters of the S+ word differentiated it from comparison words that differed by only one letter (see Fig. 11). The word test trials confirmed that Child 4 exhibited stimulus control for all three letters of the S+ words (see Fig. 11).

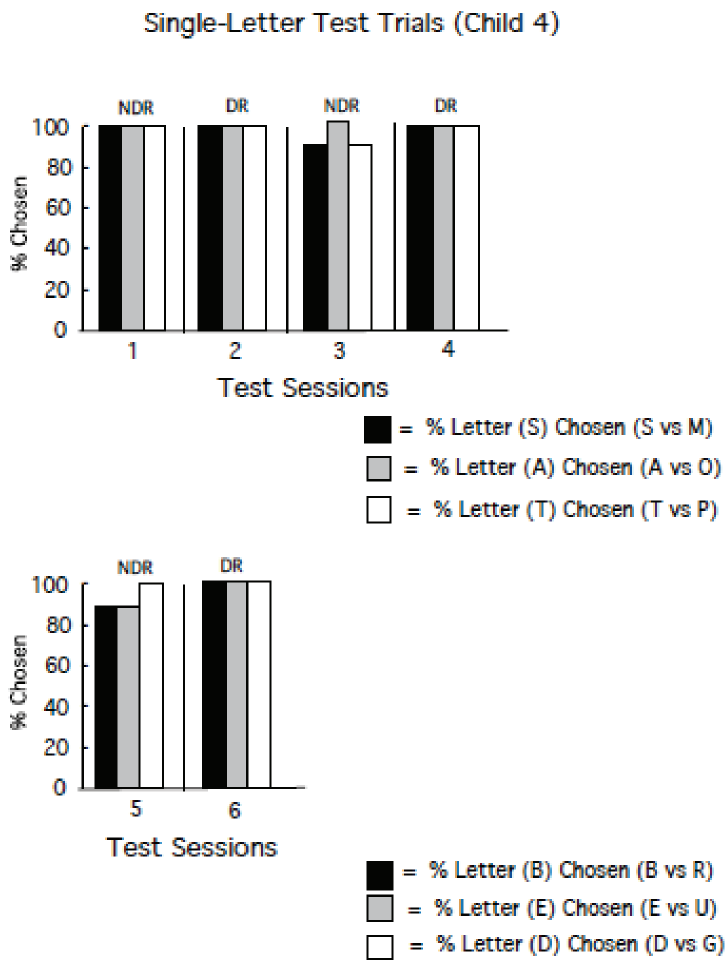



Figure 10. For Child 4, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Differential-reinforcement test condition. Child 4 also did not display overselective attention in the single-letter test trials of any of the differential-reinforcement test sessions. In each of the three differential-reinforcement test sessions, Child 4 exhibited high levels of stimulus control during the single-letter test trials for all of the individual letters of the S+ words following criterion accuracy for the word discriminations (see Fig. 10).

Child 4, in addition, did not demonstrate overselective attention during the word test trials when a differential-reinforcement contingency was utilized. He persisted in demonstrating high levels of stimulus control for each letter of the S+ words during the word test trials in all three differential-reinforcement test sessions. This was demonstrated as Child 4 consistently selected the S+ word at levels of 80% or higher when each letter of the S+ word differentiated it from comparison words that differed by only one letter (see Fig. 11).

In summary, Child 4 did not display overselective attention when two different testing procedures were provided with either a nondifferential or differential-reinforcement contingency in effect during the test trials. He instead attended consistently to each letter of both S+ words regardless of the type of reinforcement condition employed during the test trials.

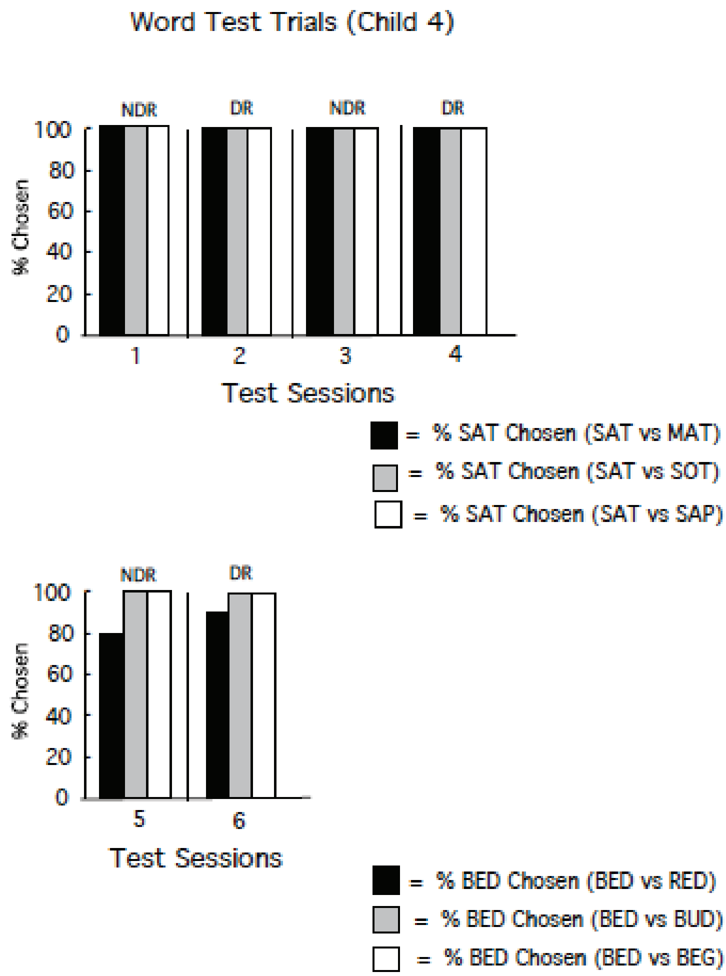



Figure 11. For Child 4, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed from the S+ word by only one letter (bottom graph). During the word test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

## Word-Discriminations: Response Topographies

The response topographies measured by the touch screen showed letter preferences for all four children. Their response topographies demonstrated a letter preference whenever the child selectively touched the same letter in the S+ words in 80% or more of the trials when criterion accuracy for the word discriminations was achieved. The number of letter preferences revealed by the touch screen differed across the four children.

The response topographies of two children (Child 1 and Child 4) demonstrated a relatively large number of letter preferences compared to the number of letter preferences indicated by their stimulus-control tests. The response topographies of Child 1, for instance, indicated a letter preference on all 12 occasions when he achieved criterion accuracy for the word discriminations (see Figs. 12 and 13). He revealed letter preferences only two times in the single-letter and word tests, in contrast, where only a single letter of the S+ word exhibited stimulus control (see Figs. 4 and 5).

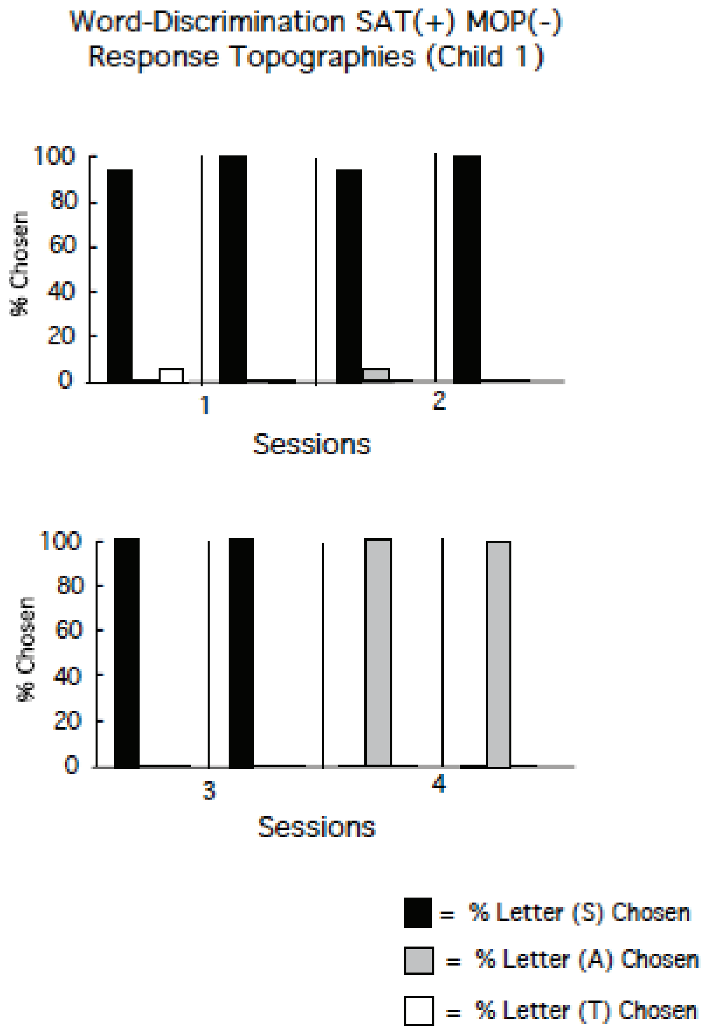



Figure 12. For Child 1, percentage individual letters of S+ word (SAT) were chosen when criterion accuracy for the word discrimination (SAT + vs. MOP-) was achieved in the first four sessions.

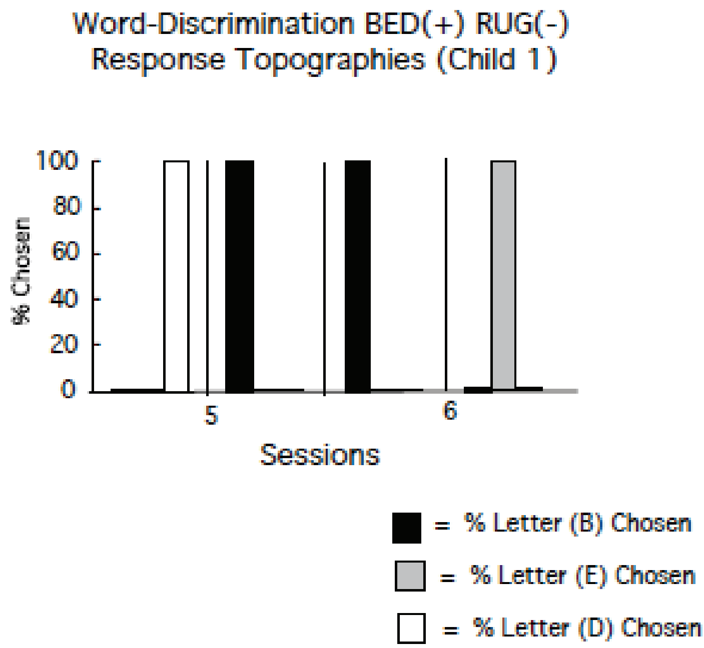



Figure 13. For Child 1, percentage individual letters of the S+ word (BED) were chosen when criterion accuracy for the word discrimination (BED+ vs. RUG-) was achieved in the fifth and sixth sessions.

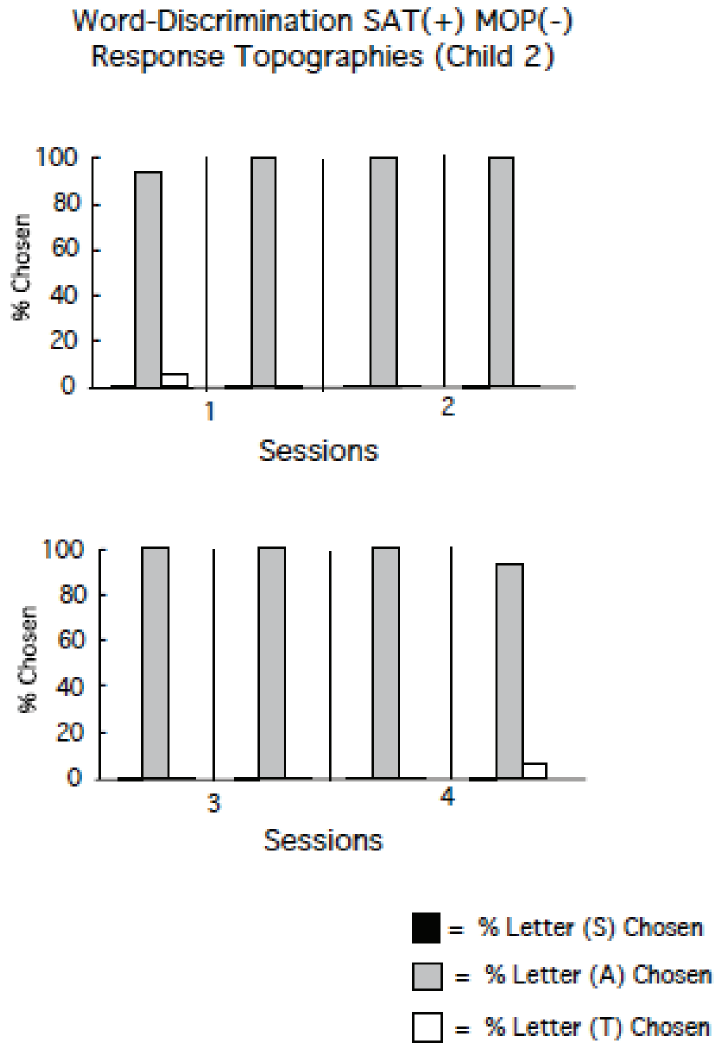



Figure 14. For Child 2, percentage individual letters of S+ word (SAT) were chosen when criterion accuracy for the word discrimination (SAT + vs. MOP-) was achieved in the first four sessions.

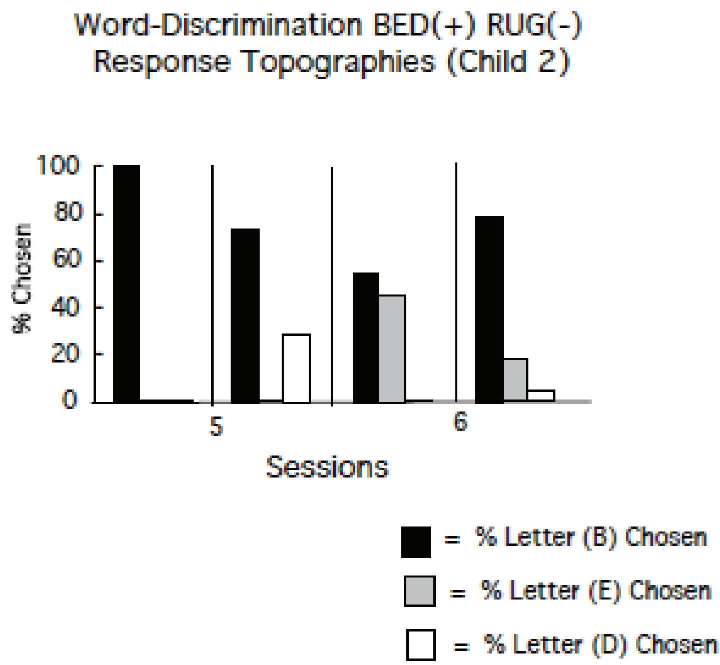



Figure 15. For Child 2, percentage individual letters of the S+ word (BED) were chosen when criterion accuracy for the word discrimination (BED+ vs. RUG-) was achieved in the fifth and sixth sessions.

The response topographies of Child 4 revealed letter preferences on nine occasions when he acquired criterion accuracy for the word discriminations (see Figs. 18 and 19). Letter preferences were not revealed, however, by his single-letter or word test results when either nondifferential or differential-reinforcement contingencies were employed, since all three letters of the S+ words consistently exhibited high levels of stimulus control (see Figs. 10 and 11).

In summary, recording response topographies with a touch screen was more sensitive for both Child 1 and Child 4 than the stimulus-control tests in revealing letter preferences when word discriminations were presented.

Although the response topographies of the remaining two children (Child 2 and Child 3) revealed letter preferences when criterion accuracy for the word discriminations was achieved, comparable levels of letter preferences were also demonstrated by the stimulus-control tests. Recording response topographies for Child 2, for instance, revealed only slightly more letter preferences than the number of letter preferences demonstrated by the stimulus-control tests. When Child 2 achieved criterion accuracy for the word discriminations, his response topographies revealed letter preferences on nine occasions (see Figs. 14 and 15) while, in comparison, he exhibited letter preferences seven times during the single-letter and word tests (see Figs. 6 and 7).

When Child 3 achieved criterion accuracy for the word discriminations, his response topographies demonstrated letter preferences on six occasions (see Figs. 16 and 17). The stimulus-control tests also revealed the same number of letter preferences as Child 3 exhibited stimulus control for a single letter on two occasions during the single-letter tests (see Fig. 8) and four occasions during the word tests (see Fig. 9). Child 3 was the only child whose response topographies did not reveal more letter preferences than those demonstrated by the stimulus-control tests.

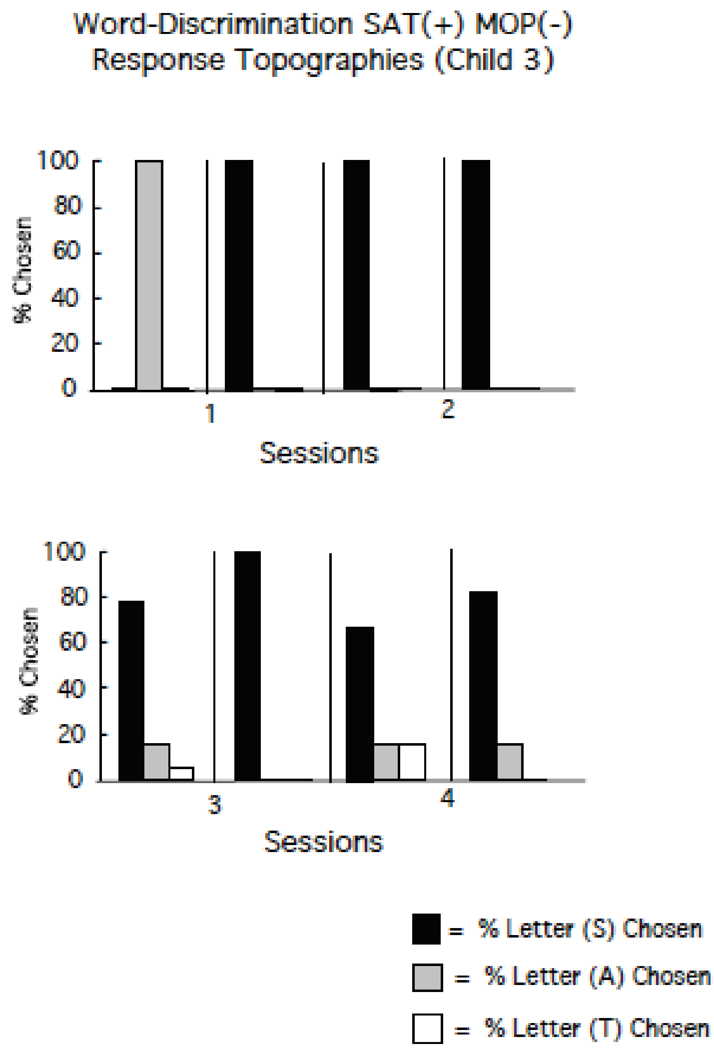



Figure 16. For Child 3, percentage individual letters of S+ word (SAT) were chosen when criterion accuracy for the word discrimination (SAT + vs. MOP-) was achieved in the first four sessions.

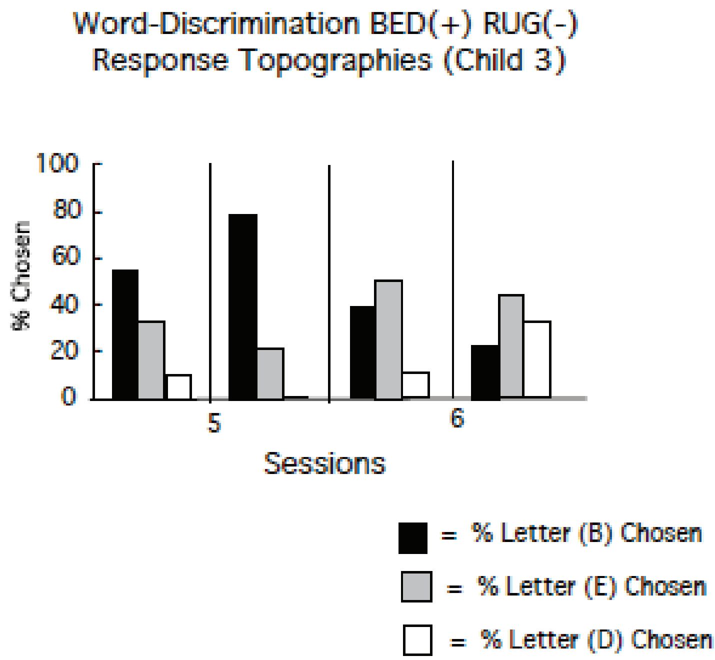



Figure 17. For Child 3, percentage individual letters of the S+ word (BED) were chosen when criterion accuracy for the word discrimination (BED+ vs. RUG-) was achieved in the fifth and sixth sessions.

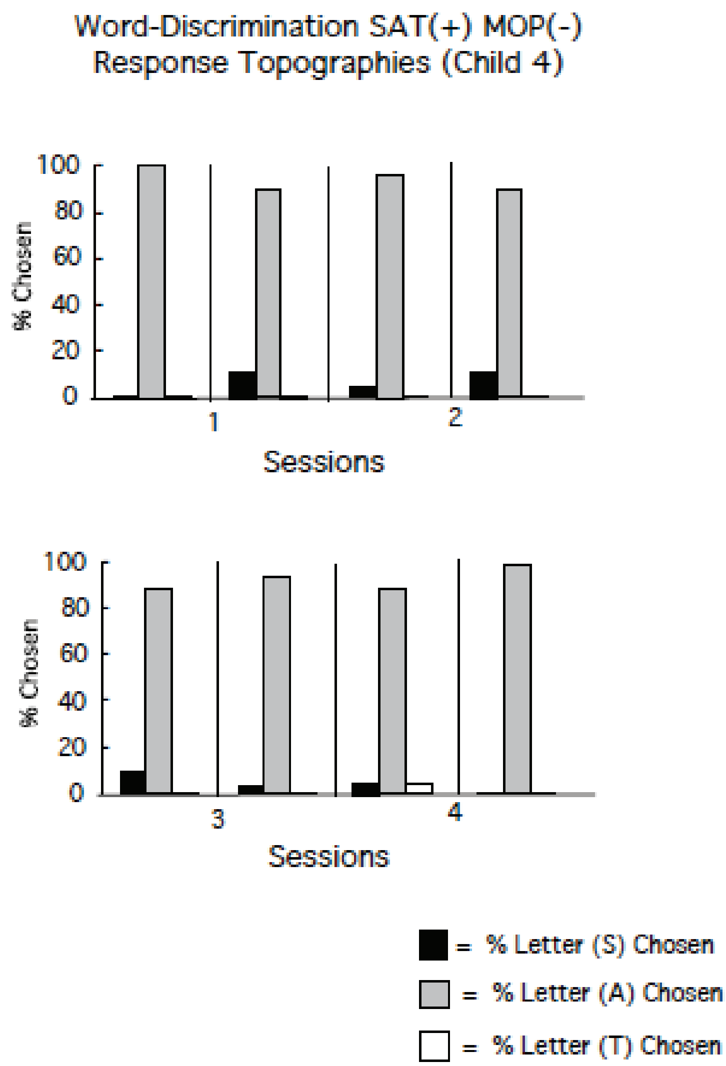



Figure 18. For Child 4, percentage individual letters of S+ word (SAT) were chosen when criterion accuracy for the word discrimination (SAT + vs. MOP-) was achieved in the first four sessions.

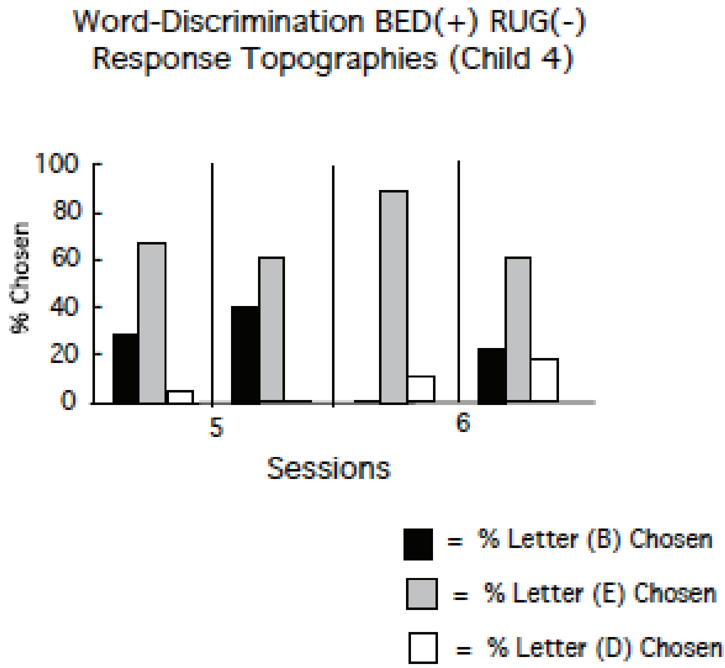



Figure 19. For Child 4, percentage individual letters of the S+ word (BED) were chosen when criterion accuracy for the word discrimination (BED+ vs. RUG-) was achieved in the fifth and sixth sessions.

## Discussion

Utilizing computer touch-screen technology to administer multiple stimulus-control tests revealed individual differences in how young children of typical development attended to words. Although four young boys learned word discriminations with few errors occurring, most of the boys did not attend to all the letters of training words because of overselective attention. Many studies investigating overselective attention in children have employed stimuli such as shapes and patterns (Birnie-Selwyn & Guerin, 1997) and pictures of familiar objects. This investigation, in contrast, demonstrated overselective attention in young children when words were presented. Detecting overselective attention when word discriminations are presented has important relevance to a child's academic achievement since attending to only a limited number of letters within words would interfere with reading acquisition.

By assessing how young children visually attended to words under a variety of test conditions, greater precision was also provided not only in identifying the presence of overselective attention but also its intensity. Although most of the children demonstrated overselective attention, employing multiple testing procedures revealed differences in the degree of their restricted attention. This was shown as the children differed in the number of test conditions and test sessions in which they displayed overselective attention.

One child only exhibited overselective attention in the single-letter and word test trials when a differential-reinforcement contingency was employed. He did not reveal restricted stimulus control during the nondifferential-reinforcement test condition. Two of the children, on the other hand, exhibited more pervasive overselective attention as they displayed restricted stimulus control in the single-letter and word test trials when both nondifferential and differential-reinforcement contingencies were utilized. The fourth child, however, did not demonstrate overselective attention in any of the test sessions. Both the single-letter and word test trials indicated he attended to all three letters of the S+ words in both reinforcement conditions. His response topographies, however, revealed letter preferences in most cases when he achieved criterion accuracy for the word discriminations.

The present investigation utilized multiple test conditions to assess both the presence and the intensity of overselective attention, while most studies have used only a single stimulus-control test to determine overselective attention. In many of those investigations, the stimulus elements of compound cues were presented separately during the test to determine which elements were attended to when criterion accuracy was achieved for the compound discrimination (e.g., Bailey, 1981; Fabio et al., 2009; Koegel & Wilhelm, 1973; Koegel, Schreibman, Britten, & Laitinen, 1979; Leader et al., 2009; Lovaas & Schreibman, 1971; Lovaas et al., 1971; Schreibman & Lovaas, 1973; Schreibman et al., 1977; McHugh & Reed, 2007; Wilhelm & Lovaas, 1976). Overselective attention was assessed in other studies using a conditional-discrimination procedure. The conditional-discrimination test consisted in most cases of a matching-to-sample task, which employed compound sample cues, and assessing whether one or both elements of the sample stimuli were attended to (e.g., Broomfield, McHugh, & Reed, 2008a; Dickson, Deutsch, Wang, & Dube, 2006; Dickson, Wang, Lombard, & Dube, 2006; Dube & McIlvane, 1999; Reed, 2006; Reed, Petrina, & McHugh, 2011). In other studies, the conditional-discrimination procedure involved compound-discrimination tasks with multiple S- compounds to determine how many stimulus elements of S+ compounds exhibited stimulus control (Huguenin, 1985, 2004, 2006; Koegel & Schreibman, 1977).

This investigation differed from previous investigations, however, by using both single-component and conditional-discrimination testing procedures as well as different test reinforcement conditions to detect the presence of overselective attention. By employing more than one type of stimulus-control test, it was possible to determine the robustness of overselective attention and whether it was a reliable occurrence and not restricted to a specific type of testing procedure. When overselective attention was demonstrated in this investigation by the single-letter test for a particular child, the word test also revealed restricted stimulus control as well with few exceptions. In some instances, the specific letters exhibiting stimulus control differed as revealed by the two stimulus-control tests, but this may have occurred because of repeated exposure to the word discriminations. The children also differed in the number of test conditions in which they exhibited restricted stimulus control, which permitted the intensity of their overselective attention to be determined and not merely its presence.

In addition, the effect of repeated testing on whether young children learned to attend to each letter of training words was discovered in this investigation to depend on the type of reinforcement contingency utilized during the test trials. If a nondifferential-reinforcement contingency was employed during the single-letter and word test trials, repeated stimulus-control testing for three of the four children did not result in attention to all three letters of the training words. One of the children, for example, failed to demonstrate stimulus control for any of the individual letters of the S+ words during both testing procedures in all of the nondifferential-reinforcement test sessions. The other two children exhibited overselective attention in both the single-letter and word test trials in the initial nondifferential-reinforcement test sessions, and their overselective attention was not eliminated with repeated testing when a nondifferential-reinforcement contingency was in effect.

In contrast, repeated testing, with a differential-reinforcement contingency employed during the test trials, eliminated the overselective attention that the three children displayed in the initial test sessions. Following extended testing with a differential-reinforcement contingency, all of the children now attended to each individual letter of the training words as revealed by one or both stimulus-control tests. For one child, repeated testing, with a differential-reinforcement contingency in effect during the test trials, eliminated the overselective attention that he initially exhibited during the single-letter test trials. He continued to display, however, restricted attention during the word test trials even after his overselective attention was no longer evident in the single-letter test trials. The other two children did not exhibit overselective attention in either the single-letter or word test trials after repeated testing with a differential-reinforcement contingency. The rate at which overselective attention was eliminated in the different test conditions when a differential-reinforcement contingency was employed proved to be another index of the intensity of their overselective attention.

Even though the stimulus-control tests revealed that one child did not demonstrate overselective attention, the response topographies measured by a touch screen showed letter preferences for all four children. The response topographies of two of the children revealed letter preferences comparable to the frequency of letter preferences indicated by their stimulus-control tests. For the remaining two children, however, recording response topographies with a touch screen proved to be more sensitive in revealing letter preferences than the single-letter and word tests. Although their single-letter and word tests indicated the individual letters of words exercised comparable levels of stimulus control with few exceptions, the response topographies of these two children revealed, in contrast, letter preferences in most cases. Recording response topographies with a touch screen to detect letter preferences support and extend the findings of a previous investigation (Huguenin, 2008), which also showed the effectiveness of touch-screen technology in providing a more complete assessment of how children attend to letters and words.

The results of this study further demonstrate that overselective attention can occur in children of typical development as old as six and seven years of age when word discriminations are presented. These findings support the results of a previous investigation that also found overselective attention was not restricted to children of typical development younger than six years of age (Huguenin, 2006). This is in opposition to many studies which have found that overselective attention did not occur in children of typical development six years of age or older (e.g., Bailey, 1981; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Leader et al., 2009; Lovaas & Schreibman, 1971; Lovaas et al., 1971; Ploog & Kim, 2007; Wilhelm & Lovaas, 1976). The basis for this discrepancy may be due to the fact that less complex stimuli were utilized in those earlier studies (Birnie-Selwyn & Guerin, 1997) compared to the word discriminations, which were presented in the current investigation.

Since individual differences were discovered in the intensity of overselective attention in young children of typical development, these findings also show the potential for using similar tests to provide a detailed analysis of how students with learning and developmental disabilities attend to words. Presenting similar test conditions to students with developmental disabilities might also reveal both the presence and intensity of overselective attention, which would permit the development of more individualized programs for reading instruction. Using computer technology to administer multiple test conditions to assess the visual attention of young children could also serve as an automated screening device for identifying students with pervasive overselective attention. By testing young children prior to entering school and continuing to repeat testing procedures in the first and second grade, the persistence of their overselective attention could be determined. This information could be useful to parents and teachers in deciding whether a particular student needed additional testing by a team of professionals to assess if a developmental disability was present. As a result of identifying young children with widespread and chronic overselective attention, treatment and individualized instruction could also be provided before their restricted attention interfered with other areas of development. Providing behavioral treatment and instruction to children with autism and intellectual disabilities to improve their visual attention in the early years has been claimed to be critical in facilitating their later development and academic progress (Ploog, 2010).

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Footnotes

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