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Using Multiple Tests to Assess Intensity of Overselective Attention to Letters and Words in Young Children

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Abstract

The intent of this investigation was to utilize computer touch-screen technology for assessing how young children attended to letters and words. Assessing the visual attention of young children is important because it can identify attentional deficits, which interfere with the child's learning and development. One perceptual problem is overselective attention. Students with overselective attention demonstrate a type of "tunnel vision", as they attend to only a limited number of stimulus elements in a visual compound. Although overselective attention is frequently reported in students with developmental disabilities, it has typically not been observed in children of typical development. Stimulus compounds composed of letters and symbols and all letters were administered in the first phase of this study to see if overselective attention occurred in young children of typical development when more complex stimuli were presented. Two stimulus-control testing procedures, administered with computer touch-screen technology, assessed how the children attended to the stimulus compounds when conditional discriminations requiring simultaneous attention to two cues were provided. Three of four young boys demonstrated overselective attention, but their overselective attention was diminished with extended training. The rate at which simultaneous attention developed differed, however, across the young boys, revealing differences in the intensity of their overselective attention. In the second phase, 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 again administered. The purpose of the test trials was to determine how many letters of the word discriminations the children were attending to when they achieved criterion accuracy. Although three of the four children demonstrated overselective attention, 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 nondifferential reinforcement 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 differential reinforcement eliminated their overselective attention.

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

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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 & McIvane, 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, McIvane, 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). This may be due to the type of stimuli employed, which has usually involved shapes and patterns (Birnie-Selwyn & Guerin, 1997). In the first phase of this investigation, stimulus compounds composed of letters and symbols and all letters were administered to see if overselective attention would occur in young children of typical development of approximately six years of age when more complex stimuli were presented.

In order to accurately determine the presence of stimulus overselectivity, a fine-grained analysis of the control exhibited by the stimulus elements of compound cues is needed. Computer touch-screen technology was employed in this study to permit greater precision in identifying overselective attention in children and assist in understanding conditions responsible for its occurrence. Two stimulus-control testing procedures, administered with computer touch-screen technology, assessed how the children attended to stimulus compounds composed of letters and symbols and all letters when conditional discriminations requiring simultaneous attention to two cues were provided. One test assessed stimulus control by determining response accuracy for each component of the S+ compounds during the conditional-discrimination tests. The other testing procedure measured the response topographies of the compound stimuli by using a touch screen attached to a computer monitor screen, which automatically recorded which stimuli the children touched in the compounds.

Multiple stimulus control tests were utilized to verify and confirm the children's test performance, since without more than one test condition, false conclusions could be made about which features controlled responding in the compound. Misleading conclusions can be made about control exerted by components of compound cues, for example, when accuracy scores across probe trials are summarized. Past research has shown separate controlling stimulus-response relations can be hidden when such accuracy scores are averaged together (Bickel, Richmond, Bell, & Brown, 1986; Bickel, Stella, & Etzel, 1984; Stromer et al., 1993). Additional investigations have also shown the necessity 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). More than one testing procedure has been used infrequently, however, due to equipment limitations.

In the second phase of this investigation, it was 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. Studies investigating overselective attention in students with developmental disabilities with few exceptions have also not involved stimuli involving words (e.g., Bailey, 1981; Dickson, Deutsch, Wang, & Dube, 2006; Dickson, Wang, Lombard, & Dube, 2006; Dube & McIlvane, 1999; Fabio et al., 2009; Huguenin, 1997, 2004; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971; Ploog & Kim, 2007; Reed et al., 2009; Rincover & Ducharme, 1987; Schreibman & Lovaas, 1973; Schreibman et al., 1977; Schreibman et al., 1986; Stromer et al., 1993; Wilhelm & Lovaas, 1976). 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).

Computer touch-screen technology was again employed in the second phase to administer multiple stimulus-control tests. 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.

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 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) demonstrated, for instance, how easily different reinforcement contingencies can alter test performance. False conclusions can be drawn 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 be assessed and not merely the presence of overselective attention as previous investigations have done. Multiple testing procedures can also 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 more accurately identify overselective attention to words in children but it could also result in more individualized and effective reading programs.

The second phase of this investigation also 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 needed 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).

Experiment I

Method

Subjects

Four young boys with an average age of 6.3 years and of typical development participated. The children had no sensory, motor, or cognitive impairments. The chronological ages of the young boys were 5.8 years, 6.3 years, 6.4 years, and 6.6 years, respectively. Three of the children were enlisted as a result of an ad placed in a local newspaper, and one of the children was an acquaintance of a family who participated in the study. All of the children came from similar socioeconomic backgrounds and attended schools in the same school district.

Apparatus

The experimental sessions were automated by an Apple Power Macintosh 7500/100 desk-top computer with a 40 GB internal hard disk, 128 MB RAM, and System 8.6. A MicroTouch 14-in monitor was used. The code was generated to be fully System 8.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 subject touched during each compound trial, as well as response accuracy. A report was provided following each experimental 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 conditional-discrimination test performance before and after single-stimulus pretraining was administered and to assess if original treatment effects generalized to transfer compounds.

General Procedure

Each student sat in a chair facing a computer display screen, and the experimenter sat beside the student. Sessions consisted of 80 to 100 trials in length. A trial began when letters and symbols (Dreyfuss, 1972) or only 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. Correct choices produced the delivery of pennies, a flashing computer screen, and verbal praise. Following an incorrect choice, reinforcement was not delivered. The children traded their accumulated pennies for recreational items at the end of each session. 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 60 single-stimulus pretraining trials and 20 or 40 conditional-discrimination test trials.

Conditional-Discrimination Tests

Each child was presented two conditional-discrimination tests. Two stimulus compounds, S+ and S- compound stimuli, were presented simultaneously, and they were composed of letters and symbols or only letters. One conditional-discrimination test required choosing the stimulus compound containing the letter C and the symbol for cat to obtain reinforcement. If S- compounds displaying either the letter P and the cat symbol or the letter C and an umbrella symbol were selected, reinforcement was not provided (see Fig. 1). Reinforcement for responding to either the letter C or the cat symbol was conditional, as a result, upon both elements appearing in the same stimulus compound.

In another conditional-discrimination test presented to the children, a stimulus compound containing the letters M and U was consistently paired with reinforcement. The two S- stimulus compounds were either the letters L and U or the letters M and O (see Fig. 1). Reinforcement for responding to either the letter M or the letter U was conditional, therefore, upon both letters appearing in the same stimulus compound.

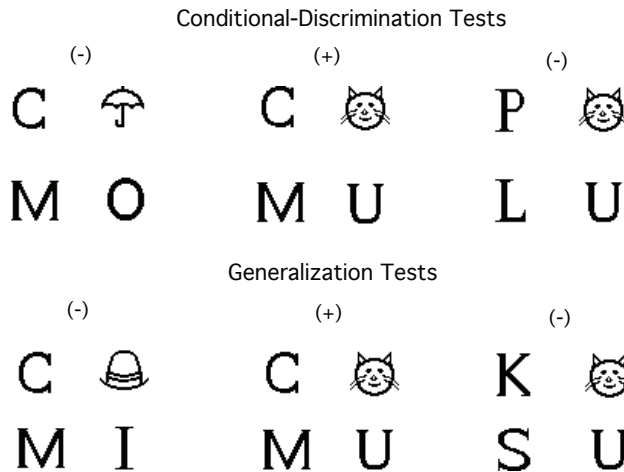


Figure 1. Diagram of the conditional-discrimination tests. Plus (+) indicates stimulus compounds paired with reinforcement and minus (-) denotes stimulus compounds paired with nonreinforcement. Two stimulus compounds, S+ and S- compound stimuli, were presented simultaneously and were composed of letter and symbol components or two letter components. The two S- conditions for each conditional-discrimination test were successively presented in a random sequence with the S+ compound with the restriction that the same S- condition could not appear more than three times in succession with the S+ compound.

The two S- conditions for each conditional-discrimination test were successively presented in a random sequence with the S+ compound with the restriction that the same S- condition could not appear more than three times in succession with the S+ compound. This procedure required sustained attention to both aspects of the S+ compounds to maintain continuous or near continuous reinforcement as selective responding to only one of the stimulus elements would have prevented continuous reinforcement.

Both conditional-discrimination tests were administered for 20 trials to determine baseline performance. The two conditional-discrimination tests also continued to be presented for 20 trials after differing amounts of single-stimulus pretraining were provided to the children.

Single-Stimulus Pretraining

Single-stimulus pretraining was provided for both conditional-discrimination tests by presenting only one S- condition at a time with the S+ compound until criterion accuracy was reached for each discrimination (see Fig. 2). One S+ compound was the letter C appearing with a cat symbol, and stimulus control by the letter component was achieved by making the cat symbol common to both the S+ and S- compounds and consistently pairing the letter C with reinforcement. The letter P was always paired with extinction. A prompt was provided during the first two trials when the experimenter, who sat beside the students during the sessions, pointed to the letter C for a few seconds and indicated it was the correct choice. Following criterion accuracy (29/30 trials correct), stimulus control by the symbol component of the C-Cat compound was next obtained. The letter C appeared in both of the S+ and S- compounds, and only the cat and umbrella symbols were now consistently paired with reinforcement and extinction, respectively. The experimenter again provided a prompt during the first two trials by pointing to the cat symbol and indicating at this point it was the correct choice. Symbol pretraining continued until criterion accuracy (29/30 trials correct) was achieved.

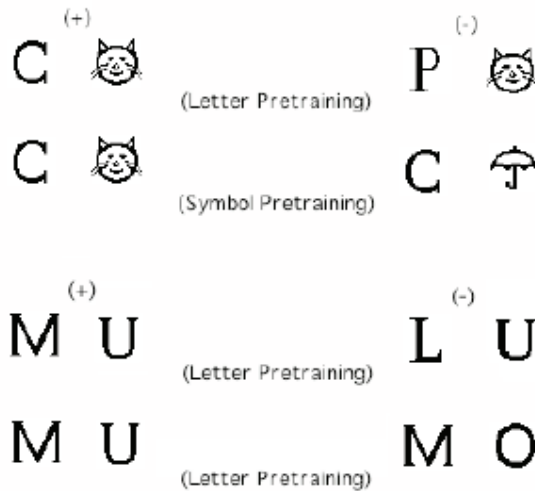


Figure 2. Diagram of four separate visual discriminations established prior to presentation of the conditional-discrimination tests. Plus (+) indicates stimulus compounds paired with reinforcement and minus (-) denotes stimulus compounds paired with nonreinforcement. The S+ and S- compounds were presented simultaneously and were composed of letter and symbol components or two letter components.

The same single-stimulus pretraining procedures were also administered for another S+ compound containing the letters M and U (see Fig. 2). Stimulus control by the letter M component was obtained by making the letter U common to both the S+ and S- compounds and consistently pairing the letter M and the letter L with reinforcement and extinction, respectively. The experimenter also provided a prompt during the first two trials by pointing to the letter M and indicating it was the correct choice. After criterion accuracy occurred, control by the letter U component of the M-U compound was established. The letter M appeared now in both of the S+ and S- compounds, and the letter U and the letter O were consistently paired with reinforcement and extinction, respectively. A gestural prompt was also provided during the

first two trials designating the letter U as the correct choice. This step continued until criterion accuracy was obtained.

Generalization Tests

Two generalization tests were also provided to the children. Two conditional discriminations were presented for 20 trials each during the generalization tests. The S+ compounds for each of the conditional discriminations involved the same stimulus elements as the original tests, but the S- compounds contained novel stimulus components during the generalization tests (see Fig. 1).

Table 1 lists the sequence of stimuli and procedures provided to the young boys in Experiment I.

Table 1

Sequence of Stimuli and Procedures in Experiment I

Young Boys (C1,C2,C3)	Young Boys-cont. (C4)
Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)
Letter Pretraining (C)	Letter Pretraining (M)
Symbol Pretraining (Cat)	Letter Pretraining (U)
Letter Pretraining (C)	Letter Pretraining (M)
Symbol Pretraining (Cat)	Letter Pretraining (U)
Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)
Letter Pretraining (C)	Letter Pretraining (M)
Symbol Pretraining (Cat)	Letter Pretraining (U)
Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)
Generaliz.Test C-Cat (+)	Generaliz. Test M-U (+)
Condit. Discrim.M-U (+)	Letter Pretraining (M)
Letter Pretraining (M)	Letter Pretraining (U)
Letter Pretraining (U)	Condit. Discrim.M-U (+)
Letter Pretraining (M)	Condit. Discrim.M-U (+)
Letter Pretraining (U)	Condit. Discrim.C-Cat (+)
Condit. Discrim.M-U (+)	Letter Pretraining (C)
Letter Pretraining (M)	Symbol Pretraining (Cat)
Letter Pretraining (U)	Letter Pretraining (C)
Condit. Discrim.M-U (+)	Symbol Pretraining (Cat)
Generaliz. Test M-U (+)	Condit. Discrim.C-Cat (+)
Letter Pretraining (M)	Letter Pretraining (C)
Letter Pretraining (U)	Symbol Pretraining (Cat)
Condit. Discrim.M-U (+)	Condit. Discrim.C-Cat (+)
Condit. Discrim.M-U (+)	Generaliz. Test C-Cat (+)

Results

Conditional-Discrimination Tests: Stimulus-Component Accuracy Scores

When the separate accuracy scores of the stimulus components of the two conditional-discrimination tests were examined, the young boys demonstrated overselective attention. Overselective attention was revealed whenever a high level of accuracy (80% or higher) was achieved for only one of the stimulus components. The young boys revealed overselective attention for both a conditional-discrimination test requiring simultaneous attention to two components composed of a letter and a symbol as well as a conditional-discrimination test requiring simultaneous attention to two letters.

Three of the four young boys achieved accuracy scores indicating overselective attention during the conditional-discrimination test sessions where simultaneous attention to both a letter and symbol component was required. Variability existed, however, in the number of test sessions that the young children demonstrated overselective attention by achieving a high level of accuracy (80% or higher) for only one of the stimulus components. Child 2 demonstrated the greatest prevalence of overselective attention as he achieved high accuracy scores for only one stimulus component in all four test sessions when the conditional-discrimination test requiring simultaneous attention to both a letter and symbol element was presented (See Fig. 3). In two of these test sessions, Child 2 achieved a high level of accuracy for only the symbol component, whereas in the remaining two conditional-discrimination test sessions, he selectively attended to the letter component. Child 1 exhibited overselective attention in three of the conditional-discrimination test sessions, and he too did not selectively attend to the same stimulus element throughout (See Fig. 3). Child 4 exhibited overselective attention in two test sessions where he achieved accuracy scores at 80% or higher for only one of the stimulus elements (See Fig. 5, bottom graph). Although one of the young boys (C3) failed to demonstrate overselective attention, Child 3 did not simultaneously attend to both the letter and symbol components until after single-stimulus pretraining was provided (See Fig 3).

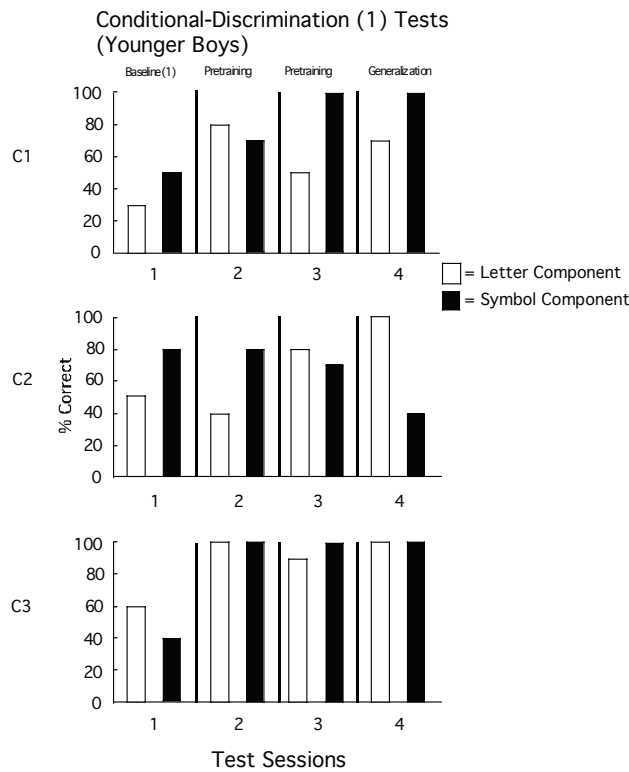


Figure 3. For three young boys, percent accuracy of responses for the letter (white bars) and symbol (black bars) components of the S+ compound of their first conditional-discrimination test in the test sessions before and following pretraining. Percent response accuracy for an individual component of the S+ compound of their first conditional-discrimination test was determined from trials in which that component predicted reinforcement and the remaining component appeared in both the S+ and S- compounds. Test results for each child appear in the order in which the different testing conditions were administered.

Three of the four young boys also displayed overselective attention when the conditional-discrimination test requiring simultaneous attention to two letters (M and U) was presented. Child 2 and

Child 4 both revealed a high prevalence of overselective attention as they achieved high accuracy levels (80% or higher) for only one of the letter components in five of the six test sessions. While Child 4 achieved a high level of accuracy for only the letter M component in these five test sessions (See Fig. 5, upper graph), Child 2 selectively attended to the letter U, with one exception (See Fig. 4). Child 1 achieved accuracy scores demonstrating overselective attention in three test sessions when the conditional-discrimination test requiring simultaneous attention to two letters was presented (See Fig. 4).

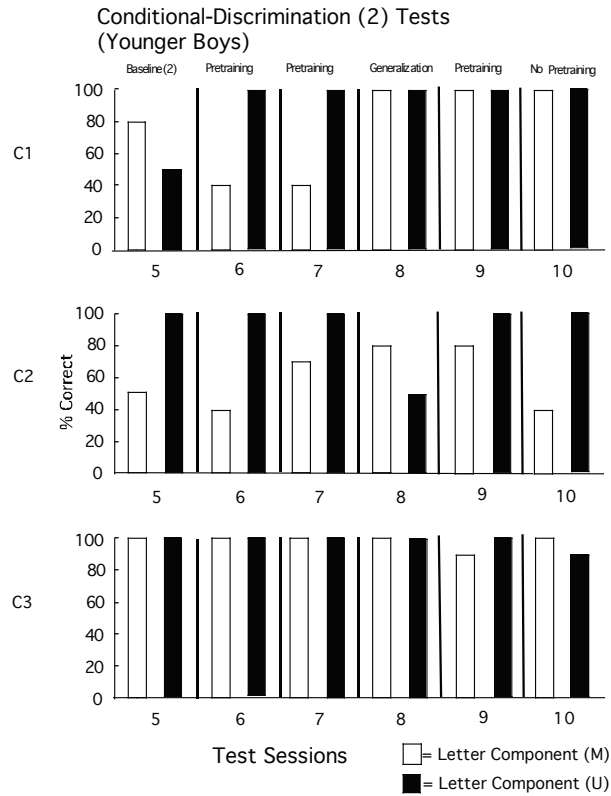


Figure 4. For three young boys, percent accuracy of responses for the letter M (white bars) and the letter U (black bars) components of the S+ compound of their second conditional-discrimination test in the test sessions before and following pretraining. Percent response accuracy for an individual component of the S+ compound of their second conditional-discrimination test was determined from trials in which that component predicted reinforcement and the remaining component appeared in both the S+ and S- compounds. Test results for each child appear in the order in which the different testing conditions were administered.

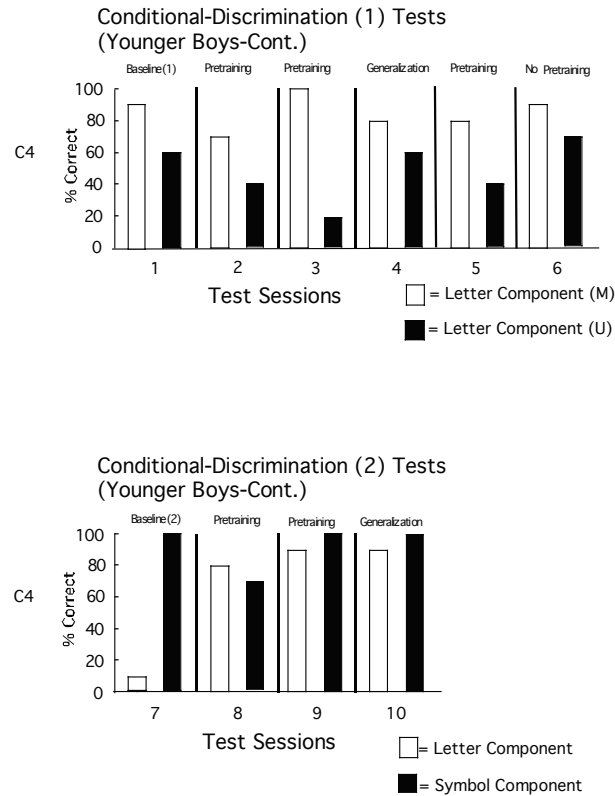


Figure 5. In the upper graph, for a fourth young boy (C4), percent accuracy of responses for the letter M (white bars) and the letter U (black bars) components of the S+ compound of his first conditional-discrimination test in the test sessions before and following pretraining. In the bottom graph, percent accuracy of responses for the letter (white bars) and symbol (black bars) components of the S+ compound of his second conditional-discrimination test in the test sessions before and following pretraining. Percent response accuracy for an individual component of the S+ compound of each conditional-discrimination test was determined from trials in which that component predicted reinforcement and the remaining component appeared in both the S+ and S- compounds. Test results appear in the order in which the different testing conditions were administered.

Conditional-Discrimination Tests: Stimulus-Component Response Topographies

When the young boys achieved accuracy scores for the stimulus components revealing overselective attention, their response topographies confirmed identical stimulus preferences in most cases. Their response topographies demonstrated a stimulus preference during the conditional-discrimination test trials whenever the child selectively touched the same stimulus element in 80% or more of the trials. Each of the three boys, whose accuracy scores revealed overselective attention when the conditional-discrimination test requiring simultaneous attention to both a letter and a symbol was presented, selectively touched stimulus elements demonstrating the same stimulus preferences. Their response topographies also indicated identical stimulus preferences, with a few exceptions, to those revealed by the stimulus-component accuracy scores when the conditional-discrimination test requiring simultaneous attention to two letters was presented.

Extended Training

Although overselective attention occurred in the young boys, their overselective attention was diminished with extended training. Extended pretraining and repeated exposure to two similar conditional-discrimination tests resulted in simultaneous attention to two stimuli eventually developing for all four young boys. The rate at which simultaneous attention developed differed, however, for the young boys, revealing differences in the intensity of their overselective attention. One young boy (C3) revealed simultaneous attention to two stimulus components when he achieved high levels of accuracy (80% or higher) for both components in his second test session after only a relatively small amount of single-stimulus pretraining. Child 3 persisted in demonstrating simultaneous attention to two stimulus elements in all of the following test sessions for both conditional-discrimination tests (See Figs. 3 & 4). Another young boy (C1), in contrast, failed to achieve high levels of accuracy for both stimulus elements during all of the first conditional-discrimination test sessions (See Fig. 3). Child 1 did not simultaneously attend to both stimulus elements until the eighth test session after extended single-stimulus pretraining and repeated exposure to the second conditional-discrimination test were administered (See Fig. 4). Child 1 continued to display simultaneous attention in the following two test sessions. The remaining two young boys (C2 and C4) also did not demonstrate simultaneous attention to both stimulus elements during the test sessions of their first conditional-discrimination test (See Fig. 3 & Fig. 5, upper graph). Neither of these two young boys displayed simultaneous attention to two stimulus elements until the ninth conditional-discrimination test session after they received extended pretraining and repeated exposure to the second conditional-discrimination test (See Fig. 4 & Fig. 5, bottom graph). Both Child 2 and Child 4 required equivalent amounts of extended training before simultaneous attention occurred despite the fact that they received the two conditional-discrimination tests in the reverse order. Although Child 4 continued to simultaneously attend to both stimulus elements in the following conditional-discrimination test session, Child 2 did not due to the recurrence of overselective attention.

In summary, these results demonstrated that for three of the young boys their overselective attention was of sufficient intensity to delay simultaneous attention to multiple cues from occurring until extended single-stimulus pretraining and repeated exposure to the conditional-discrimination tests were provided.

Experiment II

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

The apparatus was the same as in Experiment I.

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

The same general procedure of Experiment I was also employed in Experiment II. Sessions consisted of approximately 100 trials in length. A trial began in Experiment II 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. 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. An individual session consisted of approximately 40 word-discrimination training trials, 30 single-letter test trials, and 30 word-test trials.

Word Discriminations

Each child was presented two word discriminations in which the S+ word and the S- word were presented simultaneously. During the first 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. A second word discrimination was also presented in which BED was the S+ word and RUG was the S- word (See Fig. 6). The word discriminations were presented until the child achieved 90% accuracy in a block of 20 trials.

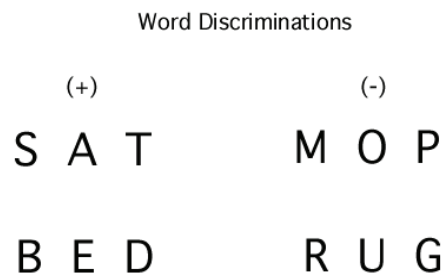


Figure 6. Diagram of the two word-discrimination tasks, which were composed of CVC words. Plus (+) indicates words paired with reinforcement and minus (-) denotes words paired with nonreinforcement. Each word-discrimination task was presented until the child achieved 90% accuracy in a block of 20 trials.

Stimulus-Control Tests

Following criterion accuracy for each word discrimination, stimulus-control tests were administered to assess how the children attended to the training words. One stimulus-control test (Single-Letter 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. 7). During the 30-trial test, each of the three letter pairs appeared alone for ten trials in an unpredictable mixed sequence.

A second stimulus-control test (Word 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. 7). During the 30-trial test, the three word pairs were presented ten trials each in an unpredictable mixed sequence.

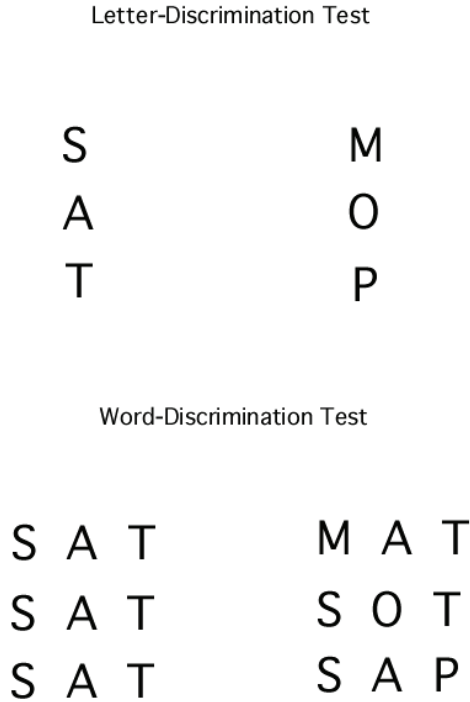


Figure 7. Diagram of two stimulus-control tests administered following criterion accuracy to assess how the children attended to the S+ word (SAT). The single-letter test consisted of recording response choice when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately. 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.

Following criterion accuracy for the second word discrimination, individual letters comprising the S+ and S- words (BED and RUG) were also presented separately in the single-letter test (see Fig. 8). In the word test, the S+ word (BED) appeared with three different words (RED, BUD, and BEG) that again differed from the S+ word by only one letter (see Fig. 8).

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

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

In addition, both nondifferential and differential reinforcement were utilized during both stimulus-control tests to determine the effect of the type of reinforcement contingency on test performance. During the nondifferential-reinforcement test trials, reinforcement was provided whichever illuminated area the child touched regardless of the letter or word presented. During the differential-reinforcement test trials, only the individual S+ letters and the S+ words resulted in reinforcement when chosen during the test trials.

Letter-Discrimination Test

B	R
E	U
D	G

Word-Discrimination Test

B E D	R E D
B E D	B U D
B E D	B E G

Figure 8. 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.

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.

Table 2 lists the sequence of stimuli and procedures provided to each of the four children in Experiment II.

Results

Utilizing computer 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 boys demonstrated overselective attention when words were presented, they differed in the degree of their overselective attention.

(Child 1)

Single-letter test (nondifferential reinforcement). The single-letter testing procedure did not reveal overselective attention for Child 1 when either word discrimination was presented if nondifferential reinforcement 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. 9). 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. 9).

Table 2

Sequence of Stimuli and Procedures
in Experiment II

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 (-)
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

Single-letter test (differential reinforcement). During the differential-reinforcement test trials, in contrast, Child 1 did display overselective attention in the single-letter test condition. 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. 9). 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. 9). 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 differential reinforcement was in effect.

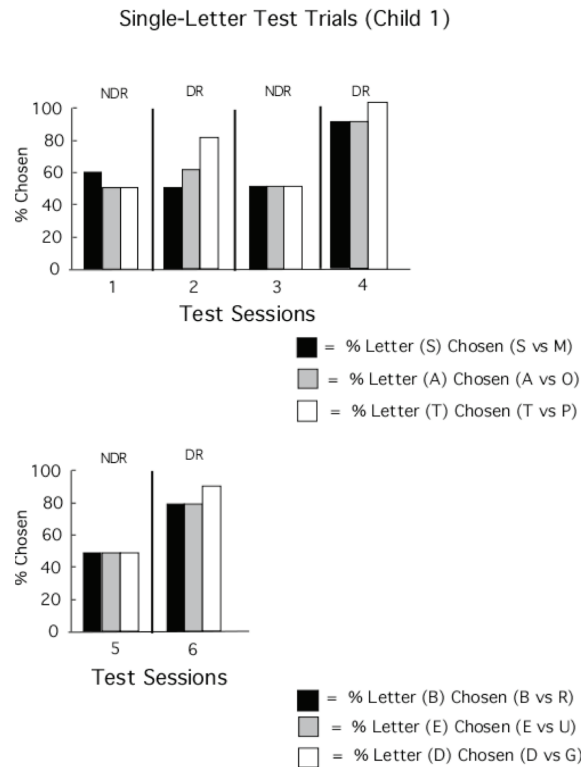


Figure 9. For Child 1, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Word test (nondifferential reinforcement). 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 nondifferential reinforcement 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. 10). 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. 10). The word testing procedure failed to demonstrate overselective attention for either word discrimination with nondifferential reinforcement during the test.

Word test (differential reinforcement). The word test trials revealed overselective attention in the first differential-reinforcement test session, however, as Child 1 exhibited stimulus control for only one of the letters of the S+ word (SAT) (see Fig. 10). When the word test trials were repeated in the second differential-reinforcement test session, Child 1 now 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. 10). 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.

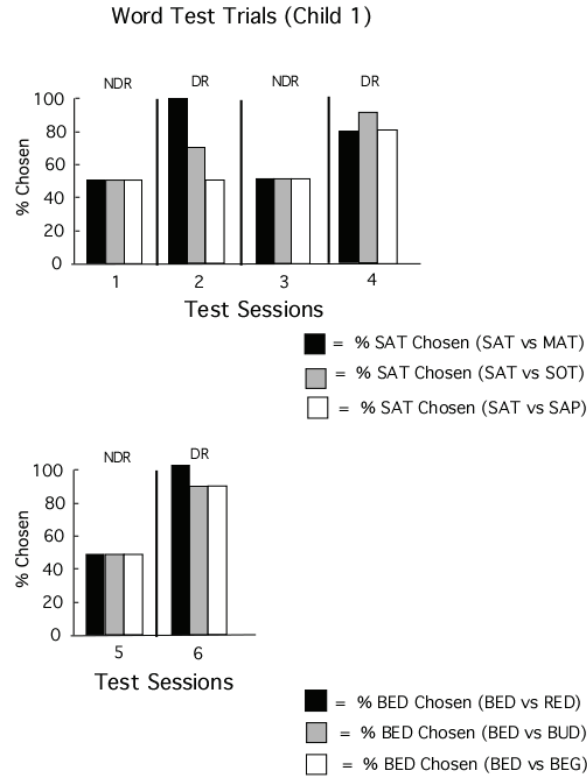


Figure 10. For Child 1, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed 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.

(Child 2)

Single-letter (nondifferential reinforcement). Child 2, in opposition to Child 1, displayed overselective attention for both word discriminations during the single-letter test trials when nondifferential-reinforcement was employed. 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. 11). 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. 11).

Single-letter (differential-reinforcement). Child 2 also displayed overselective attention when the single-letter test trials were provided with differential reinforcement. 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. 11). 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, Child 2 now exhibited stimulus control for each letter of the S+ word (SAT) (see Fig. 11). 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. 11). Child 2 demonstrated overselective attention initially during the

single-letter test trials, but repeated testing with differential reinforcement resulted in Child 2 attending to each letter of the S+ words.

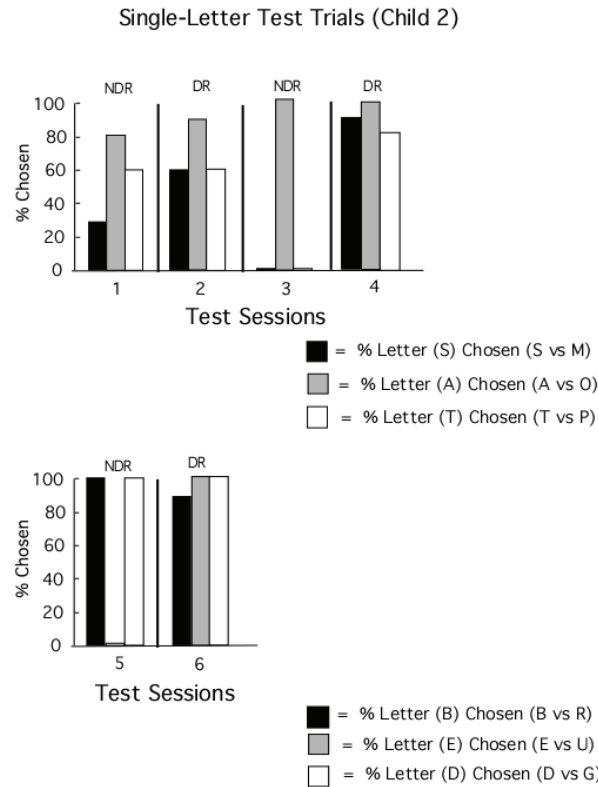


Figure 11. For Child 2, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Word test (nondifferential reinforcement). Child 2 demonstrated overselective attention during the word test trials in all of the nondifferential-reinforcement test sessions (see Fig. 12). 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. 12). 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. 12).

Word test (differential reinforcement). Child 2 persisted in exhibiting overselective attention during the word test trials when differential reinforcement 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. 12). 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. 12). In the final differential-reinforcement test session, Child 2 again displayed overselective attention in the word test trials when he exhibited stimulus control for only one of the letters of the S+ word (BED) (See Fig. 12). Repeated testing, with a differential-reinforcement contingency, was not effective in eliminating the overselective attention that Child 2

demonstrated during the word test trials. This occurred even when overselective attention was no longer evident during the single-letter test trials after differential reinforcement was employed.

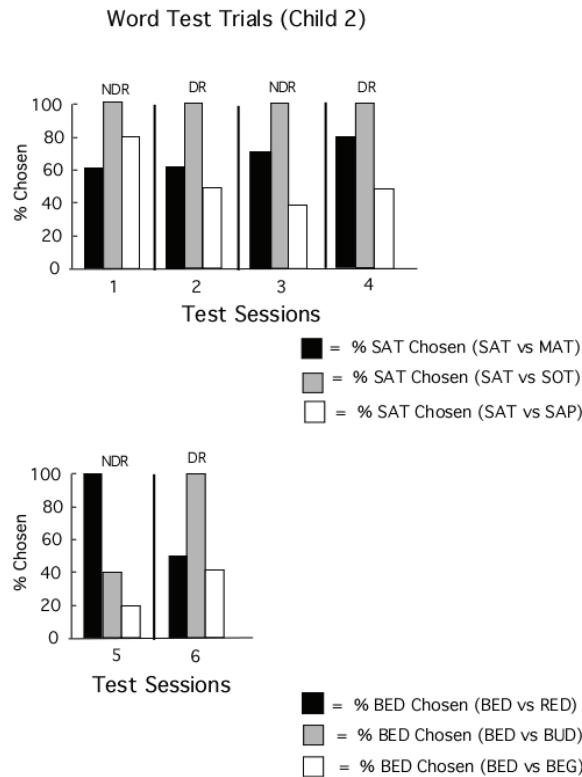


Figure 12. For Child 2, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed 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.

(Child 3)

Single-letter test (nondifferential reinforcement). 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. 13). 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 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. 13).

Single-letter test (differential reinforcement). Child 3 also displayed overselective attention during the single-letter test trials when differential reinforcement 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. 13). 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. 13). Repeated testing with a differential-reinforcement

contingency eliminated the overselective attention that Child 3 initially exhibited during the single-letter test trials, as had also occurred for Child 1 and Child 2.

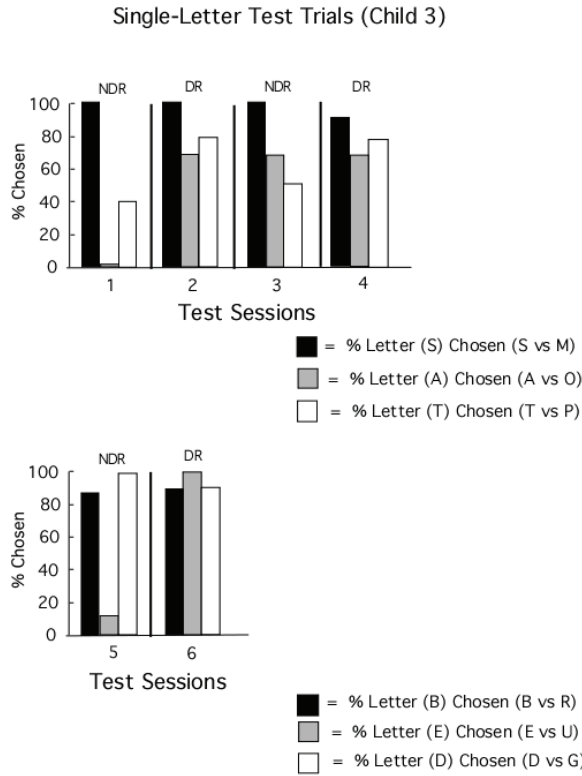


Figure 13. For Child 3, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Word test (nondifferential reinforcement). Child 3 persisted in exhibiting overselective attention in the word test trials with a nondifferential-reinforcement contingency (see Fig. 14). 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) (see Fig. 14). Child 3 continued to exhibit overselective attention in the word test trials of the third nondifferential-reinforcement test session when he displayed stimulus control for only one of the letters of other S+ word (BED).

Word test (differential reinforcement). Child 3 also 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. 14). When the word test trials were repeated with a differential-reinforcement contingency in effect, Child 3 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. 14). Repeated testing with a differential-reinforcement contingency also eliminated the overselective attention that Child 3 initially displayed during the word test trials.

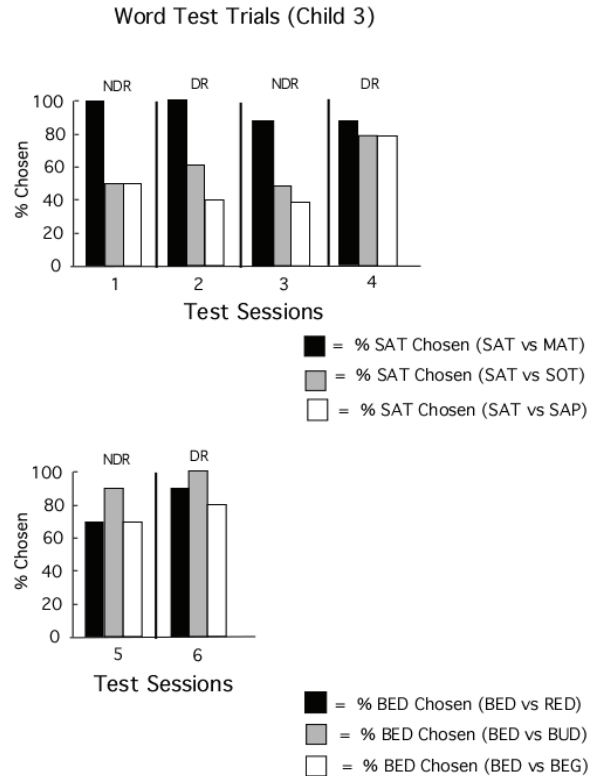


Figure 14. For Child 3, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed 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.

(Child 4)

Single-letter test (nondifferential reinforcement). When nondifferential reinforcement was employed during the single-letter test trials, Child 4 did not reveal overselective attention in any of the test sessions (see Fig. 15). He chose, in contrast to the other three children, 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.

Single-letter test (differential reinforcement). Child 4 also did not display overselective attention in the single-letter test trials 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 (see Fig. 15).

Word test (nondifferential reinforcement). 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. 16), which had not occurred for any of the other children. The word test trials confirmed that Child 4 exhibited stimulus control for all three letters of the S+ words even when nondifferential reinforcement was employed (see Fig. 16).

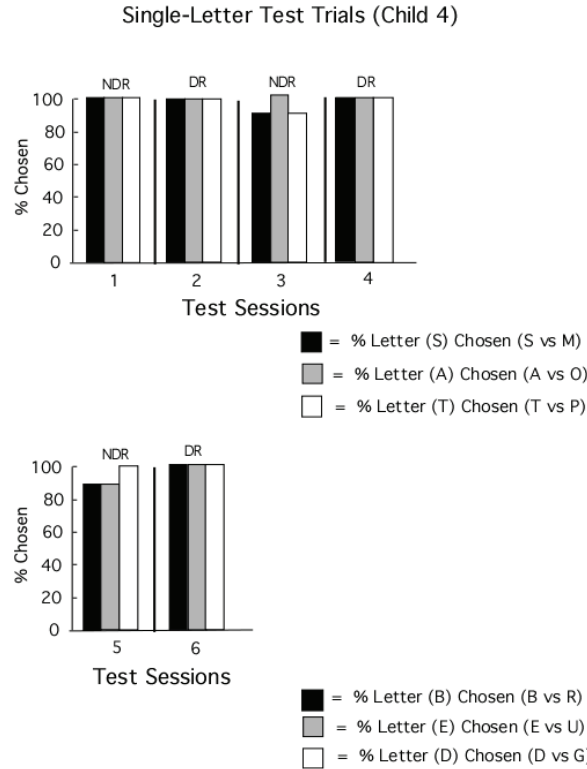


Figure 15. For Child 4, percent response choice during the single-letter test trials when letters comprising the S+ word (SAT) and the S- word (MOP) were presented separately (top graph) and letters comprising the S+ word (BED) and the S- word (RUG) were presented separately (bottom graph). During the single-letter test trials, both a nondifferential-reinforcement contingency (NDR) and a differential-reinforcement contingency (DR) were employed.

Word test (differential reinforcement). 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 differing by only one letter (see Fig. 16).

Discussion

Young boys of typical development, in the first phase of this investigation, demonstrated overselective attention for both a conditional-discrimination test requiring simultaneous attention to two stimulus components composed of a letter and a symbol as well as a conditional-discrimination test requiring simultaneous attention to two letters. Both their stimulus-component accuracy scores and response topographies revealed identical stimulus preferences with few exceptions. Their overselective attention also persisted despite extended single-component pretraining and repeated exposure to the conditional-discrimination tests. Overselective attention was also found to occur for the young boys regardless of the order in which the two conditional-discrimination tests were administered.

Although overselective attention occurred in young children, their overselective attention was diminished with extended single-stimulus pretraining and repeated exposure to conditional-discrimination tests requiring simultaneous attention to multiple cues. Extended pretraining and repeated exposure to two similar conditional-discrimination tests resulted in simultaneous attention to multiple stimuli eventually

developing for all four young boys despite the fact that three of the young boys displayed overselective attention when the compound stimuli were initially provided. The rate at which simultaneous attention developed varied, however, for the young boys revealing differences in the intensity of their overselective attention.

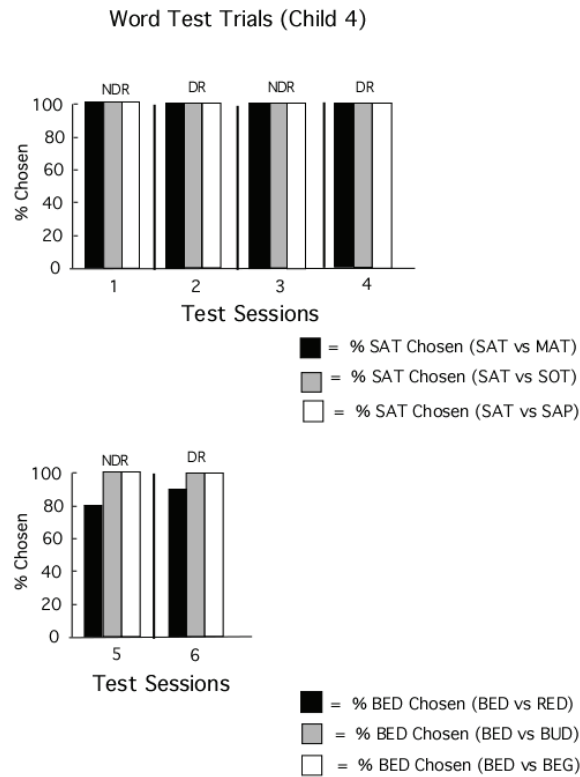


Figure 16. For Child 4, percent response choice during the word test trials when the S+ word (SAT) appeared with three different words (MAT, SOT, SAP) that differed from the S+ word by only one letter (top graph) and the S+ word (BED) appeared with three different words (RED, BUD, BEG) that differed 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.

These results support previous findings where prior exposure to a conditional discrimination led to simultaneous attention to multiple elements developing in a subsequent conditional-discrimination task for adolescents with mental retardation (Huguenin, 2004). The second conditional discrimination in this earlier study was composed of stimulus elements from classes of stimuli identical to those utilized in the preceding task. The current investigation extended these findings. It demonstrated prior exposure to a conditional discrimination can lead to simultaneous attention occurring in a second conditional-discrimination task even when it is composed of stimulus elements from classes of stimuli not identical to those previously employed. This suggests extended pretraining and repeated exposure to conditional-discrimination tasks requiring simultaneous attention to multiple cues may reduce overselective attention in subsequent tasks regardless of whether they involve stimuli from the same or different stimulus classes.

In the second phase of this study, multiple tests administered with computer technology determined if overselective attention occurred in young children of typical development when words were presented. Although 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 study, in contrast, assessed how young children attended to words. Three of the four children did demonstrate overselective attention to the training words. Assessing how young children visually attended to words

under a variety of test conditions, in addition, provided greater precision not only in identifying overselective attention but also its intensity. This was shown as young 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 differential reinforcement was employed. 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 were utilized. Only the fourth child did not demonstrate overselective attention in any of the test sessions.

While the present investigation utilized multiple test conditions to assess both the presence and the intensity of overselective attention, most studies have used only a single stimulus-control test. In many of these 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 compound discriminations (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 et al., 2008a; Dickson, Deutsch, Wang, & Dube, 2006; Dickson, Wang, Lombard, & Dube, 2006; Dube & McIlvane, 1999; Reed, 2006; Reed, Petrina, & McHugh, 2011).

This investigation in phase two differed from previous investigations, however, by using both single-component and conditional-discrimination tests as well as different reinforcement conditions in the test trials to detect overselective attention to words. By employing more than one type of stimulus-control test, it was possible to determine the robustness of overselective attention to words 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. Detecting overselective attention to words has important educational relevance since attending to only a limited number of letters within words would interfere with a child's reading achievement.

In addition, the effect of repeated testing on whether young children learned to attend to each letter of training words was discovered in the second phase of this investigation to depend on the type of reinforcement contingency utilized during the test trials. If nondifferential reinforcement 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. In contrast, repeated testing, with differential reinforcement employed during the test trials, eliminated the overselective attention that three children displayed in the initial test sessions. As a result of extended testing with differential reinforcement, all of the children attended to each letter of the training words as revealed by one or both stimulus-control tests.

Another significance of the results of this study is that overselective attention occurred in children of typical development as old as six and seven years of age when compounds composed of letters and symbols, all letters, and words were presented. This is in opposition to many other studies which 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 results of the current investigation indicate the basis for this discrepancy is due to the less complex stimuli utilized in these earlier studies (Birnie-Selwyn & Guerin, 1997).

Individual differences were also discovered in the intensity of overselective attention in young children of typical development in both phases one and two. Using similar tests to provide a detailed analysis of how students with learning and developmental disabilities attend to letters and words would permit the development of more individualized programs for reading instruction. 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).

The findings of this investigation also indicate children with overselective attention should be monitored over time. While this study demonstrates that overselective attention in a child as old as six or seven years of age is not necessarily a cause for concern, if overselective attention persists in subsequent years an attentional deficit could be present. Future research needs to assess visual attention in children of different ages to more adequately identify attentional patterns, which could be indicators of significant attentional disturbances or developmental delays. Employing computer technology to administer multiple stimulus-control tests could also provide a cost effective approach for monitoring the visual attention of children on a wide scale basis. This could serve as an automated screening device for identifying children with pervasive overselective attention. 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.

This study also points out the need for examining how educational material is presented to young children in order to reduce the likelihood of overselective attention developing and interfering with their educational progress. Although adding redundant cues to highlight educational tasks may serve to attract the child's attention, redundant cues can also produce overselective attention, especially in young children. If letters were presented in different colors in a letter recognition task, for instance, young children might not learn to recognize the individual letters because of attending solely to their color components. Presenting educational materials without redundant or unnecessary stimulus features may be the best instructional approach for young children when they are initially acquiring basic educational skills. This would certainly be a critical instructional strategy for children with developmental disabilities who have a high incidence of overselective attention.

In summary, multiple tests administered with computer technology assessed how young children of typical development attended to letters and words. Most children demonstrated overselective attention. Employing multiple test conditions revealed differences in the intensity of their restricted attention, as the children differed in the number of test sessions and test conditions in which overselective attention occurred. Determining how children attend to words using similar tests could result in more individualized and effective programs for reading instruction.

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Footnotes

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