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Employing Computer Technology to Assess Visual Attention in Young Children and Adolescents with Severe Mental Retardation

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The intent of this investigation was to establish a valid and sensitive computer measurement technique for educational assessment applications. An integral part of the investigation was to establish the similarities and differences in how prior reinforcement histories of individual stimuli affect attention to compound visual cues for young children of normal development versus adolescents with severe mental retardation, both groups having comparable mental age. A series of identical conflict compound discrimination tasks was presented to the two groups. In addition, generalization effects were investigated for both groups by presenting compounds containing some or all novel cues. The similarities and differences in performance for young children of normal development and adolescents with severe mental retardation were analyzed using multiple testing procedures. In addition to assessing stimulus control by presenting stimulus components separately following acquisition of compound discriminations, response topographies of the compound stimuli were recorded with a touch screen attached to a computer monitor screen. This study demonstrated that overselective attention did not occur only for students with severe mental retardation but also for young children of normal development if multiple tests were employed. A difference was found, however, between the two populations in the efficiency with which they shifted attention among elements of complex stimuli depending on prior conditioning histories. Presentation of compounds whose components had conflicting reinforcement histories was found to be a more sensitive assessment technique than presentation of compounds containing some or all novel components for distinguishing between the two groups. The use of multiple testing procedures was critical in preventing false conclusions from altered test performances arising from reinforcement contingencies in effect during the test.

The purpose of this study was to establish a valid and sensitive computer measurement technique for educational assessment applications. Computer

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software has been created for a wide variety of educational purposes, such as measuring social skills (Irvin, Walker, Noell, Singer, Irvine, Marquez, & Britz, 1992), teaching academic skills (e.g., Farmer, Klein, & Bryson, 1992; Stevens, Blackhurst, & Slaton, 1991; Stromer & Mackay, 1993), and providing prompts to improve staff–client interactions (Realon, Favell, & McGimsey, 1992). In addition, fewer behavior problems have been reported for students when instruction was administered by computers compared to traditional forms of instruction (Chen & Bernard-Opitz, 1993; Plienis & Romanczyk, 1985). The computer assessment program in this investigation involved procedures which determined how students participating in the project attended to complex visual cues. This type of visual attention could be objectively and sensitively measured by a computer. The need for developed language skills, which limits the effectiveness and utility of many assessment approaches, was eliminated through the use of visual symbols and pictures. The critical evaluation was accomplished through computer measurements of a series of attentional responses to computer-administered complex visual stimuli. The tests were administered and student performance recorded by the computer, thus eliminating tester bias as well.

Assessing how students attend to complex training cues is important, because it can reveal perceptual abnormalities that prevent or delay acquisition of essential skills. One type of attentional deficit, for example, that can interfere with a child's development is overselective attention in which the child attends only to restricted portions of complex displays. Researchers have discovered that when compound training cues are presented, students with mental retardation and autism frequently attend to fewer aspects of compound stimuli than nondisabled children (Bailey, 1981; 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). Since the degree of stimulus overselectivity correlates with intelligence level (Rincover & Ducharme, 1987; Whiteley et al., 1987; Wilhelm & Lovaas, 1976), this attentional deficit can be extreme among children with autism and severe levels of mental retardation.

Identifying perceptual disturbances at a young age is also critical in preventing delays in normal development (Krupski, 1981). A chronic disturbance in responding to complex stimuli could affect many areas of development, and it may explain the difficulty many children and adults with developmental disabilities have in acquiring appropriate social, language, play, and emotional behaviors (Burke, 1991; Dunlap, Koegel, & Burke, 1981). The failure of stimulus fading procedures, which use added noncriterion related prompts, may also be due to the difficulty that many students with mental retardation and autism have in attending to more than one feature of compound stimuli (Dowler, Walls, Haught, & Zawlocki, 1984; Karsh, Repp, & Lenz, 1990; Mosk & Bucher, 1984;

Repp, Karsh, & Lenz, 1990; Richmond & Bell, 1983; Schreibman, 1975; Wolfe & Cuvo, 1978). By utilizing computer technology to administer tests designed to assess visual attention, early determinations of developmental disorders and attentional deficits could be made on a widescale basis by psychologists and special educators. Neurological and attentional problems could be discovered at a critical early age and could target people for treatment, remedial education programs, or special education programs to diminish the effects of these disorders on later development. Computer software assessing visual attention could also be useful to physicians and medical staff to assess the effects of medication on behavior. In particular, positive effects and negative side effects of psychotropic medication on visual attention in children and people with developmental disabilities could be determined.

An integral part of this investigation was to establish the similarities and differences in how prior reinforcement histories of individual stimuli affect attention to compound visual cues for young children of normal development versus adolescents with severe mental retardation, both groups having comparable mental age. Previous studies demonstrated that if prior reinforcement histories were unchanged for some elements of compound stimuli and 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; Tomiser, Hollis, & Monaco, 1983). Stimulus–response relations, whose prior reinforcement histories were reversed, produced errors in the compound. When paired with extinction, these stimulus–response relations always lowered in frequency without being topographically altered for young children of normal development if alternative controlling relations were concurrently reinforced (Huguenin, 1987). Reversing prior reinforcement contingencies for adults with severe mental retardation, in contrast, often disrupted controlling relations associated with extinction in the compound (Huguenin & Touchette, 1980). Loss of stimulus control or a reversal of original discriminations was discovered. These findings suggested the possibility that presenting compounds whose components have conflicting reinforcement histories could prove to be an effective diagnostic technique for identifying neurologically impaired students with attentional deficits. That possibility was investigated in this study by presenting a series of identical conflict compound discrimination tasks to both young children of normal development and adolescents with severe mental retardation, both groups having a comparable mental age, to determine similarities and differences in performance. In addition, generalization effects were investigated for both groups by presenting compounds containing some novel cues. As a control procedure, compounds composed of all novel cues were also presented.

Multiple stimulus control tests were provided to the two groups for totally pretrained compounds and compounds containing some or all novel cues to determine which components the students attended to when they achieved compound criterion accuracy. One of the tests assessed stimulus control by presenting stimulus components separately following acquisition of the compound discriminations. The other test measured the response topographies of the compound stimuli, which were automatically recorded through use of a touch screen attached to the computer monitor screen. In particular, whichever stimuli the students touched in the compounds were automatically recorded through the utilization of a touch screen in order to verify test results. By administering multiple stimulus control tests, the validity and reliability of the students' test performance could be easily determined. If only one type of stimulus control test had been provided, in contrast, it would not have been possible to determine if test variables may have contaminated the test results. Indeed, it was previously demonstrated how easily test performance can be altered by the reinforcement contingency in effect during the test trials (Huguenin & Touchette, 1980). Without more than one test condition, this would not have been revealed and false conclusions would have been made about which features controlled responding in the compound. Other investigators have also shown the necessity of multiple test conditions for accurately assessing stimulus control (Danforth, Chase, Dolan, & Joyce, 1990; Fields, 1985; Huguenin, 1987; Merrill & Peacock, 1994; Newman & Benefield, 1968; Smeets, Hoogeveen, Striefel, & Lancioni, 1985; Wilkie & Masson, 1976). Computer software was developed for this study to record multiple response topographies while presenting stimulus displays in order to assess visual perception in young children of normal development and adolescents with mental retardation.

METHOD

Subjects

Three young children of normal development and three adolescents with mental retardation participated in this research project. The chronological age and gender of the young children of normal intelligence were 4.5 years (male), 5.0 years (female), and 5.5 years (male), respectively. Two of the subjects were children of acquaintances of the author. The third child was enlisted through material describing the study. The chronological ages and gender of the adolescents with mental retardation were 14 years (female), 15 years (female), and 17 years (female), respectively. They were enlisted through material describing the study. All three adolescents attended the same special-education program consisting of a self-contained classroom which was located in a vocational high school building. Their mental ages were assessed to be approximately 4–6 years in age. 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. All of the adolescents were diagnosed within the severe range of mental retardation.

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 7.1. 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 7.1 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 was employed to present stimuli and record responses. When stimuli appeared on the display screen, the computer decoded the correct position for each trial. In addition, the computer kept a running account of trials, stimuli presented, and the area on the display screen where the subject touched during each compound trial, as well as response accuracy. Following each experimental session, a printout was provided which supplied this information. A BCI, Inc. token/coin dispenser was located to the left of each subject. When this device was operated after each correct response, pennies dropped into a $9.6 \times 14 \times 9.6$-cm receptacle at the base of the dispenser.

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 were responded to. A within-subject reversal design was also used to assess if original treatment effects generalized to compounds containing some or all novel cues.

General Procedure

Sessions consisted of approximately 100 trials. A trial began when sets of symbols (Dreyfuss, 1972), centered on two 10×3-cm white illuminated backgrounds, appeared on the computer screen. The trial ended when the subject 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 children and adolescents traded their accumulated pennies for favorite snacks and recreational items. The stimuli were presented in an unpredictable sequence with the restriction that no stimulus appeared more than twice in succession in the same location. The symbols also occurred an equal number of times on the left and right portions of the computer screen.

Single Symbol Training

In the first step, each subject learned three separate visual discriminations which were composed of six different symbols (see Fig. 1). The S+ and S−

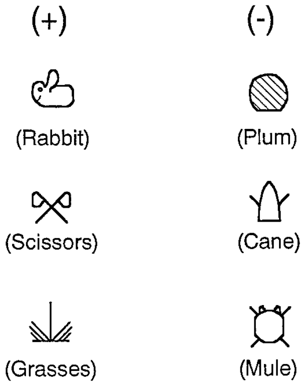


FIG. 1. Diagram of the three separate visual discriminations established prior to formation of the compound stimuli. Plus (+) refers to symbols paired with reinforcement in original training and minus (−) indicates symbols paired with nonreinforcement.

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 achieved. The first discrimination task was taught by consistently providing a penny and praise to the subjects whenever they touched rabbit (S+) on the computer screen and not providing reinforcement if they touched plum (S−). When 90% accuracy in a 10-trial sequence was achieved, scissors and cane symbols appeared on the computer screen. Now scissors was the S+ symbol, and cane was the S− symbol. Touching the scissors produced reinforcement while touching the cane did not. After 90% accuracy in a 10-trial sequence was demonstrated, grasses and mule symbols were presented on the screen. Responses to grasses (S+) were reinforced but responses to mule (S−) did not provide reinforcement, and this continued until criterion accuracy was met.

The three original symbol pairs, in an unpredictable mixed sequence, next appeared twice in a block of six trials with no more than two S+ symbols appearing twice in succession in the same location. In addition, each individual symbol 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.

Conflict Compounds and Test Conditions

The individual symbols were subsequently combined to form a conflict compound after criterion accuracy for the mixed symbol pairs was demonstrated. Conflict compounds were 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, for instance, 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, the reverse of original 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. The prior reinforcement histories for scissors vs cane and grasses vs mule in the compound were reversed (Compound 2 in Fig. 2). A third conflict compound was formed by keeping prior reinforcement contingencies unchanged for only grasses and mule and reversing them for scissors vs cane and rabbit vs plum in the compound (Compound 3 in Fig. 2). Although the positions of individual symbols within the compounds did not vary across trials, the positions of the unchanged symbols and reversed symbols did vary in the different compounds. Concerning the single unchanged symbol pair in the conflict compound, for instance, the two unchanged symbols occupied the middle positions, left positions, and right positions, respectively, in the three different conflict compounds (See Fig. 2).

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

Because the touch screen recorded the coordinates of each touch, it was possible to record where the children and adolescents touched each time the conflict compounds appeared on the screen. This permitted a direct comparison of test session results with symbols touched in the conflict compounds when compound criterion accuracy was met. These data were made available in a computer printout following the completion of the session.

Transfer Compounds and Test Conditions

Three transfer compounds were also administered. Each transfer compound was composed of two symbols whose prior reinforcement history was unchanged in the compound as well as four novel symbols. In one transfer

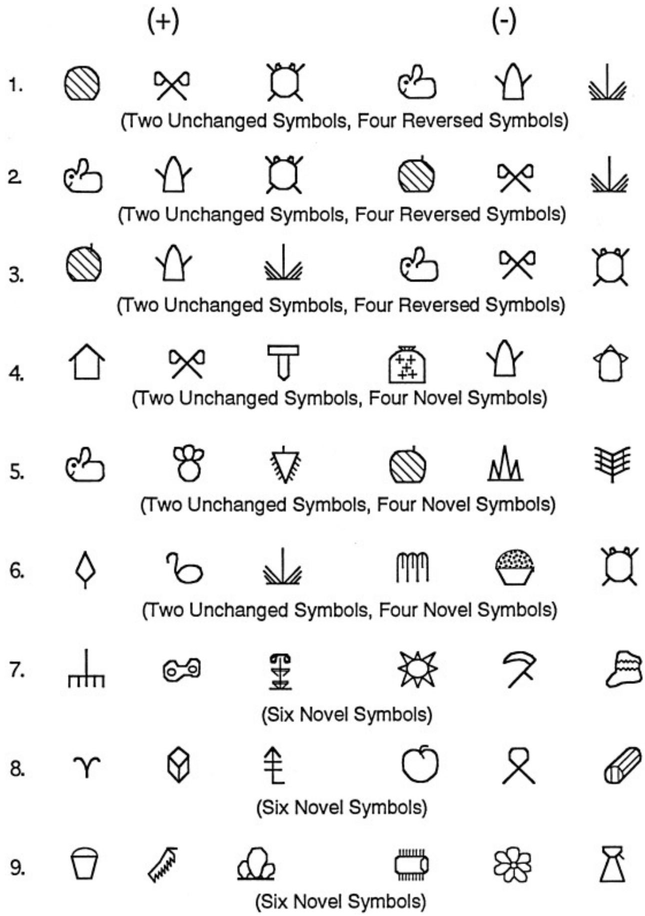


FIG. 2. Diagram of the compound discriminations. Plus (+) indicates stimulus compounds paired with reinforcement and minus (−) denotes stimulus compounds paired with nonreinforcement. The S+ and S− compounds were presented simultaneously and were each composed of three symbols. The positions of the symbols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

compound scissors and cane were the unchanged symbols, whereas the remaining symbols in the S+ and S− compounds were novel (Compound 4 in Fig. 2). Rabbit and plum were the unchanged symbols in the second transfer compound which appeared simultaneously with four novel symbols (Compound 5 in Fig. 2). The third transfer compound was composed of the unchanged symbols of grasses and mule and four novel symbols (Compound 6 in Fig. 2). Each transfer compound was presented immediately following the conflict compound with identical unchanged symbols.

Following 90% accuracy for the transfer compounds, 36 test trials were again administered. This ensured that the unchanged symbol pair and both novel symbol pairs (the S+ and S− novel symbols occupied the same position in the compounds) were presented for 12 trials each in a mixed sequence. Test sessions assessed which elements controlled responding in agreement with the reinforcement contingencies of the compound stimuli. Response topographies were also recorded by determining the symbols each subject was touching in the transfer compounds when they achieved compound criterion accuracy.

Novel Compounds and Test Conditions

Three compound discrimination tasks containing all novel symbols were presented as a control procedure to the subjects. After 90% accuracy was achieved for the novel compounds, the three novel symbol pairs (each S+ and S− novel symbol occupied the same position in the compounds) were presented for 12 trials, respectively, in a mixed sequence. These test sessions determined which elements the subjects were attending to when they learned compound discriminations containing all novel symbols. Response topographies were again examined by recording the symbols each subject touched in the novel compounds when compound criterion accuracy was achieved. Table 1 lists the sequence of stimuli and procedures provided to the three young children and the three adolescents with mental retardation. The number of trials to acquisition for each subject in the different experimental procedures is included in Appendix 1 and Appendix 2.

RESULTS

Conflict Compounds: Two Unchanged Symbols and Four Reversed Symbols (Young Children)

Figure 3 displays test results for conflict compounds containing two unchanged symbols and four reversed symbols for the young children of normal development. In this figure, the percentage agreement of responses during unchanged-element and reversed-element test trials with the reinforcement contingencies of the conflict compound is shown. These test results were interpreted as follows. If the children achieved high percentage agreement scores during unchanged-symbol test trials but not during reversed-symbol test trials, this demonstrated that they selectively attended to only the unchanged symbols in the conflict compound. If they obtained percentage agreement scores near chance levels during reversed-symbol test trials, a loss of stimulus control was indicated following acquisition of the compound discrimination. Zero percentage agreement with the contingencies of the conflict compound during reversed-symbol test trials showed that original stimulus control was not altered when prior reinforcement contingencies were reversed in the compound. Finally, if high percentage agreement scores were obtained for both the unchanged and the reversed symbols or if high percentage agreement

TABLE 1
Sequence of Stimuli and Procedures

Child 1 Adolescent 1	Child 2 Adolescent 2	Child 3 Adolescent 3
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound	Conflict Compound	Conflict Compound
Rabbit–Plum Unchanged	Scissors–Cane Unchanged	Grasses–Mule Unchanged
Four Reversed Symbols	Four Reversed Symbols	Four Reversed Symbols
Transfer Compound	Transfer Compound	Transfer Compound
Rabbit–Plum Unchanged	Scissors–Cane Unchanged	Grasses–Mule Unchanged
Four Novel Symbols	Four Novel Symbols	Four Novel Symbols
Novel Compound	Novel Compound	Novel Compound
Six Novel Symbols	Six Novel Symbols	Six Novel Symbols
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound	Conflict Compound	Conflict Compound
Scissors–Cane Unchanged	Rabbit–Plum Unchanged	Rabbit–Plum Unchanged
Four Reversed Symbols	Four Reversed Symbols	Four Reversed Symbols
Transfer Compound	Transfer Compound	Transfer Compound
Scissors–Cane Unchanged	Rabbit–Plum Unchanged	Rabbit–Plum Unchanged
Four Novel Symbols	Four Novel Symbols	Four Novel Symbols
Novel Compound	Novel Compound	Novel Compound
Six Novel Symbols	Six Novel Symbols	Six Novel Symbols
Single Symbol Training	Single Symbol Training	Single Symbol Training
Conflict Compound	Conflict Compound	Conflict Compound
Grasses–Mule Unchanged	Grasses–Mule Unchanged	Scissors–Cane Unchanged
Four Reversed Symbols	Four Reversed Symbols	Four Reversed Symbols
Transfer Compound	Transfer Compound	Transfer Compound
Grasses–Mule Unchanged	Grasses–Mule Unchanged	Scissors–Cane Unchanged
Four Novel Symbols	Four Novel Symbols	Four Novel Symbols
Novel Compound	Novel Compound	Novel Compound
Six Novel Symbols	Six Novel Symbols	Six Novel Symbols

levels were not evident for any of the stimulus elements, selective attention to unchanged symbols was not concluded.

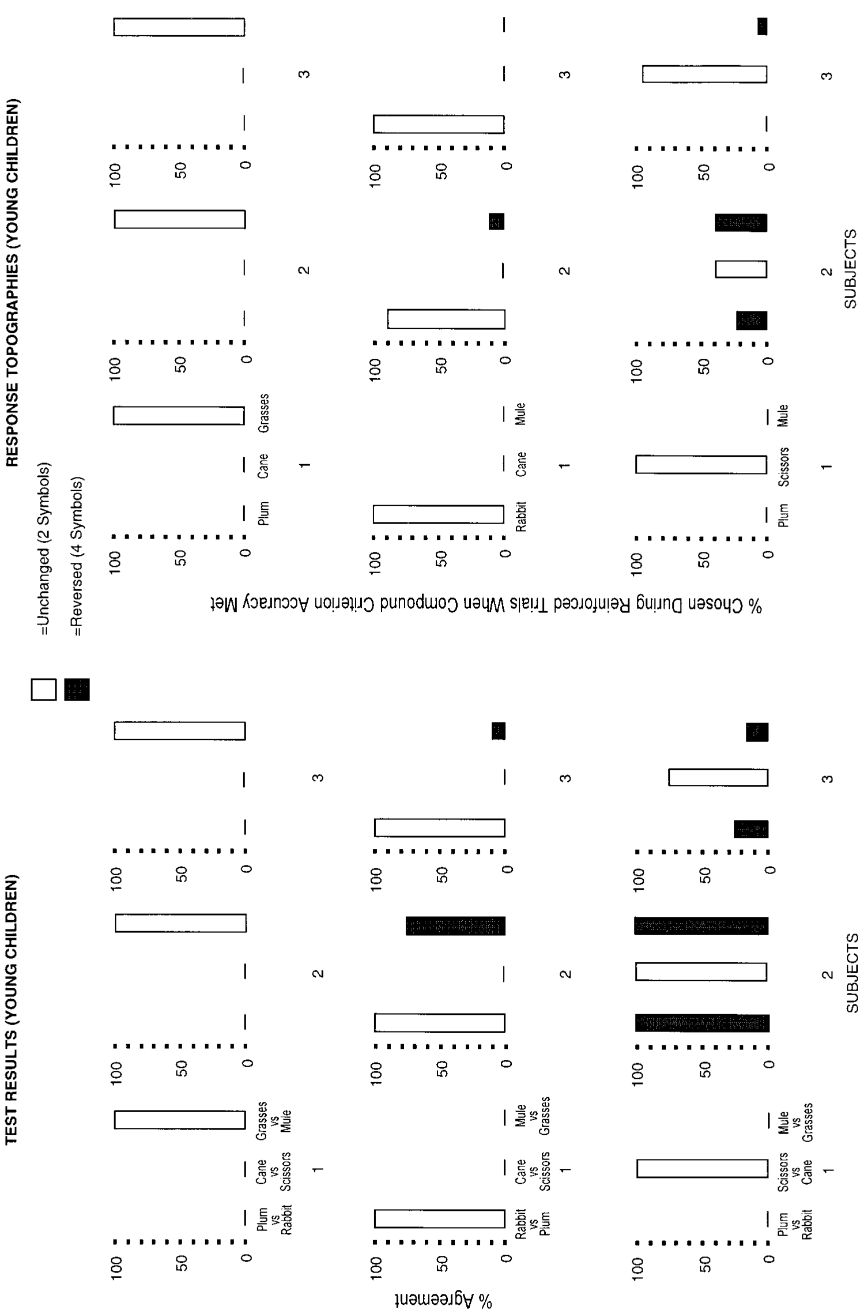
Only the unchanged symbol pair exercised stimulus control in agreement with the reinforcement contingencies of the conflict compound in the majority of test sessions. Percentage agreement scores were at 100% during the unchanged-symbol test trials, with one exception. In contrast, high percentage agreement scores (80% or greater) were not evident during the reversed-symbol test trials in eight of nine cases. Percentage agreement scores were at or near 0% for the reversed symbols in most of these test sessions, indicating that original stimulus control was not disrupted despite reversal of the original discrimination in the compound. Child 2, following acquisition of the conflict compound where rabbit and plum were unchanged symbols, achieved a percentage agreement score near the chance level for one of the reversed symbols, showing loss of control by the reversed element. Selective attention to the unchanged symbols was, therefore, inferred from most of the test sessions since high percentage agreement scores were revealed only in the unchanged-symbol test trials and not in the reversed-symbol test trials. In the majority of cases, the young children attended to only unchanged symbols while not responding to reversed symbols when criterion accuracy for the conflict compounds was achieved. Two exceptions were demonstrated. After Child 2 learned the conflict-compound discrimination in which scissors and cane were the unchanged symbol pair, she achieved high percentage agreement scores for both the unchanged and the reversed symbols. Child 3, in contrast, did not obtain high percentage agreement scores (80% or greater) for any of the elements of this conflict compound.

Response topographies recorded with the touch screen also indicated that the young children were selectively responding to only the unchanged symbols in the conflict compounds when criterion accuracy was met (Fig. 3). On most reinforced trials when compound criterion accuracy was achieved, the children touched only unchanged symbols in the conflict compounds in eight of nine cases. They did not touch reversed symbols in the compound on the majority of reinforced trials. In only one instance did selective touching of the unchanged symbol fail to occur. Child 2 touched both unchanged and reversed symbols when she learned the conflict-compound discrimination where scissors and cane were the unchanged symbols which supported her test result (see Fig. 3).

Conflict Compounds: Two Unchanged Symbols and Four Reversed Symbols (Adolescents—MR)

In contrast to the young children's test performance, the adolescents with mental retardation did not demonstrate selective attention to the unchanged symbols in most cases when criterion accuracy for the conflict compounds was achieved (Fig. 4). Although in four test sessions high percentage agreement scores (80% or greater) were evident only during unchanged-symbol test trials, this was not true for the remaining five test sessions. In two of these test sessions, selective attention to reversed symbols was revealed since the adolescents obtained high percentage agreement scores for only one symbol pair which was reversed in the compound. Selective attention to either an unchanged or a reversed symbol was not evident in the remaining three test sessions. In one of these test sessions, both the unchanged symbol pair and a reversed symbol pair exhibited stimulus control in agreement with the reinforcement contingencies of the conflict compound. High percentage agreement scores were not evident for any of the symbol pairs of the conflict compounds during the other two test sessions. Greater variability in test performance following acquisition of conflict compounds was noted for the adolescents with mental retardation compared to test performance of the young children of normal development.

Response topographies recorded with the touch screen confirmed selective responding to unchanged symbols in four instances, since on most reinforced trials when criterion accuracy was achieved, the adolescents touched only un-


TEST RESULTS (YOUNG CHILDREN)
RESPONSE TOPOGRAPHIES (YOUNG CHILDREN)
=Unchanged (2 Symbols)
=Reversed (4 Symbols)
% Agreement
% Chosen During Reinforced Trials When Compound Criterion Accuracy Met
Plum vs Rabbit
Cane vs Scissors
Grasses vs Mule
Rabbit vs Plum
Mule vs Grasses
Scissors vs Cane
Plum
Cane
Grasses
Rabbit
Mule
Scissors
100
50
0
1
2
3
SUBJECTS

changed symbols in four conflict compounds (Fig. 4). This served to support their test performance for these conflict compounds (see Fig. 4). The adolescents selectively touched only reversed symbols, however, when criterion accuracy was obtained for the remaining five conflict compounds. These response topographies confirmed their test performance for two of the conflict compounds but did not support their test performance for the remaining three conflict compounds (see Fig. 4). In one of these three discrepant test sessions, the original stimulus control of the unchanged symbols remained intact during the test trials despite selective responding to a reversed symbol in the compound as shown by the touch screen. During the other two test sessions, lack of confirmation of selective responding to reversed symbols may have been due to the nondifferential reinforcement contingency in effect during the test trials which disrupted control by the individual symbols of the conflict compounds. Inspection of response topographies also revealed that two of the three adolescents selectively responded to the same symbol pair in the 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 conflict compounds produced distinctly different results for the two groups. Unlike the children of normal development, the adolescents with mental retardation did not selectively touch only unchanged symbols in the conflict compounds when they achieved criterion accuracy.

Transfer Compounds: Two Unchanged Symbols and Four Novel Symbols (Young Children)

Figure 5 illustrates test findings for transfer compounds containing unchanged and novel symbols for the young children. After reversed symbols were removed and novel symbols substituted, selective attention to the symbols whose prior reinforcement history was maintained in the compound was revealed in three of the nine test sessions. This was concluded since in these three test sessions, high percentage agreement scores were obtained only in the unchanged-symbol test trials. Variable test performance was noted for the remaining six test sessions. In two cases, novel symbols as well as the unchanged symbol pair exerted stimulus control in accordance with the reinforcement contingencies of the com-

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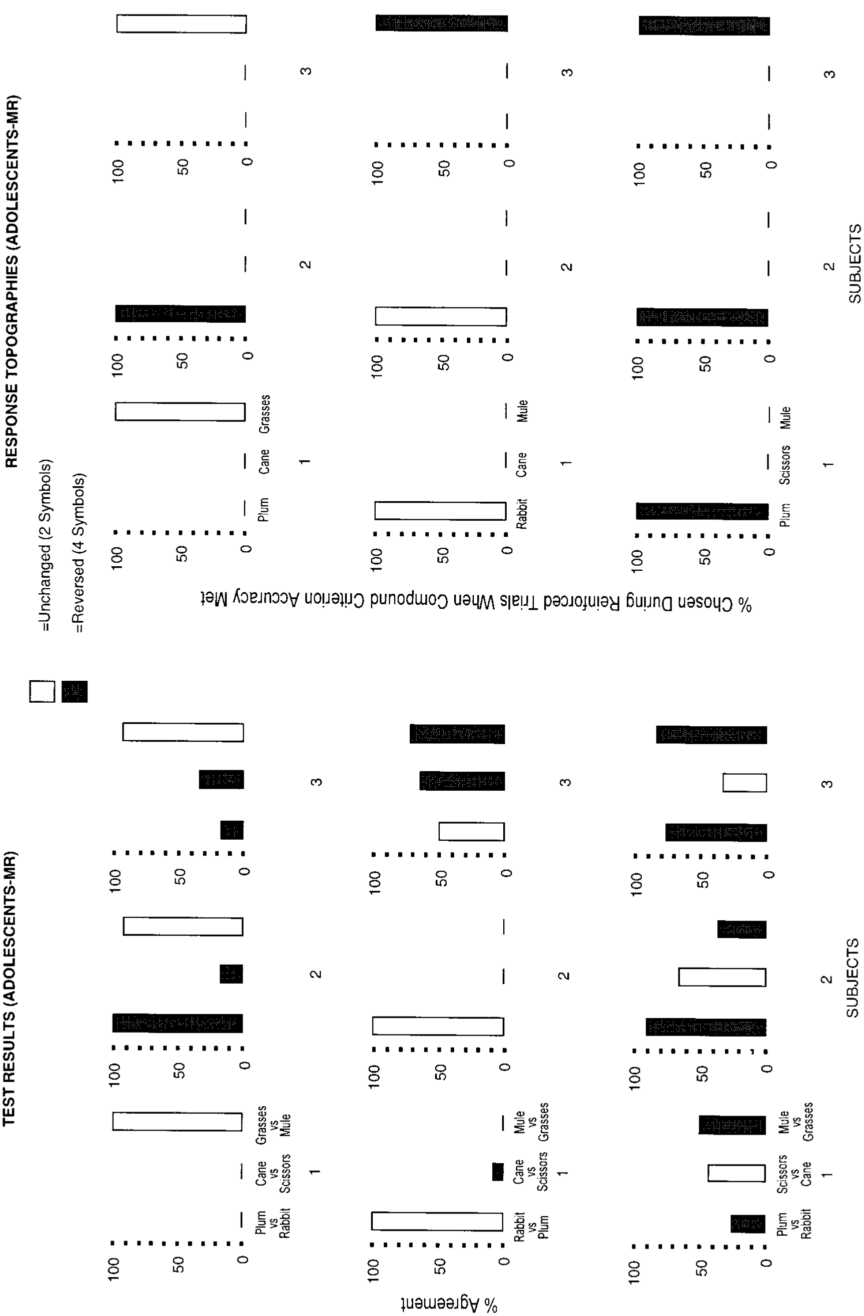
FIG. 3. Test results and response topographies of the compound stimuli (Compounds 1, 2, and 3 in Fig. 2) for the young children of normal development. (Left) Percentage agreement of responses during unchanged-symbol (white bars) and reversed-symbol (black bars) test trials with the reinforcement contingencies of the compound stimuli is shown. 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. The top symbols indicated for Child 1 in the left portion of the figure were positive and the bottom symbols were negative in the compound discriminations. (Right) Percentage unchanged symbols (white bars) and reversed symbols (black bars) chosen during reinforced trials when compound criterion accuracy was achieved for the young children of normal development is shown. The symbols indicated for Child 1 in the right portion of the figure were the three S+ symbols in the compound discriminations.



RESPONSE TOPOGRAPHIES (ADOLESCENTS-MR)
=Unchanged (2 Symbols)
=Reversed (4 Symbols)
% Chosen During Reinforced Trials When Compound Criterion Accuracy Met
Plum
Cane
Grasses
Rabbit
Cane
Mule
Plum
Scissors
Mule
SUBJECTS
TEST RESULTS (ADOLESCENTS-MR)
% Agreement
Plum vs Rabbit
Cane vs Scissors
Grasses vs Mule
Rabbit vs Plum
Cane vs Scissors
Mule vs Grasses
Plum vs Rabbit
Scissors vs Cane
Mule vs Grasses
SUBJECTS

pound stimuli. Following acquisition of the transfer compound in which rabbit and plum were the unchanged symbols, Child 2 achieved a high level of agreement for one of the novel symbol pairs. After obtaining criterion accuracy for the transfer compound where scissors and cane were the unchanged symbols, Child 2 demonstrated high levels of agreement with the reinforcement contingencies of the compound stimuli for both pairs of novel symbols. In four test sessions, however, high percentage agreement scores were not evident for any of the elements of the transfer compounds. Child 1 and Child 3 did not reveal control by any of the stimulus components following acquisition of two of the three transfer compound discriminations.

Instead of the variable test performance that was found following acquisition of the transfer compounds, highly consistent response topographies were observed across children when symbols touched in the compounds by the young children were analyzed. With one exception, the children selectively touched unchanged symbols in the transfer compounds on most reinforced trials when criterion accuracy was demonstrated and did not touch novel symbols (Fig. 5). Such findings indicate that the young children were selectively attending to the unchanged symbols in most of the transfer compounds while not responding to the novel symbols. The children's inconsistent test performance, which did not confirm this selective attention in most cases, may have been due to the nondifferential reinforcement contingency in effect during the test sessions. Since whichever symbol the children selected during novel-symbol test trials was reinforced, response patterns may have been formed during test trials. This may not only have affected control by the novel symbols, but it may also have disrupted stimulus control of unchanged symbols in some instances.

Transfer Compounds: Two Unchanged Symbols and Four Novel Symbols (Adolescents—MR)

After transfer compounds composed of unchanged and novel symbols were acquired by the adolescents, selective attention to the unchanged symbols was

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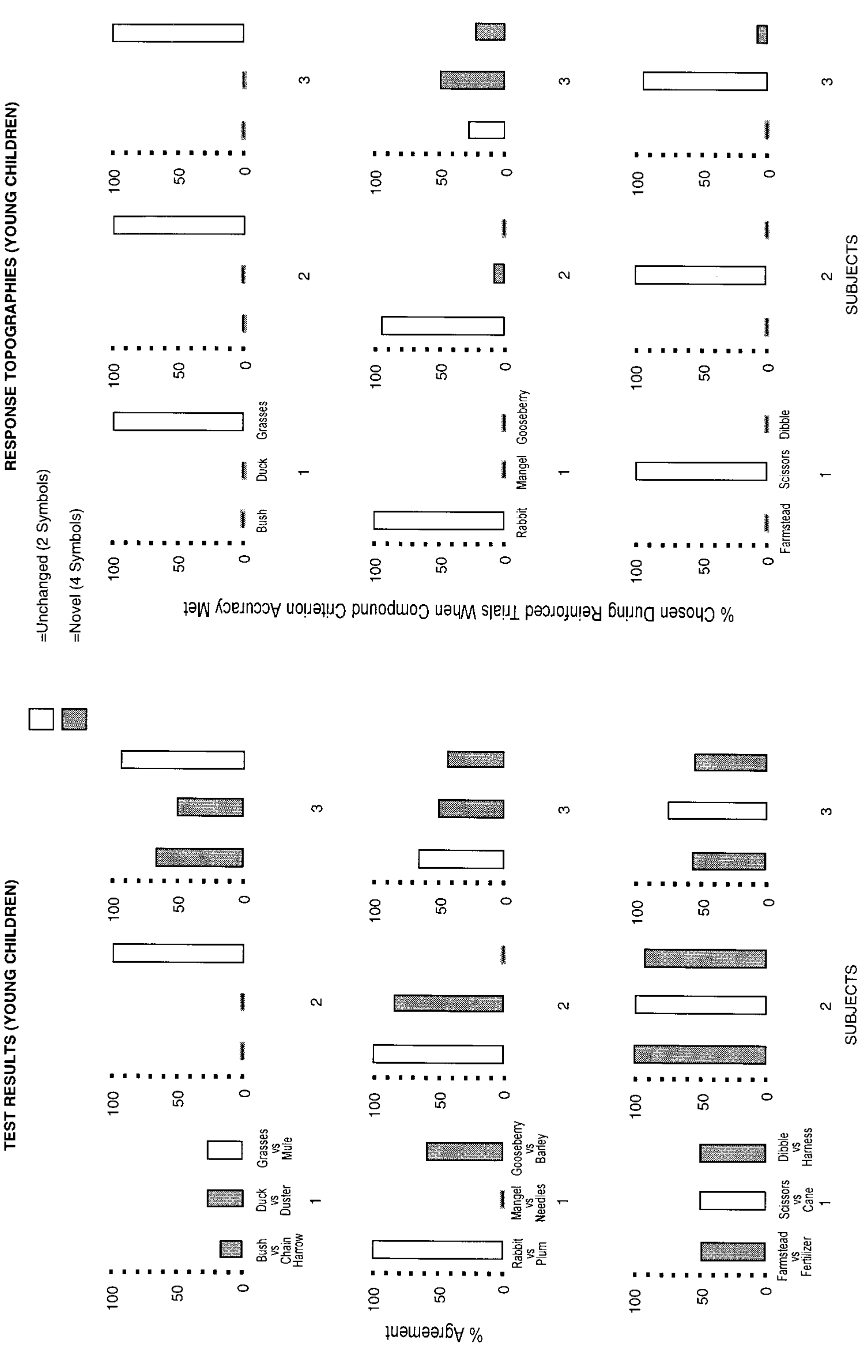
FIG. 4. Test results and response topographies of the compound stimuli (Compounds 1, 2, and 3 in Fig. 2) for the adolescents with mental retardation. (Left) Percentage agreement of responses during unchanged-symbol (white bars) and reversed-symbol (black bars) test trials with the reinforcement contingencies of the compound stimuli is shown. 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. The top symbols indicated for Adolescent 1 in the left portion of the figure were positive and the bottom symbols were negative in the compound discriminations. (Right) Percentage unchanged symbols (white bars) and reversed symbols (black bars) chosen during reinforced trials when compound criterion accuracy was achieved for the adolescents with mental retardation is shown. The symbols indicated for Adolescent 1 in the right portion of the figure were the three S+ symbols in the compound discriminations.


TEST RESULTS (YOUNG CHILDREN)
RESPONSE TOPOGRAPHIES (YOUNG CHILDREN)
=Unchanged (2 Symbols)
=Novel (4 Symbols)
% Agreement
% Chosen During Reinforced Trials When Compound Criterion Accuracy Met
SUBJECTS
Bush vs Chain Harrow
Duck vs Duster
Grasses vs Mule
Rabbit vs Plum
Mangel vs Needles
Gooseberry vs Barley
Farmstead vs Fertilizer
Scissors vs Cane
Dibble vs Harness
Bush
Duck
Grasses
Rabbit
Mangel
Gooseberry
Farmstead
Scissors
Dibble

demonstrated in only one test session where high percentage agreement scores were found in only the unchanged-symbol test trials (Fig. 6). Selective attention to novel symbols in the transfer compound was shown in two instances, since in these test sessions the adolescents obtained high percentage agreement scores for only one pair of symbols which were novel. Selective attention to either unchanged or novel symbols was not evident in the remaining six test sessions. In three of these six test sessions, both unchanged symbols and novel symbols exhibited stimulus control in agreement with the reinforcement contingencies of the transfer compounds. High percentage agreement scores were not shown for any of the symbols of the remaining three transfer compounds (see Fig. 6). The adolescents with mental retardation demonstrated, therefore, variable test performance after the transfer compounds were acquired as had also been shown by the young children of normal development.

In contrast to the adolescents' test performance, their response topographies, recorded with the touch screen, indicated that they were selectively responding to the unchanged symbols in the transfer compounds in the majority of cases (Fig. 6). This was concluded because in six of nine instances the adolescents touched unchanged symbols in the transfer compounds and did not touch novel symbols on most reinforced trials when they achieved criterion accuracy. In the other three instances, a novel symbol was selectively touched in the transfer compound when criterion accuracy was met, demonstrating in these instances that the adolescents selectively responded to novel symbols in the compounds. The response topographies of the transfer compounds for the adolescents with mental retardation more closely resembled those of the young children than had been observed when the response topographies of the conflict compounds for the two groups were compared. The adolescents' variable test performance which did not confirm their selective attention in most cases may again have been the result of the nondifferential reinforcement contingency employed during the test trials. As proposed for the young children, nondifferential reinforcement during test trials not only may have established control by the novel symbols but it may have disrupted control of the unchanged symbols in some instances. In summary, unlike the results using

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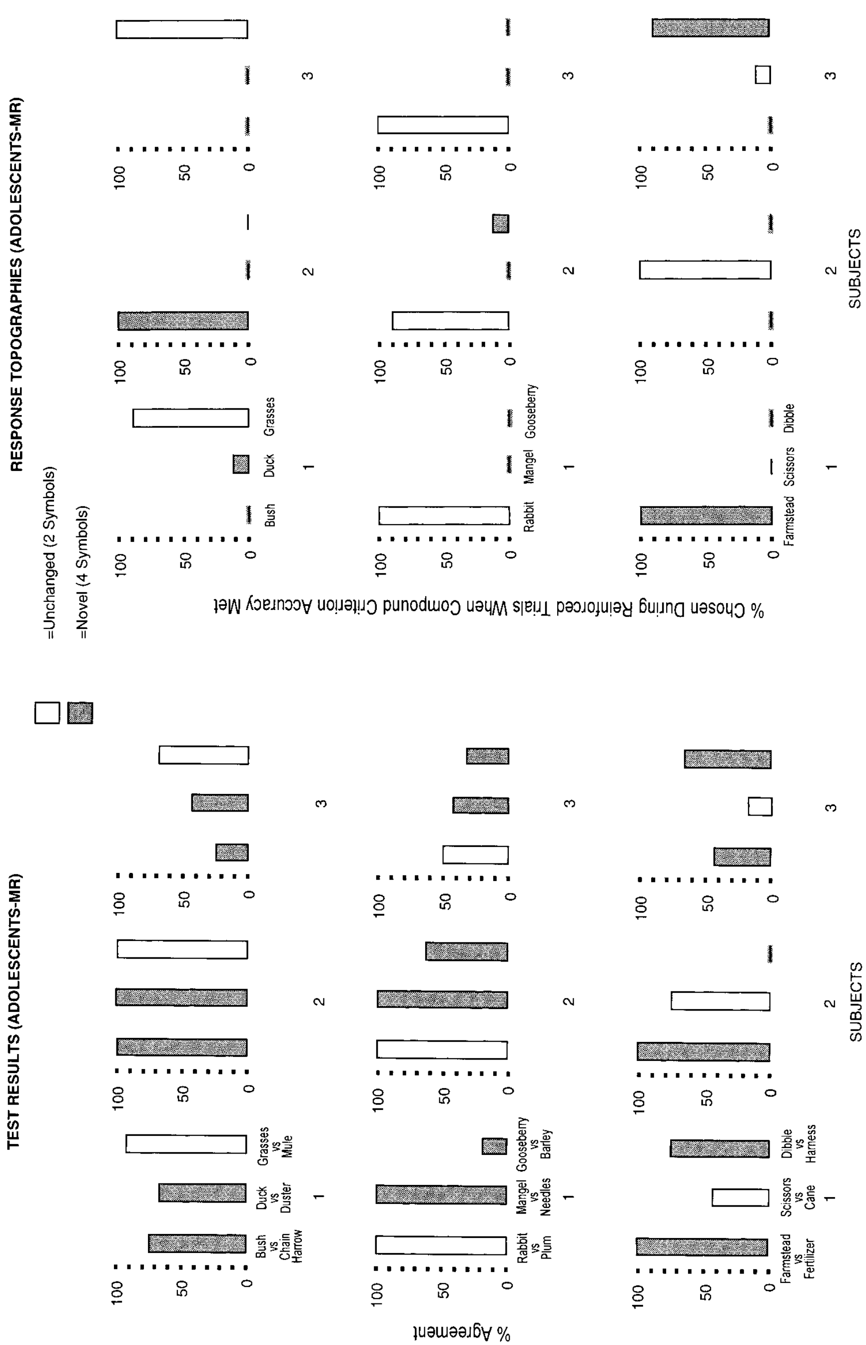
FIG. 5. Test results and response topographies of the compound stimuli (Compounds 4, 5, and 6 in Fig. 2) for the young children of normal development. (Left) Percentage agreement of responses during unchanged-symbol (white bars) and novel-symbol (gray bars) test trials with the reinforcement contingencies of the compound stimuli is shown. 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. The top symbols indicated for Child 1 in the left portion of the figure were positive and the bottom symbols were negative in the compound discriminations. (Right) Percentage unchanged symbols (white bars) and novel symbols (gray bars) chosen during reinforced trials when compound criterion accuracy was achieved for the young children of normal development is shown. The symbols indicated for Child 1 in the right portion of the figure were the three S+ symbols in the compound discriminations.



TEST RESULTS (ADOLESCENTS-MR)
RESPONSE TOPOGRAPHIES (ADOLESCENTS-MR)
=Unchanged (2 Symbols)
=Novel (4 Symbols)
% Agreement
% Chosen During Reinforced Trials When Compound Criterion Accuracy Met
Bush vs Chain Harrow
Duck vs Duster
Grasses vs Mule
Rabbit vs Plum
Mangel vs Needles
Gooseberry vs Barley
Farmstead vs Fertilizer
Scissors vs Cane
Dibble vs Harness
Bush
Duck
Grasses
Rabbit
Mangel
Gooseberry
Farmstead
Scissors
Dibble
SUBJECTS

conflict compounds, the transfer compounds produced no notable difference between the two populations. Both groups, in the majority of cases, selectively attended to the unchanged symbol pair.

Novel Compounds: Six Novel Symbols (Young Children)

A lack of reliable test results was again found after the young children learned compound discriminations containing all novel symbols. Variability in test performance occurred both within and across children (Fig. 7). When Child 1 reached criterion accuracy for two of the novel compound discriminations, none of the stimulus elements exhibited a high level of control in agreement with the reinforcement contingencies of the compound stimuli. His test performance indicated that he was not attending to any of the individual symbols when criterion accuracy was achieved for two of the stimulus compounds. After Child 1 acquired the third novel compound discrimination, however, he obtained high percentage agreement scores for two of the novel symbol pairs. Child 2 also failed to respond to the novel compounds in a consistent fashion as revealed by her test results. Although test trials following one of the novel compound discriminations implied that she attended to all of the stimulus components, this test result did not occur for the remaining two novel compounds. Only two components produced high percentage agreement scores when she learned another novel compound discrimination. Just one of the novel symbol pairs exerted a high level of agreement with the reinforcement contingencies of the stimulus compound after she learned the other novel compound task. Test performance for Child 3 indicated that he was not attending to any of the individual components when he acquired two of the novel compound discriminations since none of the stimulus components resulted in high percentage agreement scores. After he learned the third novel compound discrimination, in contrast, two of the novel pairs were associated with high levels of agreement with the compound's reinforcement contingencies.

Although control by only one symbol of the novel compounds was shown for the young children in just one test session, selective attention was evident in eight of nine instances when response topographies were examined. With one

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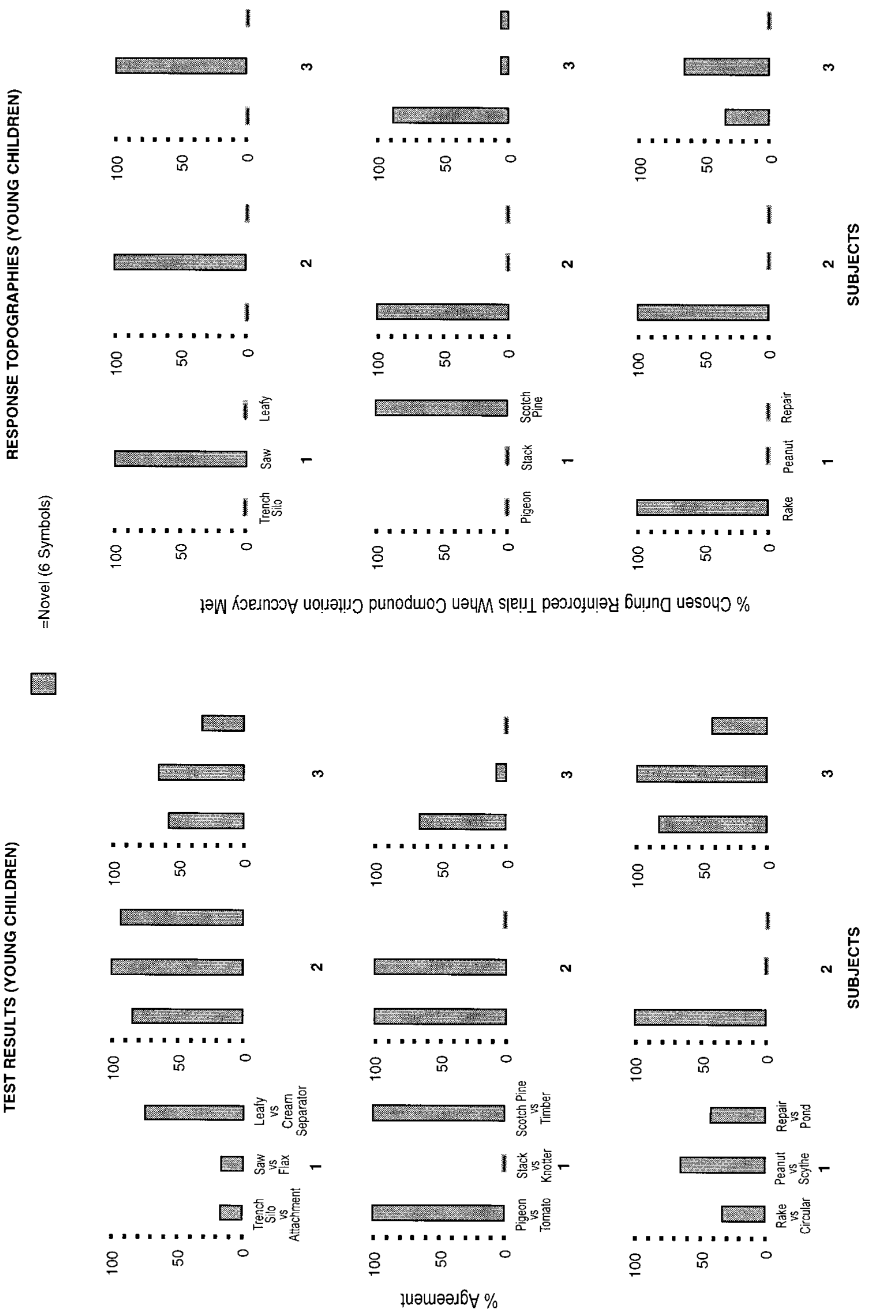
FIG. 6. Test results and response topographies of the compound stimuli (Compounds 4, 5, and 6 in Fig. 2) for the adolescents with mental retardation. (Left) Percentage agreement of responses during unchanged-symbol (white bars) and novel-symbol (gray bars) test trials with the reinforcement contingencies of the compound stimuli is shown. 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. The top symbols indicated for Adolescent 1 in the left portion of the figure were positive and the bottom symbols were negative in the compound discriminations. (Right) Percentage unchanged symbols (white bars) and novel symbols (gray bars) chosen during reinforced trials when compound criterion accuracy was achieved for the adolescents with mental retardation is shown. The symbols indicated for Adolescent 1 in the right portion of the figure were the three S+ symbols in the compound discriminations.


TEST RESULTS (YOUNG CHILDREN)
RESPONSE TOPOGRAPHIES (YOUNG CHILDREN)
=Novel (6 Symbols)
% Agreement
% Chosen During Reinforced Trials When Compound Criterion Accuracy Met
Trench Silo vs Attachment
Saw vs Flax
Leafy vs Cream Separator
Pigeon vs Tomato
Stack vs Knotter
Scotch Pine vs Timber
Rake vs Circular
Peanut vs Scythe
Repair vs Pond
Trench Silo
Saw
Leafy
Pigeon
Stack
Scotch Pine
Rake
Peanut
Repair
SUBJECTS
SUBJECTS

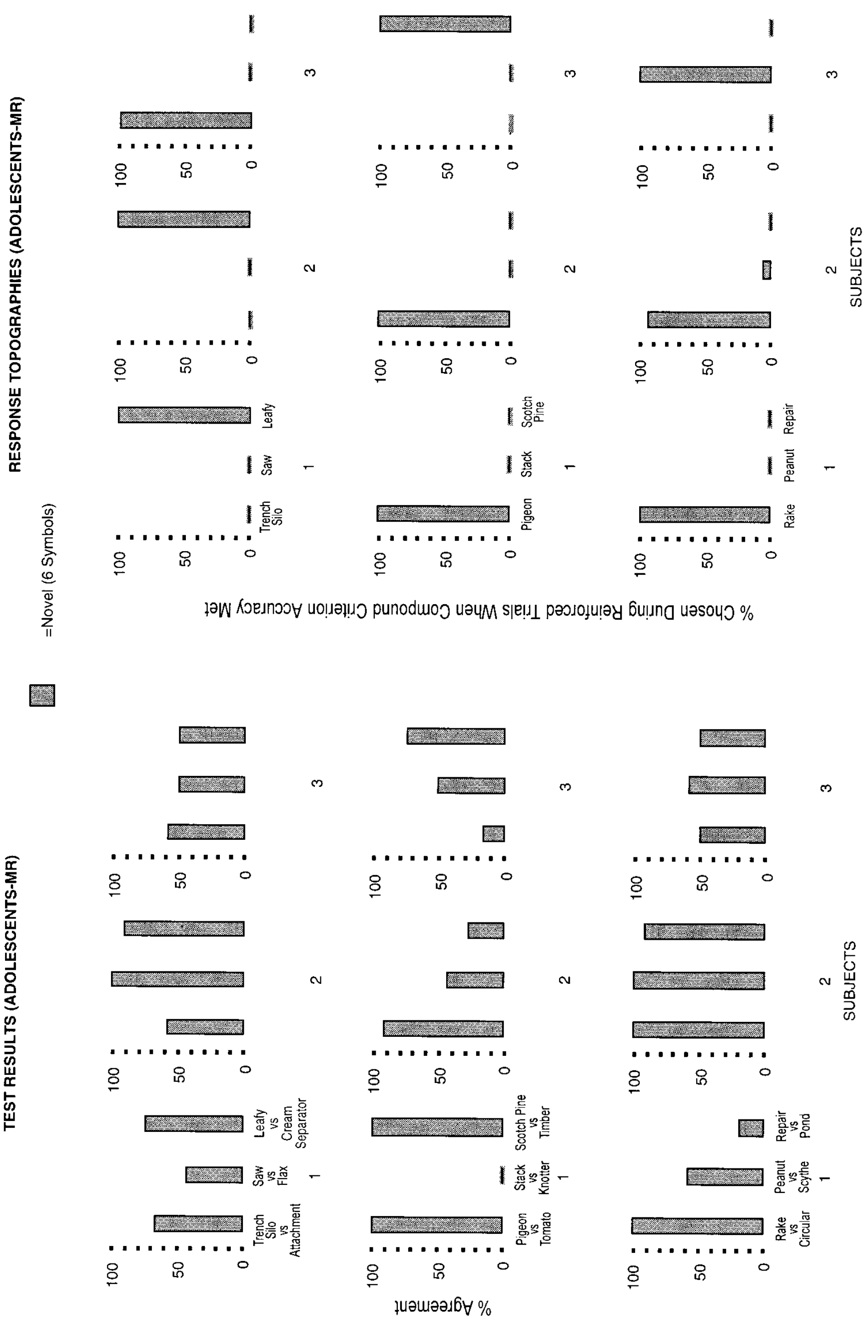
exception, the young children selectively touched only one symbol in the novel compounds on most reinforced trials when they met criterion accuracy (Fig. 7). The opposing test findings may again be explained by the nondifferential reinforcement during the test. Whichever symbol the child selected during the test trials was reinforced, and this may have established or disrupted stimulus control by the individual novel symbols depending on the symbols initially selected.

Novel Compounds: Six Novel Symbols (Adolescents—MR)

The adolescents with mental retardation also demonstrated variable test performance after they acquired compound discriminations in which all of the symbols were novel (Fig. 8). After Adolescent 2 learned one novel compound discrimination, she obtained high percentage agreement scores for two of the novel pairs. Following acquisition of the remaining two novel compound tasks, high percentage agreement scores were obtained during test trials for only one novel symbol pair and all three novel symbol pairs, respectively. In contrast, Adolescent 3 exhibited test performance which indicated that she was not attending to any of the individual symbols when criterion accuracy for the novel compounds was achieved. Adolescent 3 did not obtain high percentage agreement scores (80% or greater) for any of the stimulus components of the three novel compounds. When Adolescent 1 acquired one of the novel compound discriminations, high percentage agreement scores were not evident for any of the symbol pairs during the test trials. Two novel symbol pairs resulted in high percentage agreement scores after she learned another novel compound discrimination, and only one novel symbol pair produced high percentage agreement scores following acquisition of the third novel compound task. Both the adolescents with mental retardation and the young children of normal development revealed inconsistent test performance for compounds composed of all novel symbols.

Although test performance indicated selective attention to a single symbol in the novel compounds in only two of the nine instances, the response topographies of the adolescents showed that they selectively touched only one symbol in all of the novel compounds (Fig. 8). As had been true for the

FIG. 7. Test results and response topographies of the compound stimuli (Compounds 7, 8, and 9 in Fig. 2) for the young children of normal development. (Left) Percentage agreement of responses during novel-symbol (gray bars) test trials with the reinforcement contingencies of the compound stimuli is shown. 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. The top symbols indicated for Child 1 in the left portion of the figure were positive and the bottom symbols were negative in the compound discriminations. Gray bars reveal that all of the symbols in the stimulus compounds were novel. (Right) Percentage novel symbols (gray bars) chosen during reinforced trials when compound criterion accuracy was achieved for the young children of normal development is shown. The symbols indicated for Child 1 in the right portion of the figure were the three S+ symbols in the compound discriminations.


TEST RESULTS (ADOLESCENTS-MR)
RESPONSE TOPOGRAPHIES (ADOLESCENTS-MR)
=Novel (6 Symbols)
% Agreement
% Chosen During Reinforced Trials When Compound Criterion Accuracy Met
Trench Silo vs Attachment
Saw vs Flax
Leafy vs Cream Separator
Pigeon vs Tomato
Stack vs Knotter
Scotch Pine vs Timber
Rake vs Circular
Peanut vs Scythe
Repair vs Pond
Trench Silo
Saw
Leafy
Pigeon
Stack
Scotch Pine
Rake
Peanut
Repair
100
50
0
1
2
3
SUBJECTS

young children, variability existed both within and across adolescents in terms of which symbol they selectively responded to in the novel compounds. The nondifferential reinforcement contingency in effect during test trials was also thought to produce the conflicting test performance of the adolescents. In summary, comparable response topographies were found for both children of normal development and adolescents with mental retardation when they reached criterion accuracy for novel compound discriminations. Both groups selectively attended to only one of the novel symbols.

DISCUSSION

Establishing prior reinforcement histories for separate stimulus components determined which features of compound visual cues young children of normal development attended to. In most instances, when prior reinforcement histories were manipulated, young children of normal development selectively responded to stimulus elements whose prior reinforcement history was unchanged in the compound. Stimulus elements with a reversed prior reinforcement contingency were usually ignored. The reliability of the effect of prior reinforcement histories on the attention of young children to complex visual cues was validated by employing multiple assessment procedures, automatically administered by the computer. One stimulus control test consisted of presenting unchanged elements and reversed elements separately to the young children following acquisition of the conflict compounds. In most cases, only unchanged elements exhibited a high level of control in agreement with the conflict compound's reinforcement contingencies, indicating that the young children of normal development were selectively attending to the unchanged elements. The second assessment involved recording which symbols the young children touched in the visual compounds. Response topographies recorded with a touch screen confirmed that the young children of normal development were selectively responding to only unchanged elements of the conflict compounds when they achieved criterion accuracy. In particular, on most reinforced trials, the young children touched only unchanged symbols in the compounds and did not touch reversed symbols. These results support

FIG. 8. Test results and response topographies of the compound stimuli (Compounds 7, 8, and 9 in Fig. 2) for the adolescents with mental retardation. (Left) Percentage agreement of responses during novel-symbol (gray bars) test trials with the reinforcement contingencies of the compound stimuli is shown. 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. The top symbols indicated for Adolescent 1 in the left portion of the figure were positive and the bottom symbols were negative in the compound discriminations. Gray bars reveal all of the symbols in the stimulus compounds were novel. (Right) Percentage novel symbols (gray bars) chosen during reinforced trials when compound criterion accuracy was achieved for the adolescents with mental retardation is shown. The symbols indicated for Adolescent 1 in the right portion of the figure were the three S+ symbols in the compound discriminations.

and extend the findings of an earlier investigation (Huguenin, 1987). The current study further showed that prior conditioning histories could control whether young children of normal development selectively responded to left portions, right portions, or middle portions of compound visual stimuli.

The adolescents with severe mental retardation proved to be less sensitive to the effects of prior reinforcement histories. They demonstrated much greater variability in test performance following acquisition of conflict compounds than was observed for young children of normal development. In most cases, their test performance indicated that they did not selectively attend to the unchanged symbols when criterion accuracy for the conflict compounds was achieved. This was in direct contrast to the test performance of the young children. It was discovered that reversing prior reinforcement contingencies for adolescents with severe mental retardation disrupted the controlling relations associated with extinction in the compound. In the majority of test sessions, either loss of stimulus control or a reversal of original discriminations was noted for the adolescents. Other investigations have also shown variability in test performance for students with developmental disabilities when other procedures were administered (Huguenin & Touchette, 1980; Tomiser et al., 1983). The current study further revealed, however, that there was a distinct contrast between students with developmental disabilities and children of normal development. Much less variable test performance was observed for the young children of normal development of comparable mental age. In most cases, stimulus–response relations that were paired with extinction in the compound lowered in frequency without being topographically altered for the children of normal development. Inspection of response topographies demonstrated that two of the three adolescents with severe mental retardation selectively responded to the same symbol pair in the conflict compounds when they achieved criterion accuracy regardless of whether the prior contingencies of the symbol pair were unchanged or reversed in the compound. The adolescents with severe mental retardation did not selectively touch only the unchanged symbols in the conflict compounds on most reinforced trials when they achieved criterion accuracy in contrast to what had occurred for the young children of normal development. These findings suggest that a critical distinction between students with severe developmental disabilities and students of normal development of comparable mental age may lie in the efficiency with which they shift attention among elements of complex visual stimuli depending on prior conditioning histories. Indeed, the consistency with which students respond to compounds with conflicting prior reinforcement histories may prove to be an effective technique for identifying students with developmental disabilities and attentional deficits.

Multiple testing procedures were also utilized to determine the manner in which children of normal development and adolescents with severe mental retardation responded to transfer compounds containing some novel cues. After acquiring compound discriminations composed of unchanged and novel symbols, the two groups produced no significant differences in results. Both the children of normal development and the adolescents with severe mental retardation displayed variable test results when the unchanged and novel symbol pairs appeared alone. Selective attention to unchanged symbols in the transfer compounds was evident in only three test sessions for the young children and in only one test session for the adolescents with mental retardation. For the remaining test sessions, both novel symbols and unchanged symbols, novel symbols alone, or none of the symbols exerted control in accordance with the compound's reinforcement contingencies. Previous studies have reported increased variability in test performance following acquisition of compound discriminations containing some novel elements compared to totally pretrained compound tasks (Huguenin, 1985, 1987). In the earlier investigations, however, response topographies of the transfer compounds were not addressed through utilization of a touch screen. In contrast to diverse test results after compound acquisition, the touch screen in this study revealed that young children of normal development had consistent response topographies. On most reinforced trials, with one exception, the young children touched unchanged symbols in the compounds and did not touch novel symbols. Their response topographies indicated that the unchanged symbols were the dominant symbols in the transfer compounds when criterion accuracy was achieved. The response topographies of the adolescents with severe mental retardation, recorded with the touch screen, also indicated that they selectively responded to the unchanged symbols in the transfer compounds in the majority of cases. In six of nine instances, the adolescents touched unchanged symbols in the transfer compounds and did not touch novel symbols on most reinforced trials when they met criterion accuracy. In summary, the response topographies of the transfer compounds had greater similarity for the young children of normal development and the adolescents with mental retardation than was revealed for the conflict compounds. In addition, stimulus overselectivity which had been evident for two of the three adolescents with mental retardation when response topographies of the conflict compounds were recorded was not observed for any of the adolescents when response topographies of the transfer compounds were analyzed. This implies that presentation of compounds whose components have conflicting reinforcement histories is a more sensitive assessment technique than presentation of compounds containing some novel components for distinguishing between students of normal development and students with mental retardation of comparable mental age.

Inconsistent test results were again evident after the children of normal development and the adolescents with severe mental retardation acquired compound discriminations containing all novel cues. Response topographies of the novel compounds were also recorded with a touch screen to confirm interpretations of test performance. Although test findings indicated that the young children of normal development selectively attended to a single stimulus component in only one instance, their response topographies revealed that one symbol was selectively responded to in the novel compounds in most cases when criterion accuracy was met. With one exception, the children touched only one symbol in the novel compounds on most reinforced trials when criterion accuracy was demonstrated.

Unlike the compounds containing some or all pretrained stimulus components, however, the portion of the compound to which the young children selectively responded varied. The test performance of the adolescents with severe mental retardation also indicated selective attention to a single symbol in the novel compounds in only a few instances, but their response topographies also showed that they selectively touched only one symbol in the novel compounds. Variability existed both within and across adolescents in terms of which symbol they selectively responded to in the novel compounds as was observed for the young children.

The discrepant findings of two different testing procedures, which assessed attention to compounds containing some or all novel cues, points out the necessity of multiple testing procedures for accurately resolving how students respond to compound cues. Nondifferential reinforcement during test trials contributed to the opposing test results since whichever symbol the student selected during the test trials was reinforced and stimulus control by individual symbols could be established or disrupted depending on symbols initially selected. To reduce this disruption by the reinforcement contingency, probe trials could be administered in which single symbol test trials are provided unpredictably within a sequence of stimulus compound trials. This would result in prolonged testing, however, and it would not rule out the necessity for multiple testing procedures since additional test variables could still be a source of contamination. Although past studies have shown the importance of multiple tests (Danforth et al., 1990; Fields, 1985; Huguenin, 1987; Huguenin & Touchette, 1980; Merrill & Peacock, 1994; Newman & Benefield, 1968; Smeets et al., 1985; Wilkie & Masson, 1976), more than one testing procedure is seldom used to assess stimulus control by environmental cues. Improved technology, having now made touch screens for desk-top computers more affordable and widely available, enhances the economy and practicality of multiple assessment procedures for determining visual perception. The author acknowledges, however, the need for relatively sophisticated computer equipment and an expertise in discrimination learning in order to carry out the described procedures for assessing visual attention to stimulus compounds. Even without a touch screen, the recommended tests could still be conducted by teaching students to indicate their choice of compounds by clicking with a mouse. Where exactly they clicked in the compound across trials could help to identify which elements the students responded to in the stimulus compounds. Software could also be created which would automatically analyze the student's test results and provide recommendations based on the student's test performance. In fact, we are currently developing ''intelligent'' software for this purpose with the eventual goal of making it available to special educators and professionals who do not have a background in discrimination learning.

Overselective attention to compound training cues has often been implicated as 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). This study demonstrated, through employing multiple tests, that selective attention was also found among young children of normal development. A difference was found, however, between young children of normal development and adolescents with severe retardation in the efficiency with which they shifted attention among elements of complex stimuli depending on prior conditioning histories. This suggests the possibility that further research might identify training procedures which could instruct students with autism and severe mental retardation how to more quickly shift their attention from one stimulus feature to another within training compounds in accordance with prior reinforcement histories. Perhaps, through longer single stimulus pretraining, additional exposure to compounds whose components have conflicting reinforcement histories, or manipulating the physical proximity of stimulus components in the training compound displays, effective techniques might be found. This could potentially alleviate stimulus overselectivity and control what aspects of complex visual cues the student attends to. These training procedures could thereby help to ensure that the student with special needs is attending to the relevant aspects of educational material.

APPENDIX 1

Number of Trials to Acquisition for Each Young Child of Normal Development in the Different Experimental Procedures

	Child		
	1	2	3
Single Symbol Training	27	28	27
Single Symbol Training	27	29	39
Single Symbol Training	27	28	28
Conflict Compound Scissors–Cane Unchanged, Four Reversed Symbols	20	111	27
Conflict Compound Rabbit–Plum Unchanged, Four Reversed Symbols	22	39	68
Conflict Compound Grasses–Mule Unchanged, Four Reversed Symbols	20	20	20
Transfer Compound Scissors–Cane Unchanged, Four Novel Symbols	18	41	18
Transfer Compound Rabbit–Plum Unchanged, Four Novel Symbols	18	27	33
Transfer Compound Grasses–Mule Unchanged, Four Novel Symbols	19	18	21
Novel Compound	20	23	32
Novel Compound	18	19	26
Novel Compound	19	20	18

APPENDIX 2

Number of Trials to Acquisition for Each Adolescent with Mental Retardation in the Different Experimental Procedures

	Adolescent		
	1	2	3
Single Symbol Training	37	28	39
Single Symbol Training	32	27	44
Single Symbol Training	29	31	29
Conflict Compound Scissors–Cane Unchanged, Four Reversed Symbols	22	97	49
Conflict Compound Rabbit–Plum Unchanged, Four Reversed Symbols	18	18	49
Conflict Compound Grasses–Mule Unchanged, Four Reversed Symbols	27	44	31
Transfer Compound Scissors–Cane Unchanged, Four Novel Symbols	19	18	32
Transfer Compound Rabbit–Plum Unchanged, Four Novel Symbols	19	24	19
Transfer Compound Grasses–Mules Unchanged, Four Novel Symbols	19	30	24
Novel Compound	19	18	19
Novel Compound	26	41	49
Novel Compound	18	58	61

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