ELSEVIER

Research in Developmental Disabilities
21 (2000) 93–113

Research
in
Developmental
Disabilities

Reducing overselective attention to compound visual cues with extended training in adolescents with severe mental retardation

Nancy H. Huguenin*

Behavior Analysis and Technology, Inc., P.O. Box 327, 61 Long Hill Road, Groton, MA 01450, USA

Abstract

Because of the devastating impact a disturbance in responding to multiple cues can have on a child's development, this investigation determined whether computer touch-screen technology could be utilized to improve the attentional skills of students with severe developmental disabilities after attentional deficits were initially identified. In particular, we assessed whether establishing prior reinforcement histories for separate stimuli would control how adolescents with severe mental retardation attended to visual compounds when extended training was given. Initially, prior reinforcement contingencies of individual stimuli failed to control the attention of the adolescents (Huguenin, 1997). Longer single stimulus pretraining and additional exposure to compounds containing stimulus components with conflicting reinforcement histories, however, eventually proved effective in determining what aspects of complex visual cues they attended to. In most instances, the adolescents selectively responded to stimulus elements whose prior reinforcement histories were unchanged in the compound after additional training was administered. Stimulus elements with a reversed prior reinforcement contingency were usually ignored. The reliability of the effect of prior reinforcement histories of individual stimulus elements on attention to visual compounds following additional training was confirmed with multiple testing procedures, automatically administered by a computer. Even though presenting conflict compounds initially identified students with overselective attention, extended exposure to single stimulus training and conflict compounds alleviated stimulus overselectivity and improved their attentional skills. After individual stimulus-response relations were reestablished and sufficiently reinforced to reduce disrupting effects when compound training cues were presented, stimulus overselectivity was eliminated. Through longer single stimulus pretraining and additional exposure to training

* Corresponding author. Tel.: +1-978-448-6262.
E-mail address: rnhuguenin@net1plus.com (N.H. Huguenin).

PII: S0891-4222(00)00027-5

compounds, adolescents with severe mental retardation learned to selectively attend to each component of visual compounds when prior reinforcement histories associated with the individual stimulus elements were manipulated. The findings of this investigation indicated that overselective attention among students with developmental disabilities is not an unmodifiable perceptual characteristic. They also revealed that overselective attention may be due to the disrupting effects of compound training cues which can be minimized through longer single stimulus pretraining and repeated presentations of compound training cues. Utilizing computer technology to administer procedures similar to those described in this study may permit students with developmental disabilities to acquire essential attentional skills for learning educational tasks involving complex cues.

1. Introduction

Determining how individuals with developmental disabilities attend to complex cues is important because they often display attentional deficits which interfere with the acquisition of fundamental skills (Touchette, 1968; Zeaman & House, 1963). Overselective attention is one type of attentional deficit that can interfere with a child's development in which the student only attends to restricted portions of complex displays. When compound training cues are presented, students with mental retardation and autism frequently attend to fewer aspects of compound stimuli than nondisabled peers (Bailey, 1981; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971; Rincover & Ducharme, 1987; Schreibman & Lovaas, 1973; Schreibman et al., 1986; Stromer et al., 1993; Ullman, 1974; Whiteley et al., 1987; Wilhelm & Lovaas, 1976). Although numerous studies have demonstrated overselective attention among students with developmental disabilities, few investigations have examined manipulations that affect which features of stimulus compounds they attend to. To fully understand overselective attention and to develop effective remedial treatment programs, its controlling variables need to be addressed. Prior reinforcement contingencies associated with individual stimuli is one manipulation that can determine which features of compound stimuli are responded to (Dube & McIlvane, 1997; Huguenin, 1987, 1997; Huguenin & Touchette, 1980; Ray, 1969; Tomiser et al., 1983). Past investigations have shown when prior reinforcement histories of some stimulus elements were unchanged in stimulus compounds but reversed for the remaining stimulus elements, only the unchanged stimuli exerted control in the compound. The reversed elements were usually not responded to (Huguenin, 1987; Huguenin & Touchette, 1980; Ray, 1969; Tomiser et al., 1983).

The purpose of the present investigation was to examine the effects of prior reinforcement histories of individual stimuli on attention to compound visual cues for students with severe mental retardation when extended training was provided. Extended exposure to single symbol training and compounds containing stimulus components with conflicting reinforcement histories was administered in the present investigation. In a previous study (Huguenin, 1997), prior reinforcement contingencies of separate stimulus components failed to control attention to visual compounds for adolescents with severe mental retardation. It was wondered, however, if longer single stimulus pretraining and additional exposure to conflict compounds would prove effective in alleviating stimulus overselectivity and determining what aspects of complex visual cues adolescents with severe mental retardation attended to. Because of extended training, the durability of separately trained stimulus-response relations might be increased. As a result, the disrupting effects of compound training cues might be reduced and, hence, prior reinforcement histories of the separate stimulus components could control which features of stimulus compounds students with severe mental retardation attended to.

Two different stimulus control testing procedures were provided by a computer to assess which stimulus elements the adolescents with mental retardation were attending to when compound criterion accuracy was achieved. One test determined stimulus control by presenting stimulus components separately after the adolescents acquired the compound discriminations. The other testing procedure measured the response topographies of the compound stimuli. This was done by using a touch screen attached to a computer monitor screen, which automatically recorded which stimuli the adolescents touched in the compounds. Investigations have shown the necessity of multiple test conditions for accurately assessing stimulus control (Danforth et al., 1990; Fields, 1985; Huguenin, 1987; Huguenin, 1997; Huguenin & Touchette, 1980; Merrill & Peacock, 1994; Newman & Benefield, 1968; Smeets et al., 1985; 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 many different response parameters can be simultaneously recorded whenever compound stimuli appear on the computer screen. Recording spatial locations of responses, for example, can be accurately determined with a touch screen and can identify which features of compound visual stimuli are selectively attended to (e.g., Huguenin, 1987; Huguenin, 1997). Utilizing touch screen technology in this manner may prove to be critical for accurately identifying overselective attention and may contribute to the development of procedures for reducing this attentional deficit among students with developmental disabilities.

2. Materials and methods

2.1. Subjects

Three female adolescents with mental retardation participated in this research project. Their chronological ages were 14 years, 15 years, and 17 years, respectively, and they were enlisted through material describing the study. All three adolescents attended the same special-education program consisting of a self-contained classroom located in a vocational high school building. Their mental ages were assessed to be approximately 4–6 years of age, and all of the adolescents were diagnosed within the severe range of mental retardation. Diagnostic tests included the Stanford-Binet (4th ed.), Beery Test of Visual Motor Integration, Goodenough-Harris Draw a Person Test, and Brigance Diagnostic Inventory of Early Development.

2.2. Apparatus

The experimental sessions were automated by a Macintosh IIsi desk-top computer with a 240 MB internal hard disk, 17 MB RAM, and System 7.6. A MicroTouch 14-in touch screen with internally mounted electronics was also fitted to the Apple Color Monitor screen. The code was generated to be fully System 7.x compatible, using Macintosh-standard graphical user interface dialogue boxes to initialize the sessions, fully automated event-driven procedure implementation and data acquisition, and automatic output file generation.

The computer presented stimuli and recorded responses. When stimuli appeared on the display screen, the computer decoded the correct position for each trial. The computer also kept a running account of trials, stimuli presented, the location on the display screen where the student touched during each compound trial, and 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.

2.3. Experimental design

A within-subject reversal design was utilized to determine whether prior reinforcement histories associated with individual stimuli controlled which elements of compound stimuli the students responded to when extended training was provided.

2.4. General procedure

Sessions consisted of approximately 100 trials. A trial began when sets of symbols (Dreyfuss, 1972), centered on two 10- by 3-cm white illuminated backgrounds, appeared on the computer screen. The trial ended when the student touched either illuminated area. A 3-s intertrial interval followed in which the computer screen was dark, and then the next trial began. Correct choices during training sessions produced the delivery of pennies, a flashing computer screen, and verbal praise. Following an incorrect choice, reinforcement was not delivered. During test sessions, pennies were dispensed regardless of which symbol was touched, and social praise was not provided following correct choices. At the end of each session, the adolescents traded their accumulated pennies for favorite snacks. The stimuli were presented in an unpredictable sequence with the restriction that no stimulus appeared more than twice in succession in the same

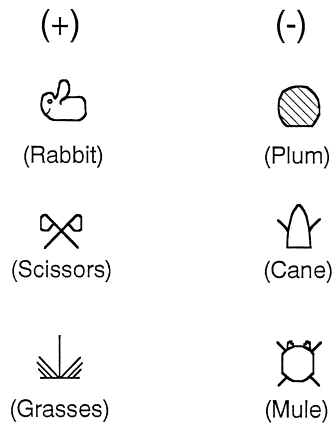

Fig. 1. Diagram of the three separate visual discriminations established prior to formation of the compound stimuli. Plus (+) refers to symbols paired with reinforcement and minus (−) indicates symbols paired with extinction.

location. The symbols also occurred an equal number of times on the left and right portions of the computer screen.

2.5. Additional training

Each adolescent was given additional exposure to stimulus control procedures following their participation in an earlier investigation (Huguenin, 1997). These procedures were repeated to determine whether prior reinforcement histories would control which elements of compound stimuli the adolescents attended to when additional training was provided. The specific steps that were repeated in this investigation are described below.

2.5.1. Single symbol training

In the first step, each student had additional exposure to three separate visual discriminations which they had previously acquired. The three visual discriminations, composed of six different symbols (see Fig. 1), were presented for a second time until criterion accuracy was achieved. The S+ and S− stimuli were presented simultaneously, and each individual symbol appeared an equal number of times on the left and right portions of the computer screen in a block of 20 trials. No S+ symbol appeared more than twice in succession in the same location. During single symbol training, each pair of individual symbols was presented on the computer screen until criterion accuracy was again achieved. The first discrimination task was taught by consistently providing a penny and praise to the adolescents whenever they touched rabbit (S+) on the computer screen. Reinforcement was not provided if they touched plum (S−). After 90% accuracy in a 10-trial sequence was achieved, scissors and cane symbols next

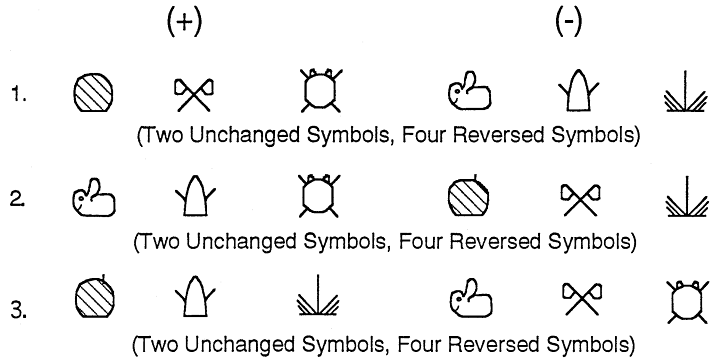

Fig. 2. Diagram of the conflict compound discriminations. Plus (+) indicates stimulus compounds paired with reinforcement and minus (−) denotes stimulus compounds paired with extinction. The S+ and S−compounds were presented simultaneously and were each composed of three symbols. The positions of the symbols within the compounds are shown in the diagram and remained constant across trials. The number of unchanged symbols and reversed symbols in each conflict compound discrimination are included.

appeared on the computer screen where scissors was the S+ symbol, and cane was the S− symbol. Touching scissors produced reinforcement but touching cane did not. When 90% accuracy in a 10-trial sequence was demonstrated, grasses and mule symbols were presented on the screen. Responses to grasses (S+) were reinforced while responses to mule (S−) were not reinforced, and this continued until criterion accuracy was met.

The three original symbol pairs next appeared twice in a block of six trials in an unpredictable mixed sequence with no more than two S+ symbols appearing twice in succession in the same location. Each individual symbol also occurred an equal number of times on the left and right portions of the computer screen in a block of 18 trials. This mixed symbol training continued until 90% accuracy for each symbol pair was maintained within a 30-trial sequence.

2.5.2. Conflict compounds

The individual symbols were next combined for a second time to form conflict compounds after criterion accuracy for the mixed symbol pairs was achieved. Conflict compounds were again created by keeping prior reinforcement histories unchanged for one symbol pair in the compound and reversing them for the remaining two symbol pairs. One conflict compound was established by maintaining prior reinforcement contingencies for scissors and cane in the compound. The prior reinforcement histories for the remaining four symbols were reversed. Plum and mule were paired with reinforcement in the compound while rabbit and grasses were paired with extinction, which was the reverse of original single symbol training (Compound 1 in Fig. 2). A second conflict compound was created by keeping the prior reinforcement histories unchanged for rabbit and plum in the compound, while the prior reinforcement histories for scissors vs. cane and grasses vs. mule were reversed (Compound 2 in Fig. 2). A third conflict compound was formed by keeping prior reinforcement contingencies unchanged for grasses and mule in the compound but reversing them for scissors vs. cane and rabbit vs. plum (Compound 3 in Fig. 2). Although the positions of individual symbols within the compounds did not change across trials, the positions of the unchanged symbols and reversed symbols did vary in the three different conflict compounds. The two unchanged symbols in the three different conflict compounds, for instance, occupied the middle positions, left positions, and right positions, respectively (See Fig. 2).

2.5.3. Test conditions

After 90% accuracy was met once more for the conflict compounds, test trials were administered. A total of 36 test trials were provided, insuring the three symbol pairs were presented 12 times each in a mixed sequence. During testing, whichever illuminated area the student touched produced the delivery of a penny, regardless of the symbol presented. The purpose of the test was to assess which stimulus elements each student was attending to when they achieved criterion accuracy for the compound discrimination. This was determined by calculating the percentage of responses during unchanged-element and reversed-element test trials that were in agreement with the reinforcement contingencies of the conflict compound. Stimulus elements associated with high percent agreement scores (80% or greater) were said to control responding in the compound when criterion accuracy was obtained.

Because the touch screen recorded the coordinates of each touch, it also recorded where the adolescents touched each time the conflict compounds appeared on the screen. A direct comparison of test session results with symbols touched in the conflict compounds when compound criterion accuracy was met was, therefore, made available. These data were provided in a report following the completion of the session.

Table 1 lists the sequence of stimuli and procedures provided to the three adolescents in the original study (Huguenin, 1997) and during the current investigation when additional training was provided. The number of errors to acquisition for each subject in the different experimental conditions is included in Appendix 1.

3. Results

3.1. Original training

Fig. 3 summarizes test results when conflict compounds containing two unchanged symbols and four reversed symbols were originally presented to the adolescents with mental retardation. In this figure, percent agreement of re-

Table 1
Sequence of stimuli and procedures in original training (OT) and additional training (AT)

Adolescent 1	Adolescent 2	Adolescent 3
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound (OT)	Conflict Compound (OT)	Conflict Compound (OT)
Rabbit-Plum Unchanged	Scissors-Cane Unchanged	Grasses-Mule Unchanged
Test Trials	Test Trials	Test Trials
Single Symbol Trianing	Single Symbol Training	Single Symbol Training
Conflict Compound (OT)	Conflict Compound (OT)	Conflict Compound (OT)
Scissors-Cane Unchanged	Rabbit-Plum Unchanged	Rabbit-Plum Unchanged
Test Trials	Test Trials	Test Trials
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound (OT)	Conflict Compound (OT)	Conflict Compound (OT)
Grasses-Mule Unchanged	Grasses-Mule Unchanged	Scissors-Cane Unchanged
Test Trials	Test Trials	Test Trials
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound (AT)	Conflict Compound (AT)	Conflict Compound (AT)
Rabbit-Plum Unchanged	Scissors-Cane Unchanged	Grasses-Mule Unchanged
Test Trials	Test Trials	Test Trials
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound (AT)	Conflict Compound (AT)	Conflict Compound (AT)
Scissors-Cane Unchanged	Rabbit-Plum Unchanged	Rabbit-Plum Unchanged
Test Trials	Test Trials	Test Trials
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound (AT)	Conflict Compound (AT)	Conflict Compound (AT)
Grasses-Mule Unchanged	Grasses-Mule Unchanged	Scissors-Cane Unchanged
Test Trials	Test Trials	Test Trials

sponses during unchanged-element and reversed-element test trials with the reinforcement contingencies of the conflict compound are shown when additional training was not provided. These test results were interpreted as follows. If the adolescents achieved high percent agreement scores (80% or greater) during unchanged-symbol test trials but not during reversed-symbol test trials, this indicated that they selectively attended to only unchanged symbols in the conflict compound. If they achieved percent agreement scores near chance levels during reversed-symbol test trials, a loss of stimulus control was demonstrated after the compound discrimination was acquired. Less than 20% agreement with the contingencies of the conflict compound during reversed-symbol test trials showed original stimulus control was unaltered when prior reinforcement contingencies were reversed in the compound. Finally, if high percent agreement scores were achieved for both the unchanged and reversed symbols, or if high percent agreement levels were not evident for any of the stimulus components, selective attention to unchanged symbols was not revealed.

The adolescents did not demonstrate selective attention to the unchanged symbols in most cases when criterion accuracy for the conflict compounds was achieved in original training (Fig. 3). Variability in test performance was shown, instead, following acquisition of conflict compounds in original training. Although in four test sessions, high percent agreement scores (80% or greater) were

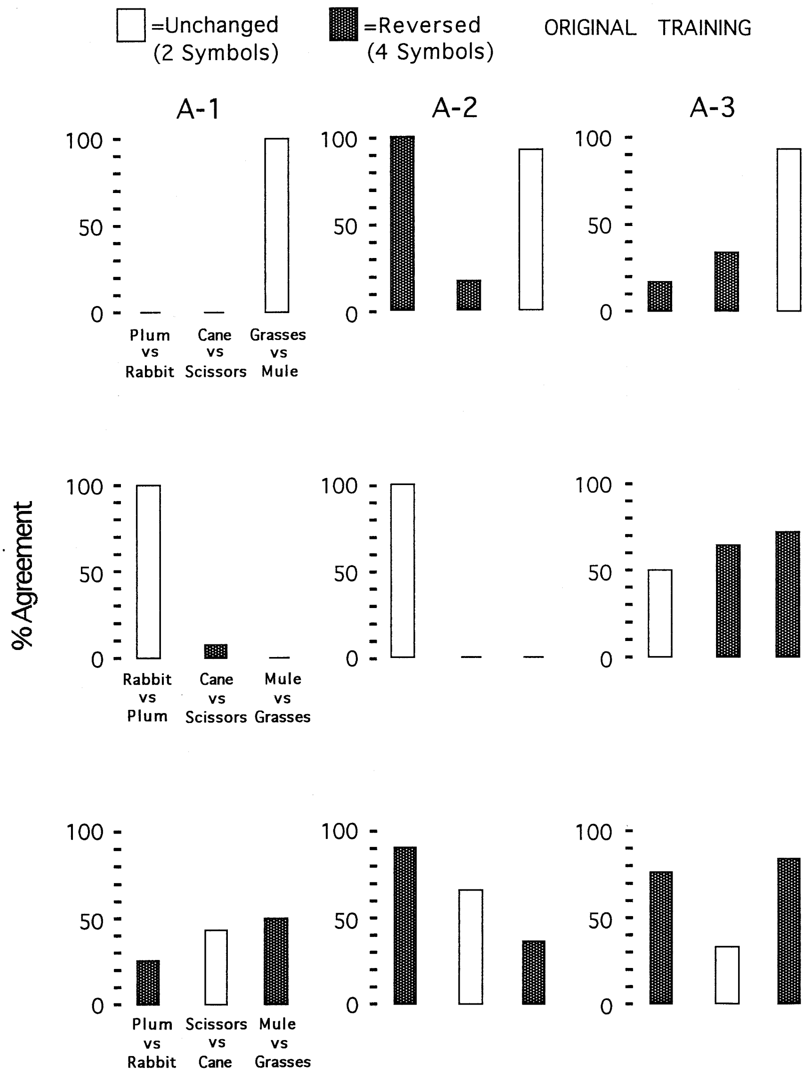

Fig. 3. Percent agreement of responses during stimulus-element test trials with the reinforcement contingencies of the conflict compound stimuli (Compounds 1, 2, and 3 in Fig. 2) which were originally presented to the adolescents. During the test, three symbol pairs (one S+ symbol and one S−symbol occupying the same positions in the stimulus compounds) were presented for 12 trials each in a mixed sequence. White bars and black bars indicate unchanged and reversed symbols, respectively. The top symbols shown for Adolescent 1 were positive and the bottom symbols were negative in the conflict compound discriminations. A-1, A-2, and A-3 denote Adolescent 1, Adolescent 2, and Adolescent 3, respectively. (The test results for the three adolescents are arranged according to the type of conflict compound and do not reflect the order in which the conflict compounds were presented to each of the students.)

only evident during unchanged-symbol test trials, this was not the case for the remaining five test sessions. In two of these test sessions, selective attention to reversed symbols was demonstrated as the adolescents obtained high percent agreement scores for only one symbol pair which was reversed in the compound. Selective attention to either an unchanged or reversed symbol was not evident in the remaining three test sessions.

Response topographies recorded with the touch screen confirmed selective responding to unchanged symbols in four instances, since on all reinforced trials when criterion accuracy was achieved, the adolescents touched only unchanged symbols in four conflict compounds (Fig. 4). In contrast, the adolescents selectively touched only reversed symbols when criterion accuracy was obtained for the remaining five conflict compounds. These response topographies confirmed their test performance for two of the conflict compounds while not supporting their test performance for the remaining three conflict compounds (See Fig. 3). Inspection of response topographies also revealed that two of the three adolescents did display overselective attention. This was demonstrated because Adolescent 2 and Adolescent 3 selectively responded to the same symbol pair in each of the three conflict compounds when criterion accuracy was met regardless of whether its prior contingencies were unchanged or reversed in the compound (See Fig. 4). In summary, the adolescents selectively touched both unchanged symbols and reversed symbols in the conflict compounds when they originally achieved criterion accuracy.

3.2. Additional training

Fig. 5 illustrates test findings for conflict compounds when additional training was provided to the adolescents. After single symbol training and presentation of conflict compounds were repeated for each of the adolescents, selective attention to the symbols whose prior reinforcement history was unchanged in the compound was now revealed in all of the test sessions. This was concluded since high percent agreement scores were only obtained in the unchanged-symbol test trials in all of the test sessions. Percent agreement scores during the reversed-symbol test trials, in contrast, were at or near 0% in most of the test sessions, showing original stimulus control was not now disrupted even though the original discriminations were reversed in the compound. The one exception was revealed by Adolescent 2 where scissors and cane were unchanged symbols. She achieved near chance levels for both reversed symbols following acquisition of this conflict-compound discrimination, showing a loss of control by the reversed elements. In most cases, however, additional exposure to both single stimulus pretraining and the conflict compounds resulted in the conflicting cues having less disrupting effects on previously established controlling stimulus-response relations. In original training when the conflict compounds were first presented, original discriminations were disrupted in 14 cases (see Fig. 3). After additional training was provided, prior stimulus control was disrupted in only two instances when conflict compounds were presented (See Fig. 5). Although errors still

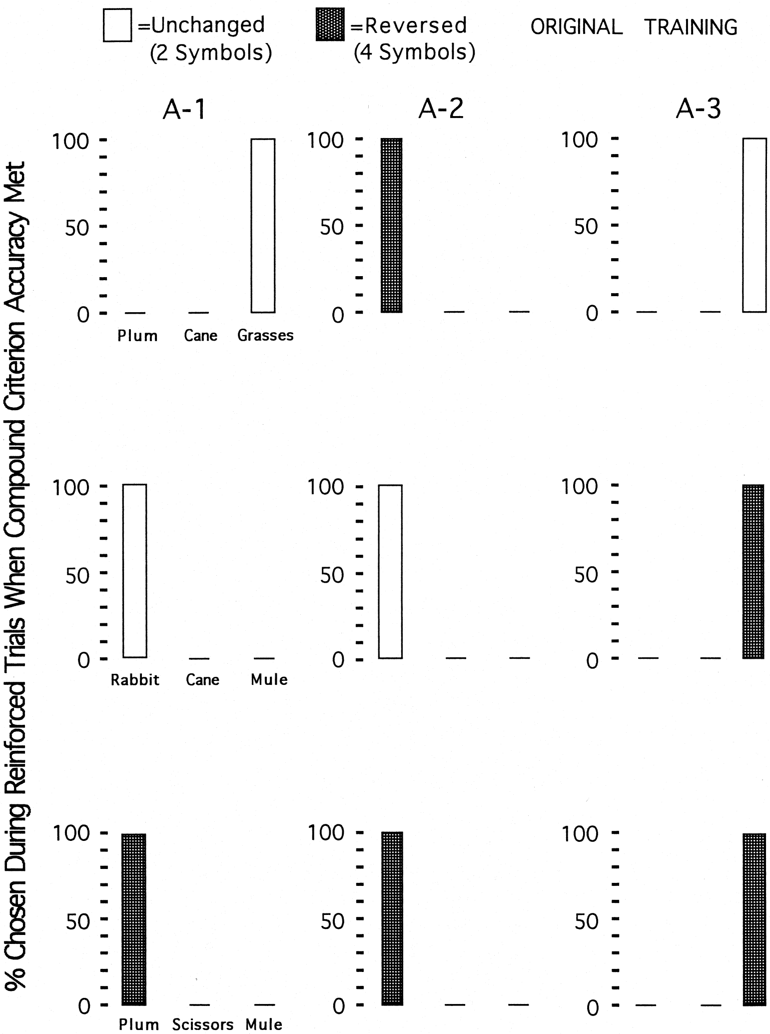

Fig. 4. Percentage unchanged symbols (white bars) and reversed symbols (black bars) were chosen during reinforced trials when conflict compound criterion accuracy (Compounds 1, 2, and 3 in Fig. 2) was originally achieved by the adolescents. The symbols shown for Adolescent 1 were the three S+ symbols in the conflict compound discriminations. A-1, A-2, and A-3 denote Adolescent 1, Adolescent 2, and Adolescent 3, respectively. (The test results for the three adolescents are arranged according to the type of conflict compound and do not reflect the order in which the conflict compounds were presented to each of the students.)

occurred (see Appendix 1) when conflict compounds were presented for a second time, previously established controlling relations were not disrupted after the adolescents had received additional single symbol training and exposure to the conflict compounds. In summary, test performance revealing selective atten-

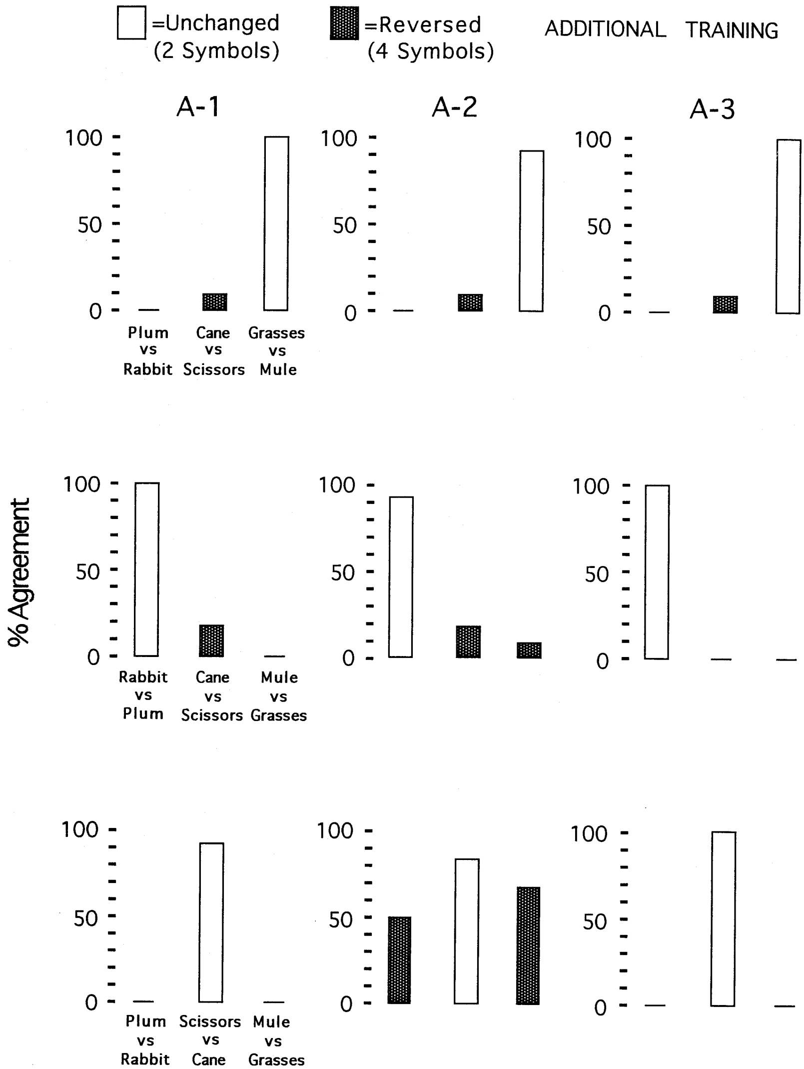

Fig. 5. Percent agreement of responses during stimulus-element test trials with the reinforcement contingencies of the conflict compound stimuli (Compounds 1, 2, and 3 in Fig. 2) when additional training was provided to the adolescents. During the test, three symbol pairs (one S+ symbol and one S− symbol occupying the same positions in the stimulus compounds) were presented for 12 trails each in a mixed sequence. White bars and black bars indicate unchanged symbols and reversed symbols, respectively. The top symbols shown for Adolescent 1 were positive and the bottom symbols were negative in the conflict compound discriminations. A-1, A-2, and A-3 denote Adolescent 1, Adolescent 2, and Adolescent 3, respectively. (The test results for the three adolescents are arranged according to the type of conflict compound and do not reflect the order in which the conflict compounds were presented to each of the students.)

tion to unchanged symbols following additional training contrasted greatly with test performance when conflict compounds were first introduced. When they were first introduced, selective attention to the unchanged symbols was not demonstrated in most cases. Although the adolescents with mental retardation displayed highly variable test performance during original training, very consistent and uniform test performance was evident after additional training was provided.

Response topographies recorded with the touch screen confirmed that the adolescents were selectively responding to only the unchanged symbols in the conflict compounds after additional training was administered (Fig. 6). The adolescents touched only unchanged symbols in the conflict compounds on most reinforced trials when compound criterion accuracy was again achieved and did not touch reversed symbols. In only one instance did selective touching of unchanged symbols fail to occur. Adolescent 2 touched a reversed symbol on most reinforced trials when she acquired the conflict-compound discrimination where scissors and cane were the unchanged symbols. In contrast, before extended training was provided, the adolescents did not selectively touch only unchanged symbols in the majority of instances when conflict compounds were first introduced. They touched, instead, both reversed and unchanged symbols in the conflict compounds when they initially achieved criterion accuracy (See Fig. 4). Selective responding to the same symbol pair in all three conflict compounds, regardless of whether its prior contingencies were unchanged or reversed in the compound, also failed to occur following additional training. This indicated that stimulus overselectivity which had been evident for two of the adolescents in original training was not revealed by any of the adolescents after additional exposure to single symbol and conflict-compound training was administered. The fact that all three adolescents were responding to unchanged symbols in each of the conflict compounds, with one exception, following additional training meant that they were now responding to left portions, right portions, and middle portions of the conflict compounds in accordance with prior training histories (See Fig. 6). By systematically manipulating which of the individual stimulus elements were associated with unchanged or reversed prior reinforcement contingencies in the compound, the adolescents selectively responded to each component of the conflict compounds after additional training was given.

4. Discussion

Initially, prior reinforcement histories of individual stimuli failed to control how adolescents with severe mental retardation attended to visual compounds. They demonstrated, instead, variable test performance when compounds containing stimulus components with conflicting reinforcement histories were originally presented. In most instances, their test performance indicated that they did not selectively attend to symbols whose prior reinforcement histories were unchanged in the compound when criterion accuracy for the conflict compounds

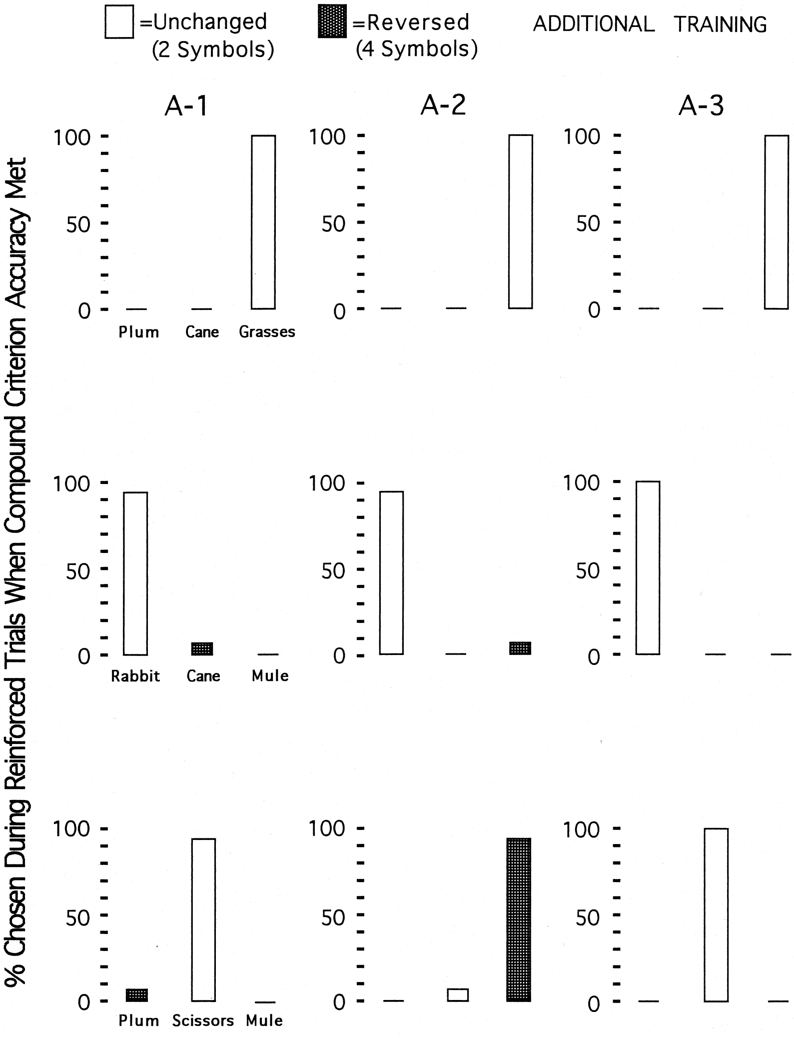

Fig. 6. Percentage unchanged symbols (white bars) and reversed symbols (black bars) were chosen during reinforced trials when conflict compound criterion accuracy (Compounds 1, 2, and 3 in Fig. 2) was again achieved by the adolescents following additional training. The symbols shown for Adolescent 1 were the three S+ symbols in the conflict compound discriminations. A-1, A-2, and A-3 denote Adolescent 1, Adolescent 2, and Adolescent 3, respectively. (The test results for the three adolescents are arranged according to the type of conflict compound and do not reflect the order in which the conflict compounds were presented to each of the students.)

was originally achieved. Reversing prior reinforcement contingencies disrupted controlling relations associated with extinction in the compound, as either loss of stimulus control or a reversal of original discriminations was noted in most test sessions (Huguenin, 1997). These findings supported other investigations that have also shown variability in test performance for students with developmental disabilities when other procedures were administered (Huguenin and Touchette, 1980; Tomiser et al., 1983). Inspection of response topographies demonstrated that two of the three adolescents displayed overselective attention, i.e., they selectively responded to the same symbol pair in all three conflict compounds when they originally achieved criterion accuracy. This was regardless of whether the prior contingencies of the symbol pair were unchanged or reversed in the compound.

After additional training was provided, however, establishing prior reinforcement histories for separate stimulus components did determine which features of compound visual cues the adolescents attended to. In most instances, the adolescents selectively responded to stimulus elements whose prior reinforcement history was unchanged in the compound after additional training was administered. Stimulus elements with a reversed prior reinforcement contingency were usually ignored. Furthermore, the overselective attention revealed initially was no longer apparent after additional training was provided. The reliability of the effect of prior reinforcement histories of individual stimulus elements on attention to visual compounds following additional training was confirmed with multiple assessment procedures, automatically administered by the computer. One stimulus control test consisted of presenting unchanged elements and reversed elements separately to the adolescents following acquisition of the conflict compounds. In every instance after single symbol training and presentation of conflict compounds were repeated, only unchanged elements exhibited a high level of control in agreement with the conflict compound's reinforcement contingencies. This indicated that the adolescents were selectively attending to the unchanged elements. The second assessment involved recording which symbols the adolescents touched in the visual compounds when criterion accuracy was achieved. Response topographies recorded with a touch screen confirmed that the adolescents were selectively responding to only unchanged elements of the conflict compounds after extended training was provided. In particular, on most reinforced trials, the adolescents touched only unchanged symbols in the compounds and did not touch reversed symbols, with one exception, after additional training was given. Since all three students responded to unchanged symbols in each of the conflict compounds following additional training, this demonstrated they selectively responded to each portion of the conflict compounds in accordance with prior training histories. By manipulating whether prior reinforcement histories associated with individual stimulus elements were unchanged or reversed in the compounds, the adolescents selectively responded to each component of the conflict compounds. The adolescents no longer responded to the same symbol pair in all three conflict compounds regardless of the prior reinforcement histories associated with individual stimulus elements as they did before additional training was provided.

When the conflict compounds were originally acquired by the adolescents with mental retardation, their variable test performance differed greatly from the test performance of young children of normal development with comparable mental age when the same stimulus compounds and tests were administered (Huguenin, 1997). After additional training was given to the adolescents, however, the difference in test performance for the two populations was eliminated. Uniform test performance was now evident for the adolescents when single symbol training and presentation of the conflict compounds were repeated. It was also virtually identical to the test performance of the young children of normal development when conflict compounds were originally presented (Huguenin, 1997). In addition, after the adolescents received additional training, stimulus-response relations that were paired with extinction in the compound lowered in frequency without being topographically altered. This was also observed when conflict compounds were initially presented to the young children. In summary, following additional exposure to single symbol training and conflict compounds, prior reinforcement histories associated with individual stimuli affected how adolescents with mental retardation attended to visual compounds. Prior reinforcement histories also affected their attention in essentially the same manner as their initial effect on the attention of young children of normal development. Prior to additional training, discrepant performance was observed for the two groups.

The adolescents' more uniform test performance following additional training may have been the result of different factors. Their stimulus-response relations may have been less susceptible to disruption because of additional single symbol training. If the durability of the individually trained stimulus-response relations was increased because of additional training, this would have reduced the disrupting effects of the conflict compounds or the nondifferential test contingency. It is also possible that extinction effects, due to errors occurring when the conflict compounds were originally presented, may have been suppressed with repeated presentations of the conflict compounds. Although extinction may have initially increased the variability of the adolescents' stimulus-response relations, which is often reported for simple operants (Reynolds, 1968), less variable stimulus-response relations eventually resulted. Students with developmental disabilities may, therefore, not only differ from children of normal development of comparable mental age in the rate at which they acquire stimulus control. They may also differ in the susceptibility of stimulus-response relations to disruption, which may explain the higher incidence of overselective attention among this population. In an earlier investigation (Huguenin, 1997), pretrained stimulus-response relations of adolescents with mental retardation were more disrupted by compound training cues with conflicting reinforcement histories than was observed for young children of normal development. Response topographies recorded with a touch screen also revealed overselective attention among the adolescents with mental retardation that was not shown by any of the children of normal development. After additional training was provided to the adolescents in the current study, however, the susceptibility of their pretrained stimulus-response relations to disruption was greatly reduced when compound training cues were presented. Pretrained stimulus-response relations were no longer disrupted with few exceptions when conflict compounds were presented again following additional training. As a result, overselective attention was now no longer shown by any of the adolescents with mental retardation. As a consequence of additional single-symbol training and repeated exposure to conflict compounds, the efficiency with which the adolescents shifted their attention in accordance with prior reinforcement histories improved. Prior reinforcement contingencies did control what aspects of complex visual cues the adolescents responded to when the initial disrupting effects of compound cues were eliminated due to additional training. Overselective attention was also eliminated.

Overselective attention to compound training cues is often a diagnostic feature of many students with autism and severe mental retardation (Bailey, 1981; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Lovaas et al., 1971; Rincover & Ducharme, 1987; Schreibman & Lovaas, 1973; Schreibman et al., 1986; Stromer et al., 1993; Ullman, 1974; Whiteley et al., 1987; Wilhelm & Lovaas, 1976). Two of the three adolescents with severe mental retardation initially displayed stimulus overselectivity when the response topographies of the original conflict compounds were recorded and analyzed, confirming earlier studies. This was concluded since both adolescents responded to the same symbol pair in all three conflict compounds regardless of whether the symbol pair's prior reinforcement histories were unchanged or reversed in the compound. After individual stimulus-response relations were reestablished and sufficiently reinforced to reduce disrupting effects when compound training cues were presented, stimulus overselectivity was eliminated by manipulating prior reinforcement histories associated with individual stimulus elements. The findings of the current investigation indicate that stimulus overselectivity is not an unmodifiable perceptual characteristic. Overselective attention may be due, instead, to the disrupting effects of compound training cues which can be minimized if individual stimulus-response relations are first established and sufficiently reinforced before compound training cues are presented.

Only a few studies (Allen & Fuqua, 1985; Huguenin, 1985; Koegel & Schreibman, 1977; Schreibman et al., 1982) have reported success employing reinforcement contingencies that require simultaneous control by multiple features of compound cues. Manipulating prior reinforcement histories of individual stimuli, when extended training is provided, may prove to be a more effective technique for preventing stimulus overselectivity and ensuring students with developmental disabilities are attending to the relevant aspects of complex educational cues. The effectiveness of prior reinforcement histories of individual stimuli in eliminating stimulus overselectivity after additional training was given was also demonstrated in multiple tests administered with computer touch-screen technology. The two adolescents, who originally revealed overselective attention, now responded to each of the unchanged symbols in all of the conflict compounds, with one exception, following additional training. Not only was this shown when individual stimulus elements were presented separately following compound acquisition, but when response topographies of the stimulus compounds were recorded as well. The response topographies of the remaining student revealed she also improved in responding to the elements of the conflict compounds in accordance with prior reinforcement contingencies. Although she failed to selectively respond to an unchanged symbol in one of the original conflict compounds, she did respond to all of the unchanged symbols after receiving additional training. By systematically manipulating which of the individual stimulus elements were associated with unchanged or reversed prior reinforcement contingencies in the compounds, all three students with one exception selectively responded to each component of the conflict compounds following additional training.

Utilizing touch-screen technology in this investigation provided the requisite precision in identifying stimulus overselectivity and evaluating the effects of prior training histories. Presenting stimulus elements separately, as had been done in previous studies, following initial acquisition of the conflict compounds did not reveal overselective attention. Stimulus overselectivity was only demonstrated when response topographies of the stimulus compounds, recorded with a computer touch screen, were analyzed. Employing computer touch-screen technology may prove to be a more sensitive technique for identifying this attentional deficit and provide greater precision in evaluating treatment procedures for reducing overselective attention among students with developmental disabilities.

In summary, through longer single stimulus pretraining and additional exposure to training compounds, adolescents with severe mental retardation learned to selectively attend to each component of visual compounds when prior reinforcement histories associated with the individual stimulus elements were manipulated. These procedures eliminated stimulus overselectivity and controlled what aspects of compound visual cues the students attended to. Teaching procedures that utilize the procedures of this study have important educational applications, as they can ensure that students with mental retardation or autism are attending to the relevant aspects of educational material. This is especially critical for students with developmental disabilities, since they frequently attend to fewer and possibly different aspects of their environment than students of normal development (Zeaman & House, 1963). Numerous studies have concluded that their impairment involving visual attention is due to the failure of individuals with developmental disabilities to suppress responding to irrelevant features of educational tasks (e.g., Cha & Merrill, 1994; Ellis & Dulaney, 1991; Merrill & Taube, 1996). By establishing stimulus-response baselines of sufficient duration and manipulating whether prior reinforcement contingencies of individual stimulus elements were reversed or unchanged in training compounds, an effective technique for directing the attention of students with developmental disabilities was discovered. This technique could prove to be beneficial when complex educational material is provided to students with special needs as it would enable instructors to determine which stimulus features the student is attending to. By manipulating prior reinforcement histories of separate stimuli, instructors could first ensure students with developmental disabilities are attending to the relevant aspects of educational material before instruction commences. A teacher trying to teach letter recognition skills, for example, could initially teach a student to attend exclusively to the critical features of targeted letters before letter-recognition instruction began by establishing stimulus-response baselines and manipulating prior reinforcement contingencies. Employing computer technology to administer procedures similar to those described in this study may permit students with developmental disabilities to acquire essential attentional skills for learning educational tasks involving complex cues.

Acknowledgment

The author thanks the educational staff of the Bi County Collaborative for their cooperation and to acknowledge the technical assistance of Manuel Cuevas and Robert Huguenin.

Appendix 1
Number of errors to acquisition for each adolescent with mental retardation in the different experimental conditions

	Subject		
	1	2	3
Conflict Compound-Original Training Scissors-Cane Unchanged	4	64	15
Conflict Compound-Additional Training Scissors-Cane Unchanged	2	14	3
Conflict Compound-Original Training Rabbit-Plum Unchanged	0	0	9
Conflict Compound-Additional Training Rabbit-Plum Unchanged	2	5	5
Conflict Compound-Original Training Grasses-Mule Unchanged	4	12	2
Conflict Compound-Additional Training Grasses-Mule Unchanged	5	16	6

References

Allen, K. D., & Fuqua, R. W. (1985). Eliminating selective stimulus control: A comparison of two procedures for teaching mentally retarded children to respond to compound stimuli. *J Exper Child Psychol, 39,* 55–71.

Bailey, S. (1981). Stimulus overselectivity in learning disabled children. *J App Behav Anal, 14,* 239–248.

Cha, K., & Merrill, E. C. (1994). Facilitation and inhibition effects in visual selective attention processes of individuals with and without mental retardation. *Am J Ment Retard, 98,* 594–600.

Danforth, J. S., et al. (1990). The establishment of stimulus control by instructions and by differential reinforcement. *J Exper Anal Behav, 54,* 97–112.

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

Dube, W. V., & McIlvane, W. J. (1997). Reinforcer frequency and restricted stimulus control. *J Exper Anal Behav, 68,* 303–316.

Ellis, N. R., & Dulaney, C. L. (1991). Further evidence for cognitive inertia of persons with mental retardation. *Am J Ment Retard, 95,* 613–62.

Fields, L. (1985). Reinforcement of probe responses and acquisition of stimulus control in fading procedures. *J Exper Anal Behav, 43,* 235–241.

Huguenin, N. H. (1985). Attention to multiple cues by severely mentally retarded adults: Effects of single-component pretraining. *App Res Ment Retard, 6,* 319–335.

Huguenin, N. H. (1987). Assessment of attention to complex cues in young children: Manipulating prior reinforcement histories of stimulus components. *J Exper Child Psychol, 44,* 283–303.

Huguenin, N. H. (1997). Employing computer technology to assess visual attention in young children and adolescents with severe mental retardation. *J Exper Child Psychol, 65,* 141–170.

Huguenin, N. H., & Touchette, P. E. (1980). Visual attention in retarded adults: Combining stimuli which control incompatible behavior. *J Exper Anal Behav, 33,* 77–86.

Koegel, R. L., & Schreibman, L. (1977). Teaching autistic children to respond to simultaneous multiple cues. *J Exper Child Psychol, 24,* 299–311.

Koegel, R. L., & Wilhelm, H. (1973). Selective responding to the components of multiple visual cues by autistic children. *J Exper Child Psychol, 15,* 442–453.

Lovaas, O. I., & Schreibman, L. (1971). Stimulus overselectivity of autistic children in a two stimulus situation. *Behav Res Ther, 9,* 305–310.

Lovaas, O. I., Schreibman, L., Koegel, R. L., & Rehm, R. (1971). Selective responding by autistic children to multiple sensory input. *J Abnorm Psychol, 77,* 211–222.

Merrill, E. C., & Peacock, M. (1994). Allocation of attention and task difficulty. *Am J Ment Retard, 98,* 588–593.

Merrill, E. C., & Taube, M. (1996). Negative priming and mental retardation: The processing of distractor information. *Am J Ment Retard, 101,* 63–71.

Newman, F. L., & Benefield, R. L. (1968). Stimulus control, cue utilization, and attention: Effects of discrimination training. *J Compar Physiolog Psychol, 66,* 101–104.

Ray, B. A. (1969). Selective attention: The effects of combining stimuli which control incompatible behavior. *J Exper Anal Behav, 12,* 539–550.

Reynolds, G. S. (1968). *A Primer of Operant Conditioning* (p. 28). Glenview: Scott, Foresman and Company.

Rincover, A., & Ducharme, J. M. (1987). Variables influencing stimulus overselectivity and “tunnel vision” in developmentally delayed children. *Am J Ment Defic, 91,* 422–430.

Schreibman, L., & Lovaas, O. I. (1973). Overselective response to social stimuli by autistic children. *J Abnorm Child Psychol, 1,* 152–168.

Schreibman, L., Charlop, M. H., & Koegel, R. L. (1982). Teaching autistic children to use extra-stimulus prompts. *J Exper Child Psychol, 33,* 475–491.

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. *Anal Intervent Develop Disabil, 6,* 109–125.

Smeets, P. M., et al. (1985). Stimulus overselectivity in TMR children: Establishing functional control of simultaneous multiple stimuli. *Anal Intervent Develop Disabil, 5,* 247–267.

Stromer, R., et al. (1993). Assessing control by elements of complex stimuli in delayed matching to sample. *J Exper Anal Behav, 59,* 83–102.

Tomiser, J. M., Hollis, V. H., & Monaco, G. E. (1983). Haptic attention and visual transfer by mentally retarded and nonretarded individuals. *Am J Ment Defic, 87,* 448–455.

Touchette, P. E. (1968). The effects of graduated stimulus change on the acquisition of a simple discrimination in severely retarded boys. *J Exper Anal Behav, 11,* 39–48.

Ullman, D. G. (1974). Breadth of attention and retention in mentally retarded and intellectually average children. *Am J Ment Defic, 78,* 640–648.

Whiteley, J. H., Zaparniuk, J., & Asmundson, G. (1987). Mentally retarded adolescents’ breadth of attention and short-term memory processes during matching-to-sample discriminations. *Am J Ment Defic, 92,* 207–212.

Wilhelm, H., & Lovaas, O. I. (1976). Stimulus overselectivity: A common feature in autism and mental retardation. *Am J Ment Defic, 81,* 26–31.

Wilkie, D. M., & Masson, M. E. (1976). Attention in the pigeon: A re-evaluation. *J Exper Anal Behav, 26,* 207–212.

Zeaman, D., & House, B. J. (1963). The role of attention in retardate discrimination learning. In N. R. Ellis (Ed.), *Handbook of Mental Deficiency* (pp. 159–223). New York: McGraw-Hill.