Behavior Analysis & Technology

Monograph 060701

Computer Assessment of Overselective Visual Attention in Six-Year and Nine-Year Old Boys

Nancy H. Huguenin, Ph. D.
Behavior Analysis & Technology, Inc.
Groton, MA, USA

Abstract

Overselective attention is a perceptual problem that interferes with a child's learning and development. Although overselective attention is frequently reported in students with developmental disabilities, it has typically not been observed in children of normal development. Stimulus compounds composed of letters and symbols and all letters were administered to see if overselective attention occurred for nondisabled children when more complex stimuli were presented. Two stimulus-control testing procedures, administered with computer touch-screen technology, assessed how the children attended to stimulus compounds when conditional discriminations requiring simultaneous attention to multiple cues were provided. In addition, four young boys and three older boys were given the same conditional-discrimination tests to assess overselective attention in different age groups. Overselective attention occurred in the young boys and persisted despite extended training, although following extended training, the young boys did eventually attend simultaneously to two stimulus elements. These findings indicate overselective attention is not only found in students with developmental disabilities but also occurs in children of normal development. The results of this study also suggest that restricted attention in young boys appears to be temporary since overselective attention was not observed in older boys. In contrast, restricted attention in children with developmental disabilities is often chronic and doesn't diminish as the child advances in age. It may not be the presence of overselective attention but how long overselective attention persists that distinguishes children with attentional disturbances and developmental disabilities.

Key Words: Stimulus Overselectivity; Visual Attention; Young Children; Computer Assessment

Behavior Analysis& Technology Monograph 060701, 1 – 22, 2006
Publication Date: 1 July 2006

(Full text follows)

BA&T Monographs is published by *BA&T, Inc.*, Groton, Massachusetts, USA,
N. H. Huguenin, Editor (contact: nhuguenin@ba-and-t.com)

The intent of this investigation was to utilize computer touch-screen technology for assessing visual attention in young children. Assessing visual attention in young children is important because it can identify attentional deficits, which can interfere with the child's development and educational progress. One perceptual problem that can interfere with a child's learning and development is overselective attention. Students with overselective attention respond to only restricted portions of complex stimulus displays. They demonstrate a type of "tunnel vision", as they attend to only a limited number of elements in a visual compound. Restricted attention can affect many areas of a child's development and may explain the difficulty children with developmental disabilities commonly have in acquiring appropriate social, language, play, and emotional behaviors (Burke, 1991; Dunlap, Koegel, & Burke, 1981).

Overselective attention is frequently reported in students with developmental disabilities in different age groups (Bailey, 1981; Huguenin, 1997, 2004; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas, Schreibman, Koegel, & Rehm, 1971; Rincover & Ducharme, 1987; Schreibman & Lovaas, 1973; Schreibman, Kohlenberg, & Britten, 1986; Stromer, McIlvane, Dube, & Mackay, 1993; Ullman, 1974; Whiteley, Zaparniuk, & Asmundson, 1987; Wilhelm & Lovaas, 1976). Overselective attention has typically not been observed, however, in children of normal development of approximately six years of age or older (e.g., Bailey, 1981; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971; 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 current investigation, stimulus compounds composed of letters and symbols and all letters were administered to see if overselective attention would occur in nondisabled boys of approximately six years of age when more complex stimuli were presented.

The current study also used conditional-discrimination tests requiring simultaneous attention to multiple cues to maintain continuous reinforcement to assess the presence of overselective attention. Using this conditional-discrimination procedure, for example, responding is only reinforced when two visual cues appear together in the same stimulus compound. If the student responds when either stimulus element is presented without the other stimulus, extinction results. Reinforcement for responding to either stimulus element is conditional, therefore, upon the remaining stimulus appearing in the same stimulus compound. Such a conditional-discrimination test can determine directly whether overselective attention is exhibited, because if the child is responding to only one component, errors are produced which prevents the student from achieving continuous reinforcement. As a result, selective attention is immediately revealed. In contrast, tests provided by presenting individual components alone after the acquisition of compound discriminations can only infer attentional patterns produced by compound training cues. Such procedures are subject to contamination by test variables and might not accurately reflect, therefore, what aspects of the stimulus compound actually do control responding. Indeed, past studies have found conflicting results when different tests were used following criterion performance for the same compound discrimination (Huguenin, 1997; Huguenin & Touchette, 1980). Despite the greater reliability of conditional-discrimination procedures requiring simultaneous attention to multiple cues for revealing overselective attention, most studies investigating overselective attention have not employed this stimulus control procedure.

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 different stimulus-control testing procedures were automatically administered to assess how children attended to stimulus compounds when conditional discriminations 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; Fields, 1985; Huguenin, 1997, 2004; Huguenin & Touchette, 1980; Merrill & Peacock, 1994; Newman & Benefield, 1968; 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.

Computer touch-screen technology is ideal for measuring visual attention, as multiple stimulus control tests can be automatically administered and response topographies recorded while presenting stimulus displays. Recording spatial locations of responses can be determined with a touch screen and assist in identifying how compound visual stimuli are attended to. Although other investigations have employed touch screens for training visual discriminations (e.g., Bhatt & Wright, 1992; Dube, W.V. & McIlvane, W.J., 1999; Huguenin, 1987; Lynch & Green, 1991; Markham, Butt, & Dougher, 1996; Saunders, Johnston, & Brady, 2000; Stromer et al., 1993), only a few investigations have used touch screens to record spatial locations of responses for identifying stimulus elements selectively attended to in visual compounds (Huguenin, 1997, 2000, 2004). It was investigated whether utilizing computer touch-screen technology to provide a fine-grained analysis of stimulus control might reveal overselective attention in young children of normal development when conditional-discrimination tests employing more complex stimuli were presented.

In addition, six-year and nine-year old boys were given the same conditional-discrimination tests requiring simultaneous attention to multiple cues to assess the occurrence of overselective attention in different age groups. By systematically assessing the visual attention of children of normal development of different ages, what constitutes an atypical attentional pattern can be determined. Perhaps, it is not the presence of overselective attention but rather the age at which it occurs that determines whether a child has an attentional disturbance or developmental delay. In contrast to students with developmental disabilities for whom overselective attention often persists into adolescence and adulthood, it was wondered how children of normal development of different ages attended to visual compounds.

Using computer touch-screen technology to assess the visual attention of young children has important educational implications. By identifying children with overselective attention, instructional programs can be modified to minimize the effects of their restricted attention on their educational progress. Treatment programs designed to reduce and eliminate overselective attention can also be provided. Finally, utilizing computer touch-screen technology to provide a detailed analysis of how children respond to visual compounds can identify age groups in which overselective attention is likely to occur. This has important significance for developing educational materials for children in order to reduce the likelihood of overselective attention occurring and interfering with their educational performance.

The present investigation also examined the effect of single-stimulus pretraining and repeated exposure to conditional-discrimination tests requiring simultaneous attention to multiple cues on how children attended to stimulus compounds. Past research has demonstrated providing compatible single-element training is effective in teaching conditional discriminations requiring simultaneous attention to multiple cues (Huguenin, 1985). The amount of single-stimulus pretraining and exposure to the conditional discriminations required before simultaneous attention occurs can differ, however, across students (Huguenin, 2004). The amount of extended training that is necessary before simultaneous attention to multiple cues occurs can be, as a result, another parameter for assessing the intensity of a child's overselective attention. In addition, by pretraining each element to exercise the same level of stimulus control, it is possible to demonstrate any overselective attention that is evident for the stimulus compound is not due to differing prior levels of stimulus control of the individual stimulus elements. Finally, by utilizing computer touch-screen technology to monitor how children respond to visual compounds over extended time periods, individual differences in children can be precisely specified and potential factors contributing to the emergence or elimination of overselective attention discovered.

Method

Subjects

Four young boys with an average age of 6.3 years and three older boys with an average age of 9.5 years of normal 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. The chronological ages of the older boys were 8.7 years, 9.7 years, and 10 years, respectively. Three of the children were enlisted as a result of an ad placed in a local newspaper, and four of the children were acquaintances of families who had participated in the study. All of the children came from similar socioeconomic backgrounds and attended schools in the same school system.

Apparatus

The experimental sessions were automated by an Apple Power Macintosh 7500/100 desktop 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 elements appearing in the same stimulus 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.

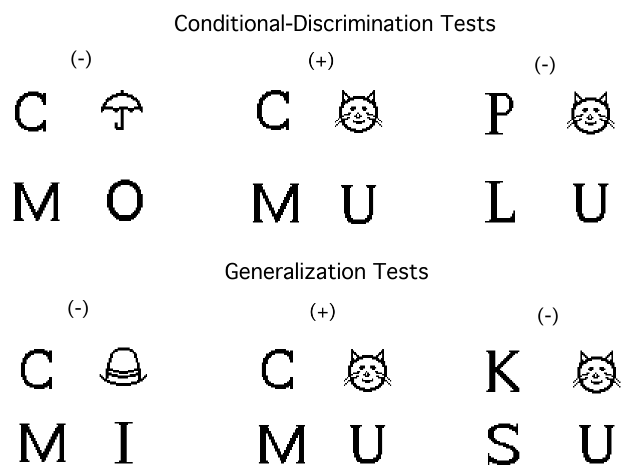


Figure 1. Diagram of the conditional-discrimination tests. Plus (+) indicates stimulus compounds paired with reinforcement and minus (-) denotes stimulus compounds paired with nonreinforcement. Two stimulus compounds, S+ and S- compound stimuli, were presented simultaneously and were composed of letter 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.

Single-Component Training and Conditional-Discrimination Testing

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. Single-stimulus pretraining was repeated at the beginning of the next session until criterion accuracy was again achieved for each component of the S+ compound. The conditional-discrimination test described previously was then presented a second time for 20 trials. During the conditional-discrimination test, the two S- compounds (P-Cat and C-Umbrella) were successively presented in a random sequence with the C-Cat S+ compound with the restriction that either S- compound could not appear more than three times in succession with the S+ compound (see Fig. 1). At the beginning of the third session, single-stimulus pretraining was repeated, and the conditional-discrimination test was presented a third time for another 20 trials which was followed by the corresponding generalization test described below.

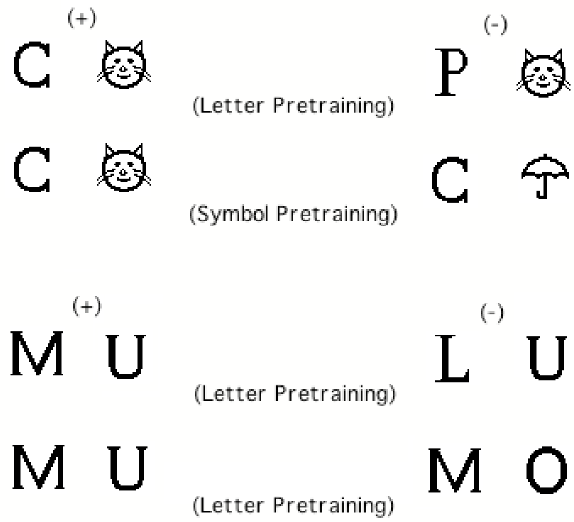


Figure 2. Diagram of four separate visual discriminations established prior to presentation of the conditional-discrimination tests. Plus (+) indicates stimulus compounds paired with reinforcement and minus (-) denotes stimulus compounds paired with nonreinforcement. The S+ and S- compounds were presented 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. Single-stimulus pretraining was repeated at the beginning of the next session until criterion accuracy was again achieved for each letter component of the S+ compound. The other conditional-discrimination test was then presented a second time for 20 trials as described previously. In this conditional-discrimination test, the two S- compounds (L-U and M-O) were successively presented in a random sequence with the S+ compound (M-U) with the restriction that either S- compound could not appear more than three times in succession with the S+ compound (see Fig.1). After single-stimulus pretraining was repeated at the beginning of the next session, the conditional-discrimination test was presented again for a third time which was followed by the corresponding generalization test described below. Additional single-stimulus pretraining was provided at the beginning of the following session until criterion accuracy was achieved, and then the original conditional-discrimination test was administered a fourth time. Finally, the original conditional-discrimination test was repeated with single-stimulus pretraining omitted.

The young boys and the older boys achieved criterion accuracy (29/30 trials correct) within 30 trials whenever single-stimulus pretraining was administered, with only two exceptions.

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).

Data Collection

Stimulus control was assessed by determining response accuracy for each component of the S+ compounds during the conditional-discrimination tests. 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. Because a touch screen was utilized, where the students touched each time the stimulus compounds appeared on the screen was also recorded. This permitted a direct comparison of accuracy scores with stimuli touched in the stimulus compounds during the 20-trial conditional-discrimination tests.

Table 1 lists the sequence of stimuli and procedures provided to the young boys and older boys.

Table 1
Sequence of Stimuli and Procedures

Young Boys (C1,C2,C3)	Young Boys-cont. (C4)	Older Boys (C5,C6,C7)
Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)	Condit. Discrim.C-Cat (+)
Letter Pretraining (C)	Letter Pretraining (M)	Letter Pretraining (C)
Symbol Pretraining (Cat)	Letter Pretraining (U)	Symbol Pretraining (Cat)
Letter Pretraining (C)	Letter Pretraining (M)	Letter Pretraining (C)
Symbol Pretraining (Cat)	Letter Pretraining (U)	Symbol Pretraining (Cat)
Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)	Condit. Discrim.C-Cat (+)
Letter Pretraining (C)	Letter Pretraining (M)	Letter Pretraining (C)
Symbol Pretraining (Cat)	Letter Pretraining (U)	Symbol Pretraining (Cat)
Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)	Condit. Discrimin.C-Cat (+)
Generaliz.Test C-Cat (+)	Generaliz. Test M-U (+)	Generaliz.Test C-Cat (+)
Condit. Discrim.M-U (+)	Letter Pretraining (M)	Condit. Discrim.M-U (+)

Table 1 – cont'd

Letter Pretraining (M)	Letter Pretraining (U)	Letter Pretraining (M)
Letter Pretraining (U)	Condit. Discrim.M-U (+)	Letter Pretraining (U)
Letter Pretraining (M)	Condit. Discrim.M-U (+)	Letter Pretraining (M)
Letter Pretraining (U)	Condit. Discrim.C-Cat (+)	Letter Pretraining (U)
Condit. Discrim.M-U (+)	Letter Pretraining (C)	Condit. Discrim.M-U (+)
Letter Pretraining (M)	Symbol Pretraining (Cat)	Letter Pretraining (M)
Letter Pretraining (U)	Letter Pretraining (C)	Letter Pretraining (U)
Condit. Discrim.M-U (+)	Symbol Pretraining (Cat)	Condit. Discrim.M-U (+)
Generaliz. Test M-U (+)	Condit. Discrim.C-Cat (+)	Generaliz. Test M-U (+)
Letter Pretraining (M)	Letter Pretraining (C)	Letter Pretraining (M)
Letter Pretraining (U)	Symbol Pretraining (Cat)	Letter Pretraining (U)
Condit. Discrim.M-U (+)	Condit. Discrim.C-Cat (+)	Condit. Discrim.M-U (+)
Condit. Discrim.M-U (+)	Generaliz. Test C-Cat (+)	Condit. Discrim. M-U (+)

Results

Conditional-Discrimination Tests: Stimulus-Component Accuracy Scores (Young Boys)

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).

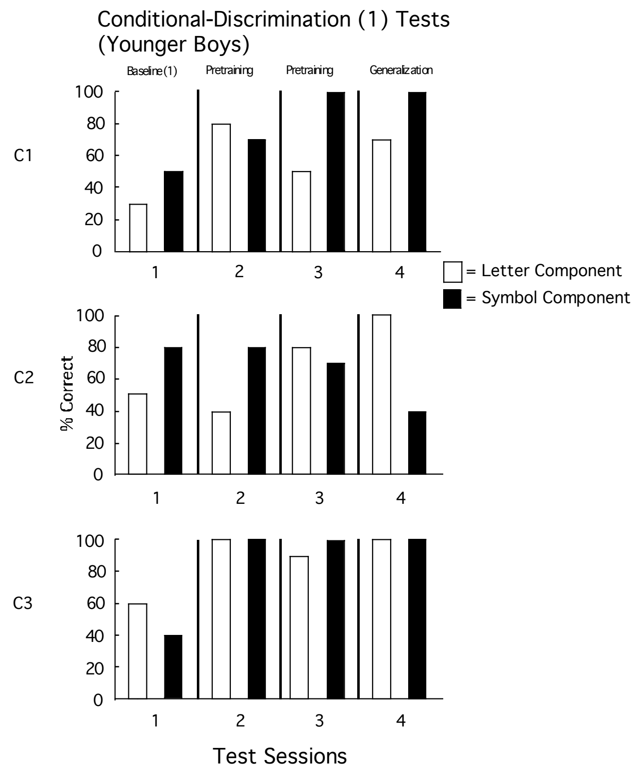
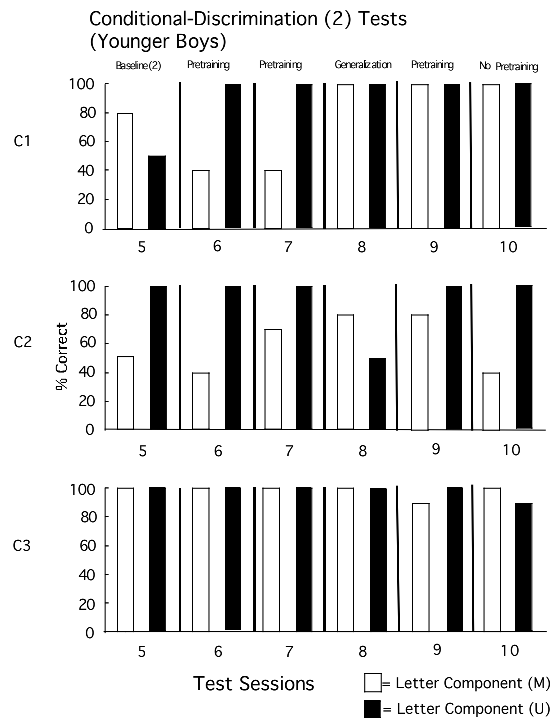


Figure 3. For three younger boys, percent accuracy of responses for the letter (white bars) and symbol (black bars) components of the S+ compound of their first conditional-discrimination test in the test sessions before and following pretraining. Percent response accuracy for an individual component 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.

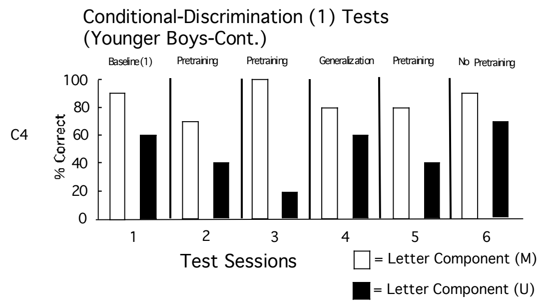
Three of the four young boys also displayed overselective attention when the conditional-discrimination test requiring simultaneous attention to two letters (M and U) was presented. Child 2 and Child 4 both revealed a high prevalence of overselective attention as they achieved high accuracy levels (80% 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).



<u>Figure 4</u>. For three younger 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.

<u>Conditional-Discrimination Tests: Stimulus-Component Response Topographies (Young Boys)</u>

When the young boys achieved accuracy scores for the stimulus components revealing overselective attention in 22 test sessions, their response topographies recorded with the touch screen confirmed identical stimulus preferences, with only three exceptions. The 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 young boys, whose accuracy scores revealed overselective attention when the conditional-discrimination test requiring simultaneous attention to both a letter and a symbol was presented, also selectively touched stimulus elements demonstrating the same stimulus preferences. Child 1 achieved a high level of response accuracy for only the letter component in one conditional-discrimination test session, and he also selectively touched the letter element when the stimulus compounds were presented (See Figs. 3 & 6). Child 1 subsequently displayed response topographies which corroborated his selective attention to the symbol component, as indicated in two other test sessions by his stimulus-component accuracy scores, by selectively touching the symbol element in 80% or more of the trials. When Child 2 achieved accuracy scores in two test sessions demonstrating selective attention to the symbol component, he also selectively touched the symbol element in the stimulus compounds during these test sessions (See Figs. 3 & 6). He selectively touched the letter component, however, during two test sessions when his accuracy scores for the stimulus components indicated he was now selectively attending to the letter component. Finally, Child 4 selectively touched the symbol component and selectively touched the letter component in two conditional-discrimination test sessions which were in agreement with his stimulus preferences revealed by the accuracy scores of the stimulus elements (See Figs. 5 & 8, bottom graphs).



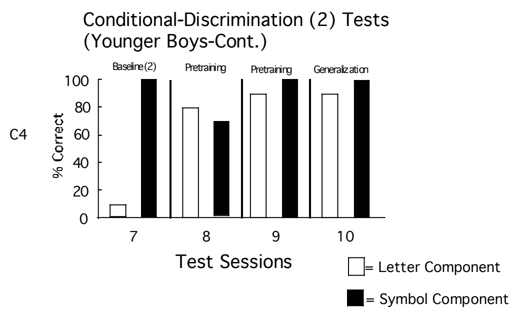


Figure 5. In the upper graph, for a fourth younger boy (C4), percent accuracy of responses for the letter M (white bars) and the letter U (black bars) components of the S+ compound of his first conditional-discrimination test in the test sessions before and following pretraining. In the bottom graph, 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.

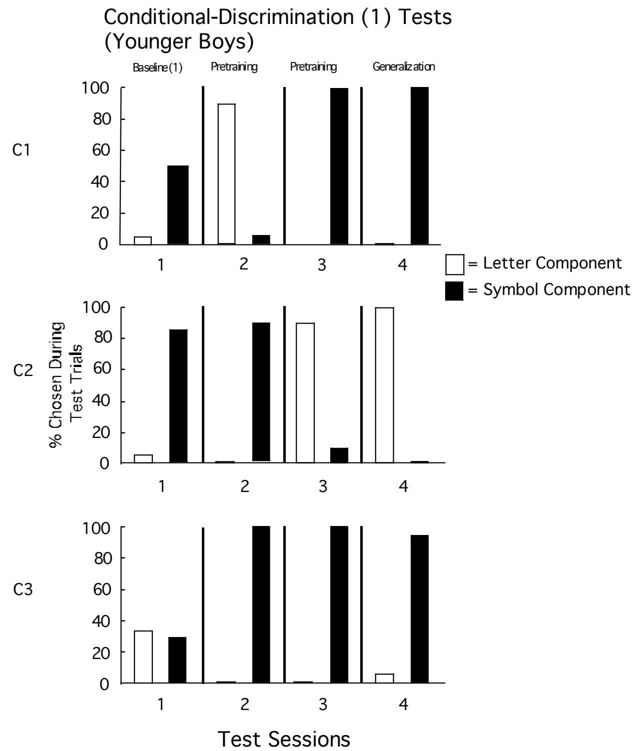


Figure 6. For three younger boys, percentage letter component (white bars) and symbol component (black bars) of the S+ compound of their first conditional-discrimination test were chosen in the test sessions before and following pretraining. Test results for each child appear in the order in which the different testing conditions were administered.

The response topographies of three of the young boys also indicated stimulus preferences which were identical to those revealed by the stimulus-component accuracy scores when the conditional-discrimination test requiring simultaneous attention to two letters was presented. Child 1, for example, in the baseline test session selectively touched the letter M in the stimulus compounds composed of two letters, which confirmed his selective attention to the letter M revealed by his accuracy scores (See Figs. 4 & 7). In the next two conditional-discrimination test sessions when Child 1 selectively attended to the letter U component, as demonstrated by his accuracy scores, he now selectively touched the letter U in the stimulus compounds in 80% or more of the trials. Child 2 achieved accuracy scores for the letter components which revealed selective attention to a single letter in five of the conditional-discrimination test sessions when simultaneous attention to two letters was required (See Fig. 4). In each of these five test sessions, Child 2 selectively touched individual letters in the stimulus compounds which indicated identical letter preferences (See Fig. 7). The accuracy scores of Child 4 demonstrated selective attention to a single letter in five of the conditional-discrimination test sessions, and his response topographies revealed stimulus preferences, in which he touched the same letter in 80% or more of the trials, in two of the test sessions (See Figs. 5 & 8, upper graphs). In both test sessions, when he selectively touched the letter M in the letter compounds, his stimulus-component accuracy scores demonstrated selective attention to the same letter component.

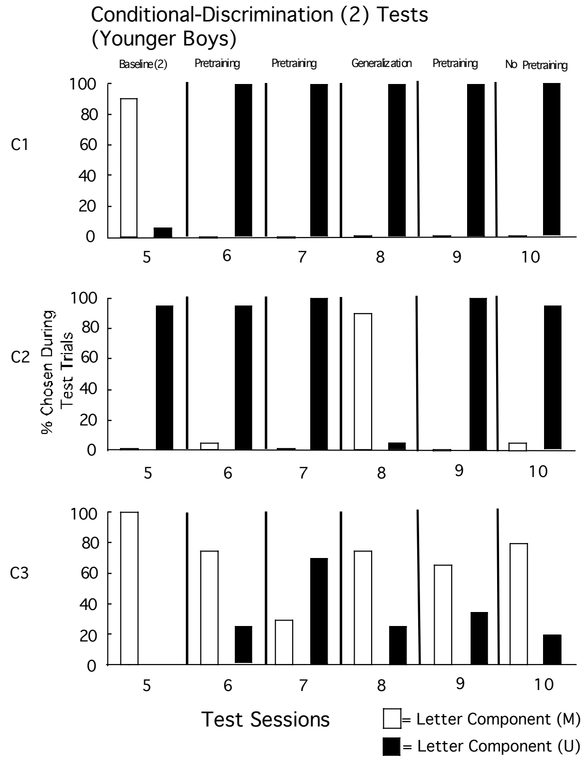


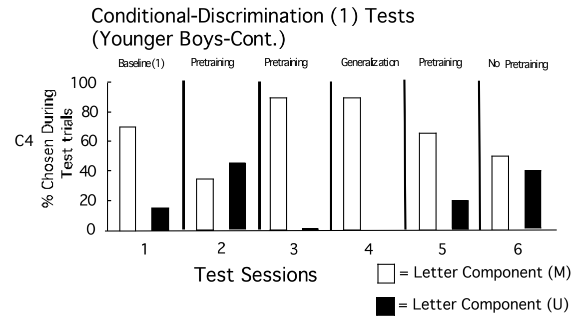
Figure 7. For three younger boys, percentage letter M component (white bars) and letter U component (black bars) of the S+ compound of their second conditional-discrimination test were chosen in the test sessions before and following pretraining. Test results for each child appear in the order in which the different testing conditions were administered.

In summary, the response topographies of the young boys revealed identical stimulus preferences in 86% of the conditional-discrimination test sessions where the accuracy scores of the young boys demonstrated stimulus overselectivity.

Conditional-Discrimination Tests: Stimulus-Component Accuracy Scores (Older Boys)

In contrast, the older boys did not display overselective attention in any of the conditional-discrimination test sessions. When accuracy scores of the conditional-discrimination test requiring simultaneous attention to both a letter and symbol component were examined, the three older boys achieved high response accuracy for both stimulus components throughout all four test sessions (See Fig. 9).

The older boys also failed to demonstrate overselective attention when the conditional-discrimination test requiring simultaneous attention to two letters was administered. They achieved high response accuracy (80% or higher) for both letter components during the six conditional-discrimination test sessions when stimulus compounds composed of all letters were provided (See Fig.10). While the majority of the young boys demonstrated overselective attention, which persisted despite extended training, none of the older boys achieved accuracy scores revealing selective attention.



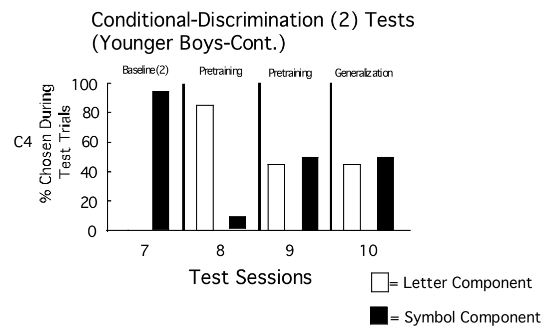


Figure 8. In the upper graph, for a fourth younger boy (C4), percentage letter M component (white bars) and letter U component (black bars) of the S+ compound of his first conditional-discrimination test were chosen in the test sessions before and following pretraining. In the bottom graph, percentage letter component (white bars) and symbol component (black bars) of the S+ compound of his second conditional-discrimination test were chosen in the test sessions before and following pretraining. Test results appear in the order in which the different testing conditions were administered.

Conditional-Discrimination Tests: Stimulus-Component Response Topographies (Older Boys)

The response topographies of the older boys, however, did demonstrate stimulus preferences in the conditional-discrimination test sessions. All three older boys selectively touched one stimulus element in all four test sessions when the conditional-discrimination test requiring simultaneous attention to both a letter and symbol element was provided (See Fig. 11). Although they did not selectively touch the same stimulus element during all of the test sessions, they selectively touched the symbol component in the majority of test sessions. The response topographies of the older boys continued to reveal stimulus preferences when the conditional-discrimination test requiring simultaneous attention to two letters was presented. The three older boys selectively touched only one of the letters in 80% or more of the test trials during all of the conditional-discrimination test sessions, with one exception (See Fig. 12).

Despite the presence of stimulus preferences for both types of conditional-discrimination tests as shown by their response topographies, the older boys achieved high accuracy scores throughout all of the conditional-discrimination test sessions in contrast to the young boys.

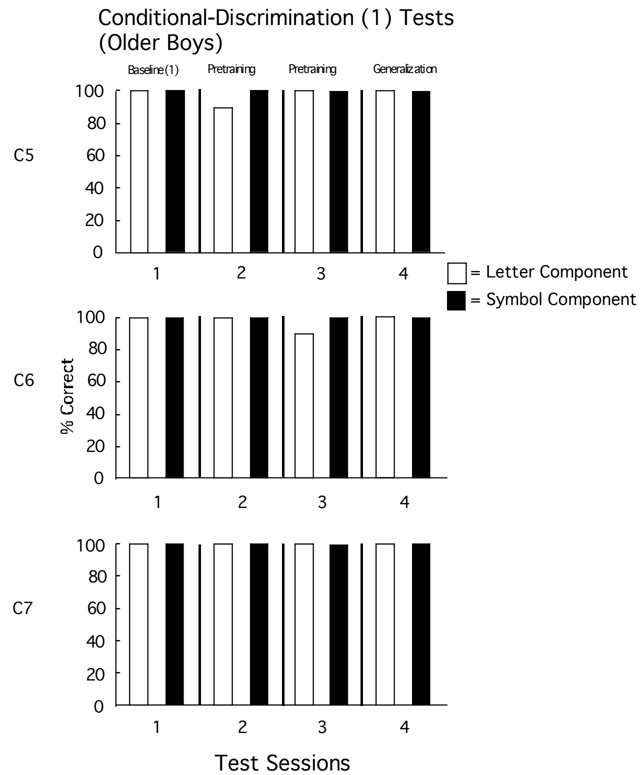


Figure 9. For three older boys, percent accuracy of responses for the letter (white bars) and symbol (black bars) components of the S+ compound of their first conditional-discrimination test in the test sessions before and following pretraining. Percent response accuracy for an individual component of 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.

Extended Training

Although three of the young boys displayed overselective attention for both types of stimulus compounds composed of letter and symbol components or two letter components, all of the young boys eventually achieved high levels of response accuracy for two stimulus components when extended training was provided. Single-stimulus pretraining and repeated exposure to two similar conditional-discrimination tests resulted in simultaneous attention to two stimulus elements ultimately developing for all four young boys. Three of the young boys were first presented the conditional-discrimination test requiring simultaneous attention to a letter and a symbol. Single-stimulus pretraining and repeated exposure to this conditional-discrimination test was effective in producing simultaneous attention to both stimulus elements for only one (C3) of the three young boys (See Fig. 3). In contrast, during the second conditional-discrimination test when simultaneous attention to two letters was required for continuous reinforcement, all three young boys eventually attended simultaneously to both letters after extended training was provided (See Fig. 4).

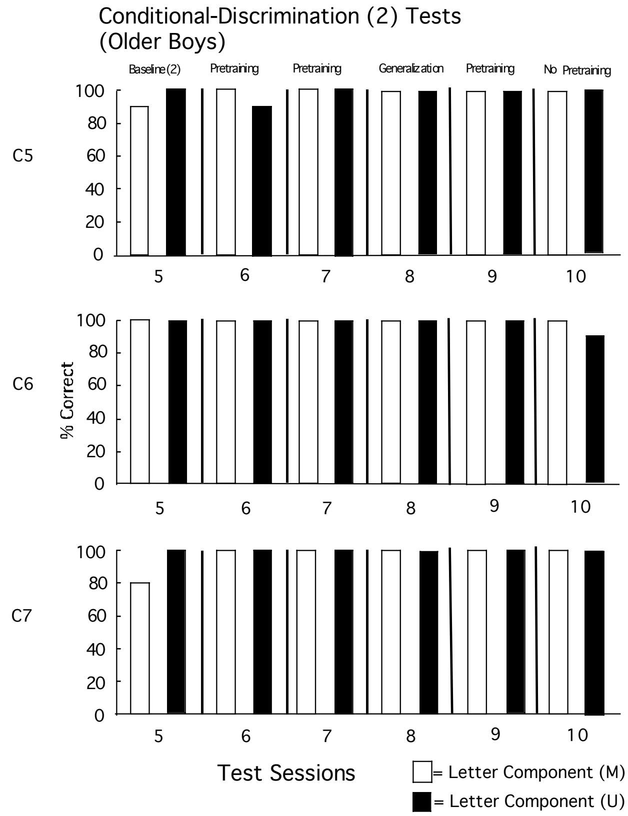


Figure 10. For three older boys, percent accuracy of responses for the letter M (white bars) and the letter U (black bars) components of the S+ compound of their second conditional-discrimination test in the test sessions before and following pretraining. Percent response accuracy for an individual component 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.

The order of the two conditional-discrimination tests was reversed for a fourth young boy (C4) and similar results were obtained. Child 4 also did not attend simultaneously to both stimulus elements during the first conditional-discrimination test sessions which in his case involved the conditional-discrimination test requiring simultaneous attention to two letters (See Fig. 5, upper graph). He too did not attend simultaneously to both stimulus elements until the second conditional-discrimination test sessions were administered which for him required simultaneous attention to letter and symbol components (See Fig. 5, bottom graph). The results of Child 4 indicate that the test results were not due to the order in which the two conditional-discrimination tests were presented.

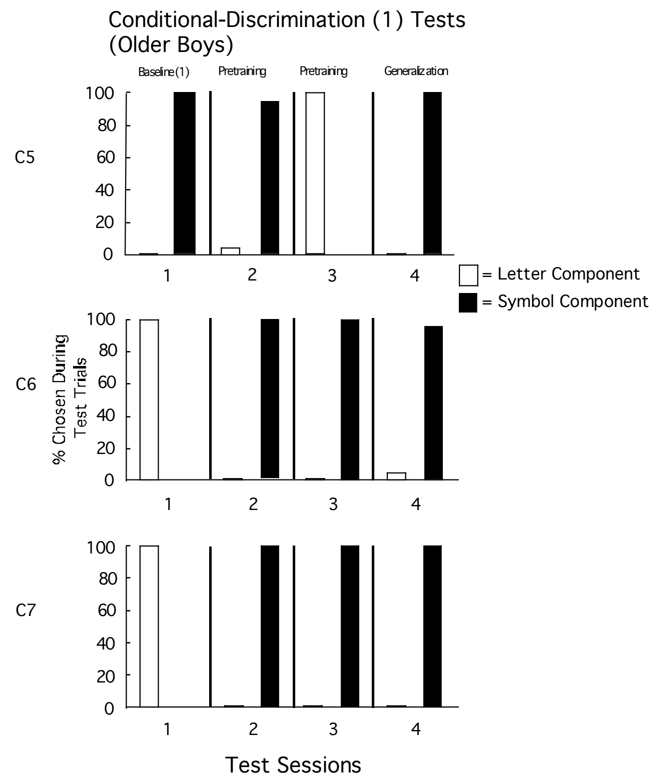


Figure 11. For three older boys, percentage letter component (white bars) and symbol component (black bars) of the S+ compound of their first conditional-discrimination test were chosen in the test sessions before and following pretraining. Test results for each child appear in the order in which the different testing conditions were administered.

Although all four young boys ultimately attended simultaneously to two stimulus elements, the young boys differed in the amount of extended training that was needed before simultaneous attention occurred. 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 the second test session of his first conditional-discrimination test after only a relatively small amount of single-stimulus pretraining (See Fig. 3). Child 3 persisted in demonstrating simultaneous attention to two stimulus elements in all of the following test sessions for both conditional-discrimination tests (See Fig. 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 Figs. 3 & 5). 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 Figs. 4 & 5). 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.

The three older boys, in opposition to the young boys, did not require any single-stimulus pretraining or additional exposure to either conditional-discrimination test before they simultaneously attended to two stimulus elements. All of the older boys achieved high levels of response accuracy for each stimulus element of both conditional-discrimination tests in the baseline session before any additional training was administered (See Figs. 9 & 10).

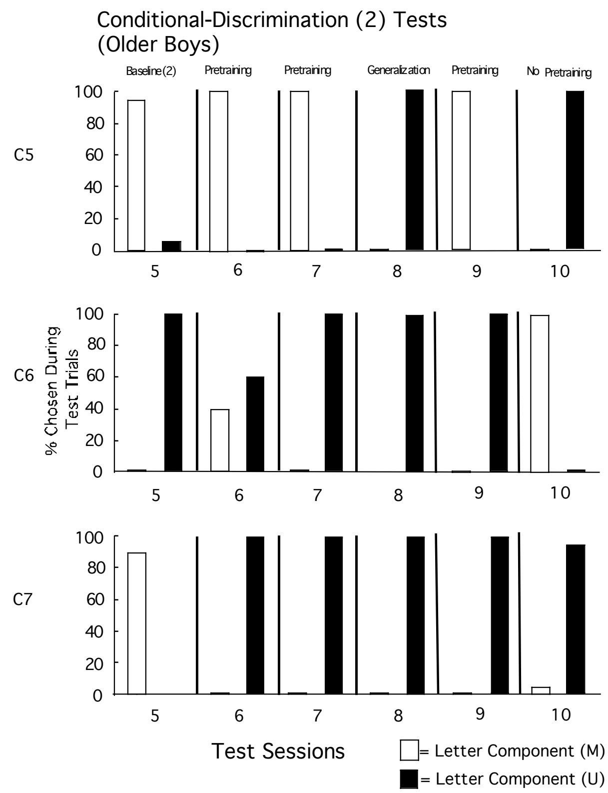


Figure 12. For three older boys, percentage letter M component (white bars) and letter U component (black bars) of the S+ compound of their second conditional-discrimination test were chosen in the test sessions before and following pretraining. Test results for each child appear in the order in which the different testing conditions were administered.

Discussion

The young boys 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. Their overselective attention also persisted despite extended single-component pretraining and repeated exposure to the conditional-discrimination tests. This was demonstrated as in more than half of the conditional-discrimination test sessions, the young boys achieved a high level of response accuracy for only one of the stimulus elements. Overselective attention was also found to occur for the young boys regardless of the order in which the two conditional-discrimination tests were administered. These findings indicate that overselective attention is not only found in students with developmental disabilities but can also occur in children of normal development as old as six years of age. Previous studies have failed to reveal overselective attention in children of normal development in this age group (e.g., Bailey, 1981; Koegel & Schreibman, 1977; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971). This may have occurred because they employed less complex stimuli than this investigation which presented stimulus compounds composed of letters and symbols or all letters. In addition, many previous investigations tested for overselective attention in young children by presenting stimulus elements separately following the acquisition of compound discriminations which can only indirectly infer attentional patterns produced by the compound training cues. In contrast, this investigation utilized conditional-discrimination tests requiring simultaneous attention to multiple cues which more directly tested the occurrence of overselective attention. By employing computer touch-screen technology to record response accuracy as well as response topographies, a more fine-grained analysis of how young children responded to visual compounds was also provided.

When the young boys' accuracy scores for the stimulus components of the conditional-discrimination tests revealed overselective attention, their response topographies confirmed identical stimulus preferences, with only a few exceptions. In approximately half of the conditional-discrimination test sessions, the response topographies and the accuracy scores of the young boys both revealed identical stimulus preferences which blocked attention to the remaining element in the visual compounds, resulting in overselective attention. This occurred for conditional-discrimination tests requiring simultaneous attention to multiple cues regardless of whether both stimulus components were from the same or different classes of stimuli.

Both procedures of recording response topographies with a touch screen and determining response accuracy of stimulus elements during the conditional-discrimination tests identified the presence of stimulus preferences in young boys. The accuracy scores of the individual stimulus elements during the conditional-discrimination tests, however, revealed the intensity of the stimulus preferences by assessing how quickly simultaneous attention to both elements developed in the conditional-discrimination tests. In over half of the conditional-discrimination test sessions, stimulus preferences were of sufficient intensity for the young boys that simultaneous attention to both stimulus elements was prevented from occurring. The young boys achieved, instead, a high level of response accuracy for only one stimulus element during these conditional-discrimination test sessions, demonstrating overselective attention. Recording response topographies proved to further confirm the young boys' accuracy scores demonstrated overselective attention by revealing the young boys consistently touched the identical preferred stimulus in the compounds, with only a few exceptions. As a result, other confounding factors, such as an unstable position pattern of responding, could be discounted as a possible basis for the children's test performance.

When the same conditional-discrimination tests were presented to the older boys, their accuracy scores did not reveal overselective attention for either conditional discrimination. Single-component pretraining and repeated exposure to the conditional-discrimination tests were also not required to establish simultaneous attention to multiple elements for any of the older boys. The older boys achieved high response accuracy for both stimulus components of the stimulus compounds in all of the conditional-discrimination test sessions.

In contrast to their accuracy scores, however, the response topographies of the older boys revealed stimulus preferences in both types of conditional-discrimination test sessions. This was demonstrated as the older boys selectively touched only one stimulus element in the stimulus compounds during all of the conditional-discrimination test sessions, with one exception. The stimulus preferences, revealed by their response topographies, indicated the stimulus elements did not exercise the same level of stimulus control despite the fact that both stimulus elements exhibited high levels of response accuracy in all of the test sessions. In opposition to the young boys, however, the conditional-discrimination tests showed the stimulus preferences of the older boys were not strong enough to prevent them from simultaneously attending to multiple cues because of overselective attention.

This study suggests that stimulus preferences may be a typical occurrence among children of normal development and their frequency may not diminish as the child advances in age. Although the frequency of stimulus preferences may not change in children of different ages, the intensity of their stimulus preferences could be affected. This investigation found that although stimulus preferences occurred in older boys, as shown by their response topographies, their accuracy scores did not reveal overselective attention, in contrast to the younger boys. Restricted attention in children with developmental disabilities is often chronic and does not lessen as the child grows older into adolescence (Wilhelm & Lovaas, 1976; Huguenin, 2004) and adulthood. It may not be the presence of overselective attention but how long overselective attention persists that distinguishes children with attentional disturbances and developmental disabilities.

One significance of the findings of this investigation is they indicate children with stimulus preferences which are associated with overselective attention should be monitored over time. While this study demonstrates overselective attention in a child as old as six years of age is not necessarily a cause for concern, it does suggest if overselective attention persists in subsequent years an attentional deficit could be noted. Future research needs to more thoroughly assess visual attention in children of different ages and gender to more adequately determine attentional patterns which could be indicators of significant attentional disturbances or developmental delays. Utilizing computer touch-screen technology to administer conditional-discrimination tests requiring simultaneous attention to multiple cues was shown in this study to provide a fine grain and reliable analysis of how children attended to visual compounds. Employing computer touch-screen technology is also an efficient and cost effective approach for both assessing visual attention in young children and for monitoring children with overselective attention on a wide scale basis. By monitoring children with overselective attention, children with chronic restricted visual attention can be identified and treatment and educational programs provided to diminish the effects of their attentional deficits on later development. Determining the presence of persistent overselective attention in a child could also prove to be an effective screening device for identifying children with learning and developmental disabilities.

These findings also point 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. They suggest that 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. While adding a redundant feature such as color to an instructional task may not be distracting for an older child, it could result in young children attending exclusively to the color component of the task due to overselective attention. 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. While the child appears to distinguish the targeted letters, the child may in fact be responding only to their color features. Although this is unlikely in older children, this investigation suggests such an occurrence could take place among children as old as five and six years of age. Presenting educational materials without redundant or unnecessary stimulus features may be the best instructional approach for young children, especially when they are initially acquiring basic educational skills. This would certainly be a critical instructional strategy for children who have been diagnosed with overselective attention using testing procedures similar to the ones described in this investigation.

Finally, although persistent 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. Simultaneous attention to multiple elements also occurred 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 differed, however, across the young boys. Extended training was also effective in eliminating overselective attention and establishing simultaneous attention to multiple elements regardless of the order in which the two conditional-discrimination tests were administered.

These results support previous findings (Huguenin, 2004) where prior exposure to a conditional discrimination led to simultaneous attention to multiple elements developing in a subsequent conditional-discrimination task for adolescents with developmental disabilities. The second conditional discrimination in this study (Huguenin, 2004) was composed of stimulus elements from classes of stimuli identical to those utilized in the preceding task. The current investigation extends these findings by demonstrating prior exposure to a conditional discrimination can lead to simultaneous attention occurring in a second conditional discrimination 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.

Extended training resulted in simultaneous attention to multiple stimulus elements eventually occurring for all four young boys. The amount of experience with compound visual cues may be a contributing factor in whether or not young children display overselective attention. Because of greater exposure to compound visual stimuli, stimulus preferences may diminish in intensity permitting young children to more easily attend to multiple features of compound stimuli.

References

Bailey, S. (1981). Stimulus overselectivity in learning disabled children. Journal of Applied Behavior Analysis, 14, 239-248.

Bhatt, R.S., & Wright, A.A. (1992). Concept learning by monkeys with video picture images and a touch screen. Journal of the Experimental Analysis of Behavior, 57, 219-225.

Bickel, W.K., Richmond, G., Bell, J., & Brown, K. (1986). A microanalysis of the controlling stimulus-response relations engendered during the assessment of stimulus overselectivity. The Psychological Record, 1986, 36, 225-238.

Bickel, W.K., Stella, M.E., & Etzel, B.C. (1984). A reevaluation of stimulus overselectivity: Restricted stimulus control or stimulus control hierarchies. Journal of Autism and Developmental Disorders, 14, 137-157.

Birnie-Selwyn, B., & Guerin, B. (1997). Teaching children to spell: Decreasing consonant cluster errors by eliminating selective stimulus control. Journal of Applied Behavior Analysis, 30, 69-91.

Burke, J.C. (1991). Some developmental implications of a disturbance in responding to complex environmental stimuli. American Journal on Mental Retardation, 96, 37-52.

Danforth, J.S., Chase, P.N., Dolan, M., & Joyce, J.H. (1990). The establishment of stimulus control by instructions and by differential reinforcement. Journal of the Experimental Analysis of Behavior, 54, 97-112.

Dreyfuss, H. (1972). Symbol sourcebook. New York: McGraw-Hill.

Dube, W.V., & McIlvane, W.J. (1999). Reduction of stimulus overselectivity with nonverbal differential observing responses. Journal of Applied Behavior Analysis, 32, 25-33.

Dunlap, G., Koegel, R.L., & Burke, J.C. (1981). Educational implications of stimulus overselectivity in autistic children. Exceptional Education Quarterly, 2, 37-49.

Fields, L. (1985). Reinforcement of probe responses and acquisition of stimulus control in fading procedures. Journal of the Experimental Analysis of Behavior, 43, 235-241.

Huguenin, N.H. (1985). Attention to multiple cues by severely mentally retarded adults: Effects of single-component pretraining. Applied Research in Mental Retardation, 6, 319-335.

Huguenin, N.H. (1987). Assessment of attention to complex cues in young children: Manipulating prior reinforcement histories of stimulus components. Journal of Experimental Child Psychology, 44, 283-303.

Huguenin, N.H. (1997). Employing computer technology to assess visual attention in young children and adolescents with severe mental retardation. Journal of Experimental Child Psychology, 65, 141-170.

Huguenin, N.H. (2000). Reducing overselective attention to compound visual cues with extended training in adolescents with severe mental retardation. Research in Developmental Disabilities, 21, 93-113.

Huguenin, N.H. (2004). Assessing visual attention in young children and adolescents with severe mental retardation utilizing conditional-discrimination tasks and multiple testing procedures. Research in Developmental Disabilities, 25, 155-181.

Huguenin, N.H., & Touchette, P.E. (1980). Visual attention in retarded adults: Combining stimuli which control incompatible behavior. Journal of the Experimental Analysis of Behavior, 33, 77-86.

Koegel, R.L., & Schreibman, L. (1977). Teaching autistic children to respond to simultaneous multiple cues. Journal of Experimental Child Psychology, 24, 299-311.

Koegel, R.L., & Wilhelm, H. (1973). Selective responding to the components of multiple visual cues by autistic children. Journal of Experimental Child Psychology, 15, 442-453.

Lovaas, O.I., & Schreibman, L. (1971). Stimulus overselectivity of autistic children in a two stimulus situation. Behavior Research and Therapy, 9, 305-310.

Lovaas, O.I., Schreibman, L., Koegel, R.L., & Rehm, R. (1971). Selective responding by autistic children to multiple sensory input. Journal of Abnormal Psychology, 77, 211-222.

Lynch, D.C., & Green, G. (1991). Development and crossmodal transfer of contextual control of emergent stimulus relations. Journal of the Experimental Analysis of Behavior, 56, 139-154.

Markham, M.R., Butt, A.E., & Dougher, M.J. (1996). A computer touch-screen apparatus for training visual discriminations in rats. Journal of the Experimental Analysis of Behavior, 65, 173-182.

Merrill, E.C., & Peacock, M. (1994). Allocation of attention and task difficulty. American Journal on Mental Retardation, 98, 588-593.

Newman, F.L., & Benefield, R.L. (1968). Stimulus control, cue utilization, and attention: Effects of discrimination training. Journal of Comparative and Physiological Psychology, 66, 101-104.

Rincover, A., & Ducharme, J.M. (1987). Variables influencing stimulus overselectivity and "tunnel vision" in developmentally delayed children. American Journal of Mental Deficiency, 91, 422-430.

Saunders, K.J., Johnston, M.D., & Brady, N.C. (2000). Identity matching of consonant-vowel-consonant words by prereaders. Journal of Applied Behavior Analysis, 33, 309-312.

Schreibman, L., & Lovaas, O.I. (1973). Overselective response to social stimuli by autistic children. Journal of Abnormal Child Psychology, 1, 152-168.

Schreibman, L., Kohlenberg, B.S., & Britten, K.R. (1986). Differential responding to content and intonation components of a complex auditory stimulus by nonverbal and echolalic autistic children. Analysis and Intervention in Developmental Disabilities, 6, 109-125.

Sloutsky, V. M., & Napolitano, A.C. (2003). Is a picture worth a thousand words? Preference for auditory modality in young children. Child Development, 74, 822-833.

Smeets, P.M., Hoogeveen, F.R., Striefel, S., & Lancioni, G.E. (1985). Stimulus overselectivity in TMR children: Establishing functional control of simultaneous multiple stimuli. Analysis and Intervention in Developmental Disabilities, 5, 247-267.

Stromer, R., McIlvane, W.J., Dube, W.V., & Mackay, H.A. (1993). Assessing control by elements of complex stimuli in delayed matching to sample. Journal of Experimental Analysis of Behavior, 59, 83-102.

Ullman, D.G. (1974). Breadth of attention and retention in mentally retarded and intellectually average children. American Journal of Mental Deficiency, 78, 640-648.

Van Laarhoven, T., Johnson, J.W., Repp, A.C., Karsh, K.G., & Lenz, M. (2003). Discrimination training: A comparison of two procedures for presenting multiple examples within a fading and non-fading paradigm. Research in Developmental Disabilities, 24, 1-18.

Whiteley, J.H., Zaparniuk, J., & Asmundson, G. (1987). Mentally retarded adolescents' breadth of attention and short-term memory processes during matching-to-sample discriminations. American Journal of Mental Deficiency, 92, 207-212.

Wilhelm, H., & Lovaas, O.I. (1976). Stimulus overselectivity: A common feature in autism and mental retardation. American Journal of Mental Deficiency, 81, 26-31.

Wilkie, D.M., & Masson, M.E. (1976). Attention in the pigeon: A re-evaluation. Journal of the Experimental Analysis of Behavior, 26, 207-212.

Footnotes

The author wishes to thank the children's families and to acknowledge the technical assistance of Robert Huguenin. Correspondence may be addressed to Nancy H. Huguenin, Ph. D., Behavior Analysis & Technology, Inc., P.O. Box 327, Groton, MA 01450, USA. Email: nhuguenin@ba-and-t.com.