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Assessment of Attention to Complex Cues in Young Children: Manipulating Prior Reinforcement Histories of Stimulus Components

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Computer technology was employed to teach attentional skills to six young children. The procedure involved manipulating prior reinforcement histories of individual stimuli to examine whether this variable controlled the features of compound cues which young children attended to. Initially, three separate visual discriminations were conditioned. After criterion accuracy was achieved, stimuli were combined by keeping prior reinforcement contingencies unchanged for some elements and reversing them for remaining elements. Tests revealed when conflict-compound discriminations were acquired, children responded selectively to unchanged elements while not responding to reversed elements. Transfer effects were investigated by presenting compounds containing some or all novel cues. Variable test performance was observed following acquisition of compounds composed of novel cues. Consistent test performance occurred across children for compounds containing all pretrained cues. Separately training each stimulus component was the most reliable procedure for controlling the attention of young children. © 1987 Academic Press, Inc.

Discovering manipulations which determine how children attend to complex cues is an important area of research as it has significant educational applications. Attending to irrelevant aspects of instructional materials can prevent or postpone the acquisition of essential skills (Touchette, 1968; Zeaman & House, 1963). Skills may also fail to generalize across settings if children attend to irrelevant features of the educational task. Rincover and Koegel (1975) demonstrated this when they taught imitation and receptive speech skills to 10 autistic children. Four of the children did not display the newly taught skills in a transfer condition because only incidental cues (e.g., unrelated hand movements by the

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teacher) controlled their responding during original training. Other investigators have shown that errors can be minimized and generalization enhanced if educational procedures are employed which increase the student's likelihood of attending to relevant features of the training stimulus (Dowler, Walls, Haught, & Zawlocki, 1984; Guralnick, 1975; Halle, Marshall, & Spradlin, 1979; Meador, 1984; Schreibman, 1975; Wolfe & Cuvo, 1978). Letter recognition skills (Guralnick, 1975; Wolfe & Cuvo, 1978) and nonspeech communication skills (Meador, 1984) have been taught with fewer errors if techniques were used which either initially exaggerated or highlighted distinctive features of the target stimuli.

In addition, controlling which components of comopund cues are attended to has importance for errorless transfer of stimulus control. Investigators have found that in order for fading procedures to be successful, both the prompting and training cues must be simultaneously attended to before the stimulus prompt is completely removed (Doran & Holland, 1979; Fields, Bruno, & Keller, 1976). Doran and Holland (1979) discovered the importance of this prerequisite skill while attempting to teach errorless size discriminations to children. A luminance cue prompted the correct response. Over a series of trials, the stimulus prompt was gradually faded until only the size cues remained. Errorless transfer of stimulus control did not occur if children failed to attend to both the luminance and size cues during early or intermediate phases of fading. When both cues simultaneously controlled responding, the size discrimination was always learned without errors. Fields (1979, 1981) also found that training techniques which facilitated attention to training cues while stimulus prompts were present improved stimulus control transfer.

One manipulation that affects which components of stimulus compounds control responses is prior reinforcement contingencies associated with individual stimuli. We demonstrated by employing Ray's (1969) procedure that prior reinforcement histories paired with color and line orientation stimuli controlled the attention of severely retarded adults when these stimuli were combined (Huguenin & Touchette, 1980). If the prior reinforcement history was unchanged for one of the stimulus elements and reversed for the remaining stimulus, only the unchanged element exerted control in the compound. The mentally retarded adults usually did not respond to the reversed element. Tomiser, Hollis, and Monaco (1983) showed this variable to be a determinant of attention for training compounds composed of haptic cues. Furthermore, the acquisition of conditional discriminations requiring attention to multiple cues is also influenced by prior conditioning histories (Huguenin, 1985; Williams, 1982).

This investigation extended earlier findings to include an analysis of the effects of prior reinforcement contingencies of separate stimuli on attention to multielement compound displays in young children. Although attentional deficits interfere with the cognitive and social development of children (Allen & Fuqua, 1985; Bailey, 1981; Dunlap, Koegel, & Burke, 1981; Wilhelm & Lovaas, 1976; Smeets, Hoogeveen, Striefel, & Lancioni, 1985), environmental factors which influence how they attend to complex cues have not been thoroughly investigated. Whether prior reinforcement histories of individual stimulus components controls children's attention to compound cues, for example, was not previously determined. To address this issue, three separate visual discriminations were first conditioned utilizing computer technology. The stimuli were next combined. After criterion accuracy for compound discriminations was achieved, tests assessed whether the children selectively responded to component stimuli in accordance with their prior contingencies of reinforcement. If this occurred, it would also demonstrate that the degree of complexity of compound stimuli did not limit the generality of previous research (Huguenin & Touchette, 1980). Finally, transfer effects were examined. Additional tests wre administered to resolve if attentional patterns, established by manipulating prior reinforcement histories, persisted after original training compounds were altered. By introducing some or all novel cues in the compounds following training, generalization for each child was assessed. Investigators (Huguenin & Touchette, 1980; Ray, 1969; Tomiser et al., 1983) who discovered prior reinforcement contingencies controlled responding to complex cues did not determine if attentional skills generalized to untrained compounds. They did not specify the conditions under which stimulus control patterns were disrupted. The results of this or similar testing techniques may help to explain why children sometimes fail to generalize skills across settings. They could also serve to identify children with attentional deficits, providing critical information for their educational programming.

An additional purpose of this study was to develop computer technology for administering attentional tests and recording student performance without direct teacher involvement. Despite the fact that computer software currently exists for providing intelligence tests and teaching academic skills (Hassett, 1984; Lepper, 1985), software has not been devised for assessing visual perception in young children. Since stimulus materials can be presented in a standardized fashion and multiple response topographies precisely recorded, opportunities for assessment error are greatly reduced. When tests are given by teachers, even subtle differences in their performance can affect test outcome (e.g., Rincover & Koegel, 1975). Although identifying attentional deficits at a young age can be critical in preventing delays in intellectual development (Krupski, 1981), administering perceptual tests on a wide scale basis is not economically feasible. Utilizing computer technology which requires only minimal staff supervision would substantially decrease the cost of such assessment.

METHOD

Subjects and Setting

Six chilldren with no sensory or motor impairments participated in the study. Their chronological ages varied between 4 years 11 months and 6 years 11 months, and they were of normal intelligence. The age and sex of each of the children are shown in Table 2. Two subjects were children of acquaintances of the author. The remaining four children were recruited by placing ads in local newspapers. Their socioeconomic status was middle class. The study was performed in a laboratory room (150 square feet) at the University. Each child sat in a chair facing a computer display screen, and the experimenter sat beside the subject.

Apparatus

All experimental sessions were automated by a Hewlett Packard Model HP 9845C color vector graphics minicomputer with 250 KBytes of accessible RAM and 500 KBytes of ROM. A TSD Associates 12-in. touch screen digitizer (0.001-in. resolution, solid glass screen) was fitted to the CRT and interfaced via RS232C to the processor. A BCI, Inc., token/coin dispenser was interfaced to the computer via a 16-bit parallel interface.

Stimuli were presented and responses recorded by the desk-top computer. The stimuli appeared on the display screen, and the computer decoded the correct position for a given trial. The computer also kept a running account of the onset of trials, stimuli, the area on the display screen that the child touched during each trial, and response accuracy. This information was provided in a printout following each experimental session. A reinforcement dispenser, located to the left of the subject, operated after each correct response, and pennies dropped into a 9.6- by 14- by 9.6-cm receptacle at the base of the dispenser.

Experimental Design

A within-subject reversal design was used to reveal if prior reinforcement histories of individual stimuli controlled which features of compound training cues young children responded to. A reversal design also determined whether original treatment effects generalized to untrained conditions.

General Procedure

Sessions consisted of approximately 100 trials. A trial began when agricultural symbols (Dreyfuss, 1972), centered on two 8- by 4-cm white illuminated backgrounds, were presented on the computer screen. The trial ended when the subject touched either illuminated area. A 3-sec intertrial interval followed during which the computer screen was dark, and a full 3-sec period without touching the screen was required before

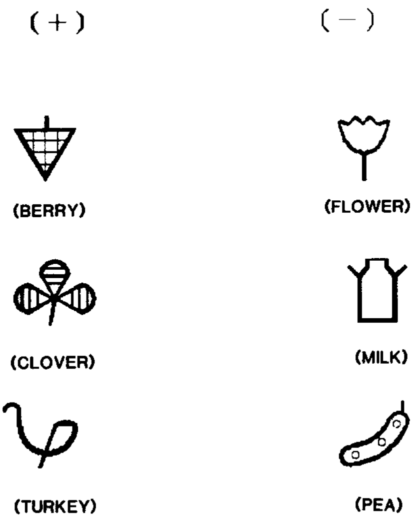

FIG. 1. Diagram of the three separate visual discriminations established prior to formation of the compound stimuli (pretrained). Plus (+) refers to symbols paired with reinforcement in original training and minus (−) indicates symbols paired with extinction.

the next trial began. During training sessions, correct choices resulted in the automatic delivery of pennies and verbal praise ("Good"). If an incorrect choice occurred, a penny was not delivered and the experimenter said "No." During test sessions, social feedback did not occur, and pennies were automatically dispensed regardless of which stimulus the child touched. At the end of each session, the children had the option to keep all of their accumulated pennies or to trade part of them for a favorite snack. The stimuli were administered in an unpredictable sequence with the restriction that no stimulus appeared more than twice in succession in the same location. Each symbol 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 child learned three separate visual discriminations. The S+ and S− stimuli were presented simultaneously and were composed of six different agricultural symbols (see Fig. 1). During single symbol training, two individual symbols appeared on the computer screen until criterion accuracy was met. Stimulus control in the first discrimination task was conditioned by consistently reinforcing the subjects whenever they touched berry on the computer screen and not reinforcing them if they touched flower. When 90% accuracy in a 10-trial sequence was demonstrated, clover and milk symbols appeared on the screen, and clover was the S+ symbol. After criterion accuracy was achieved for these stimuli, responses to turkey were consistently reinforced and responses to pea extinguished.

The three original symbol pairs were next delivered in an unpredictable mixed sequence. Each symbol pair occurred twice in a block of six trials, and no more than two S+ symbols remained twice in succession in the same location. This step continued until 90% accuracy was maintained for each of the three symbol pairs during a 30-trial sequence.

Conflict Compounds and Test Conditions

Following criterion accuracy for the intermixed symbol pairs, individual symbols were combined. Conflict compounds were created by keeping prior reinforcement contingencies unchanged for some symbols and reversing them for remaining symbols. One conflict compound presented to each of the six children was formed by maintaining prior reinforcement histories for only the clover and milk symbols. Prior reinforcement histories for the remaining two symbol pairs were reversed. Flower and pea were paired with reinforcement and berry and turkey with extinction in the compound which was the reverse of original training (Compound A in Fig. 2). Another conflict compound was formed by keeping prior reinforcement contingencies unchanged for two of the original symbol pairs (berry vs. flower and turkey vs. pea) and reversing them for the clover and milk symbols (Compound B in Fig. 2). The positions of individual elements within the conflict compounds remained constant across trials.

When each child achieved 90% accuracy for the "conflict" compound discriminations, 36 test trials were administered. During these test trials, the three original symbol pairs appeared alone for 12 trials each in a mixed sequence, and whichever symbol the child touched produced reinforcement. The purpose of the test was to determine which elements of the compound stimuli the children were attending to when criterion accuracy was achieved. This information was obtained by determining percentage of responses during the 36 symbol-pair test trials that was in agreement with the compound's reinforcement contingencies. The percentage agreement during reversed-element and unchanged-element test trials was calculated by taking the number of responses in agreement with the reinforcement contingency of the conflict compound, dividing it by the total number of trials, and then multiplying the quotient by 100. Elements associated with high percentage scores were concluded to exert control in the compound when the compound discrimination was acquired.

In addition, test results were corroborated by determining their correspondence with symbols consistently touched in the conflict compounds. A touch screen digitizer attached to the computer screen recorded precisely where the child was touching each time conflict compounds were presented. These data were provided in computer printouts following completion of each compound session.

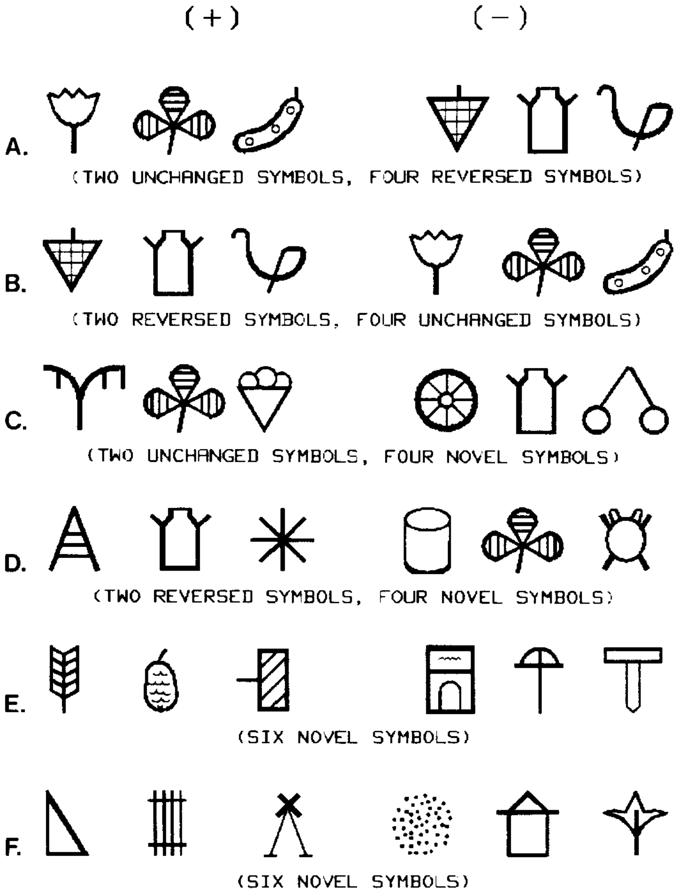

FIG. 2. Diagram of the compound discriminations acquired by the six subjects. Plus (+) denotes stimulus compounds paired with reinforcement and minus (−) denotes stimulus compounds paired with extinction. The S+ and S− compounds were presented simultaneously and were each composed of three agricultural symbols. The positions of the symbols within the compounds are shown in the diagram and remained constant across trials. The number of unchanged symbols, reversed symbols, and novel symbols in each compound discrimination are indicated.

Transfer Compounds and Test Conditions

If tests revealed the children selectively attended to unchanged symbols and did not attend to reversed symbols of the conflict compounds in accordance with past findings (Huguenin & Touchette, 1980; Ray, 1969), transfer compounds were administered. In one transfer task, the compound stimuli consisted of an unchanged symbol pair appearing simultaneously with four novel agricultural symbols (Compound C in Fig. 2). Following criterion accuracy, another test session took place. During the 36-trial test, the unchanged symbol pair and two novel symbol pairs (one S+ symbol and one S− symbol occupying the same positions in the compound stimuli) were presented for 12 trials each in a mixed sequence. These test trials assessed whether only the unchanged symbols of the transfer compound continued to control the children's responding in accordance with the compound's contingencies after reversed symbols were removed and novel symbols introduced. This transfer task was administered after the children had learned to respond to only unchanged symbols in the training compound to determine whether or not the introduction of novel cues disrupted their selective attention. Generalization of selective attention was assessed for each child in this transfer condition.

In a second transfer task, compound stimuli were composed of a reversed symbol pair and four novel symbols (Compound D in Fig. 2). Following criterion accuracy, 36 test trials assessed if only the reversed symbols of the transfer compound failed to control responding in agreement with the reinforcement contingencies of the compound after unchanged symbols were withdrawn and novel symbols substituted. The second transfer task was given after the children had learned to selectively ignore reversed symbols in the training compound to resolve whether or not the introduction of novel cues would disrupt this attentional pattern. Generalization of selective ignoring was assessed for each child in this transfer condition.

Novel Compounds and Test Conditions

As a control procedure, two compound discrimination tasks containing all novel agricultural symbols were also provided (Compounds E and F in Fig. 2). When criterion accuracy was met, three symbol pairs (one S+ symbol and one S− symbol occupying the same positions in the compounds) were each presented for 12 trials to examine attentional patterns for compounds containing all novel symbols. Table 1 indicates the sequence of stimuli and procedures administered to the six children. The number of trials to acquisition for each subject in the different experimental procedures is included in the Appendix.

RESULTS

Conflict Compound: Two Unchanged Symbols and Four Reversed Symbols

Figure 3 illustrates the percentage agreement of responses during stimulus–element test trials with the reinforcement contingencies of the conflict compound containing two unchanged symbols and four reversed symbols (Compound A in Fig. 2). These test results were interpreted as follows. If high percent agreement scores were obtained during unchanged-symbol test trials and not during reversed-symbol test trials, this indicated that the children selectively attended to only unchanged elements in the conflict

TABLE 1
SEQUENCE OF STIMULI AND PROCEDURES

Subjects 1–3	Subjects 4–6
Single symbol training	Single symbol training
Conflict compound	Conflict compound
Clover–Milk unchanged	Clover–Milk reversed
Four reversed symbols	Four unchanged symbols
Test trials	Test trials
Transfer compound	Transfer compound
Clover–Milk unchanged	Clover–Milk reversed
Four novel symbols	Four novel symbols
Test trials	Test trials
Novel compound	Novel compound
Six novel symbols	Six novel symbols
Test trials	Test trials
Single symbol training	Single symbol training
Conflict compound	Conflict compound
Clover–Milk reversed	Clover–Milk unchanged
Four unchanged symbols	Four reversed symbols
Test trials	Test trials
Transfer compound	Transfer compound
Clover–Milk reversed	Clover–Milk unchanged
Four novel symbols	Four novel symbols
Test trials	Test trials
Novel compound	Novel compound
Six novel symbols	Six novel symbols
Test trials	Test trials

compound. Agreement levels near 50% during reversed-symbol test trials signified a loss of stimulus control following compound discrimination training. Zero percent agreement with the conflict compound's contingencies during reversed-symbol test trials indicated the original discrimination was retained despite its reversal in the compound. On the other hand, if high percent agreement scores were obtained for both the reversed and unchanged elements, selective attention to unchanged symbols was not inferred.

When criterion accuracy was reached for the conflict-compound discrimination containing two unchanged symbols and four reversed symbols, attention to only the unchanged elements of the training compounds occurred. Only the unchanged clover vs. milk symbols controlled responding in accordance with the reinforcement contingencies of the compound stimuli (Fig. 3). Percentage agreement for this symbol pair, whose prior reinforcement history was maintained in the S+ and S− compounds, was at 100% for each of the six children. During test trials for the reversed symbols, however, percentage agreement with the compound's contingencies was consistently at 0% levels which revealed the conflict compound

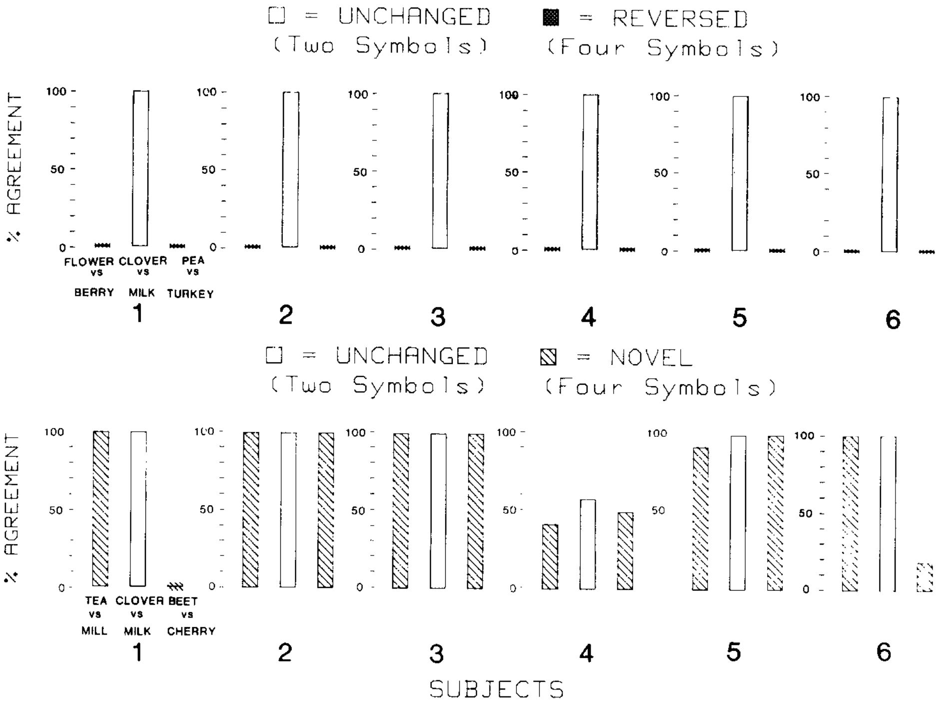

FIG. 3. Percentage agreement of responses during stimulus–element test trials with the reinforcement contingencies of the compound stimuli (Compounds A and C in Fig. 2). During the test, three symbol pairs (one S+ symbol and one S− symbol occupying the same positions in the stimulus compounds) were presented simultaneously for 12 trials each in a mixed sequence. White bars, black bars, and slashed bars indicate unchanged symbols, reversed symbols, and novel symbols, respectively. The top symbols denoted for Subject 1 were positive and the bottom symbols were negative in the compound discriminations.

did not disrupt the original discriminations. Prior reinforcement histories were reversed for berry vs. flower and turkey vs. pea, and neither of these symbol pairs were responsible for providing criterion accuracy when the compound discrimination was learned. In each case, the children did not respond to the reversed symbols in the compound and attended exclusively to the unchanged symbols. These test results were confirmed by response topographies recorded when the conflict compound was presented as shown in Table 2. When criterion accuracy was achieved for the compound dscrimination, each of the children on the majority of reinforced trials selectively touched only unchanged symbols in the compound display. They did not touch reversed symbols on most trials.

TABLE 2
RESPONSE TOPOGRAPHIES FOR CONFLICT COMPOUND COMPOSED OF TWO UNCHANGED SYMBOLS AND FOUR REVERSED SYMBOLS

Subject	Percentage chosen during reinforced trials when compound criterion accuracy was achieved: Unchanged symbols	Reversed symbols
1 Male, 4 years 11 months	89	11
2 Male, 6 years 0 months	100	0
3 Male, 5 years 0 months	94	6
4 Female, 6 years 0 months	94	6
5 Male, 6 years 11 months	94	6
6 Male, 6 years, 7 months	100	0

Transfer Compound: Two Unchanged Symbols and Four Novel Symbols

Selective attention to unchanged clover and milk symbols was not revealed in tests following compound training in which the reversed symbols were removed (Compound C in Fig. 2). After novel symbols appeared in the S+ and S− compounds, two or three stimulus components exhibited control in agreement with the compound's reinforcement contingencies for the majority of children (Fig. 3). Although the pretrained symbol pair whose prior reinforcement history was maintained in the compound continued to produce high percent agreement scores for five of the six children, novel components also exercised control. Subjects 2, 3, and 5 achieved greater than 90% agreement with the reinforcement contingencies of the compound stimuli throughout the novel symbol test trials. For Subjects 1 and 6, only half of the novel symbol pairs were associated with high agreement scores in the test. Subject 4, in contrast to the other children, did not demonstrate control by any of the individual stimulus components.

Separately training stimulus components and keeping their prior reinforcement contingencies unchanged in the compound did not produce selective control by these stimuli if some components were novel. The presence of reversed components was a prerequisite for selective attention to unchanged stimuli. Finally, in opposition to uniform test results following acquisition of a compound discrimination containing unchanged and reversed components, variable test performance occurred after novel symbols appeared in the training compound.

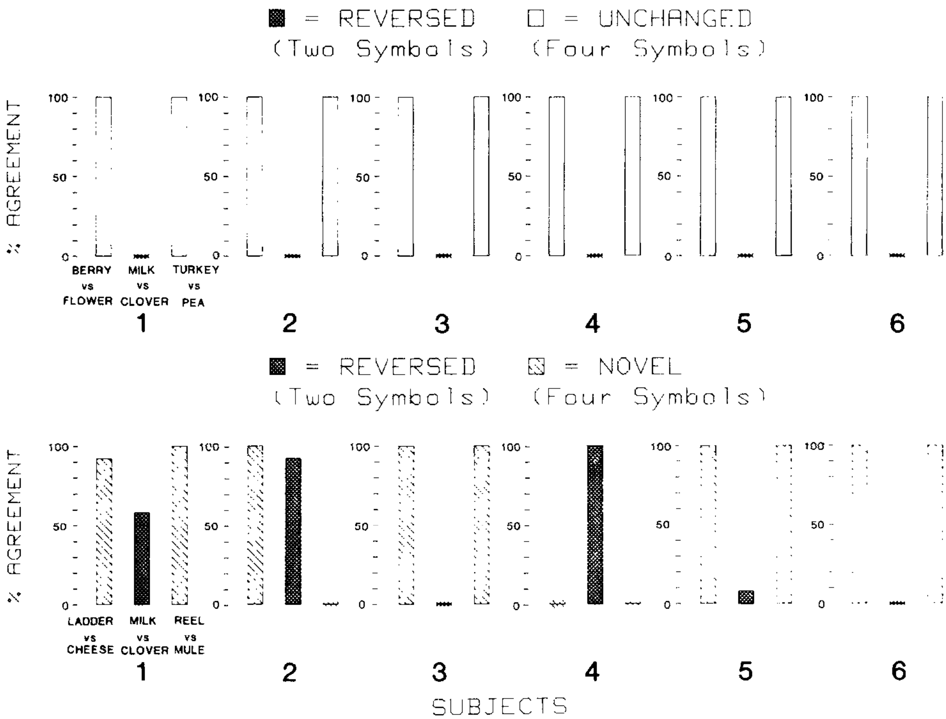

FIG. 4. Percentage agreement of responses during stimulus–element test trials with the reinforcement contingencies of the compound stimuli (Compounds B and D in Fig. 2). During the test, three symbol pairs (one S+ symbol and one S− symbol occupying the same positions in the stimulus compounds) were presented simultaneously for 12 trials each in a mixed sequence. White bars, black bars, and slashed bars indicate unchanged symbols, reversed symbols, and novel symbols, respectively. The top symbols denoted for Subject 1 were positive and the bottom symbols were negative in the compound discriminations.

Conflict Compound: Two Reversed Symbols and Four Unchanged Symbols

If prior reinforcement contingencies were unchanged for four symbols and reversed for two symbols (Compound B in Fig. 2), tests again demonstrated only unchanged symbols controlled responding in the training compound. Each of the six children achieved 100% agreement during unchanged symbol test trials. Zero percent agreement always occurred during reversed clover vs. milk test trials which demonstrated that original stimulus control was preserved for these symbols despite a reversal of their prior contingencies in the compound (Fig. 4). The tests indicated that when this conflict compound discrimination was acquired, the subjects attended to unchanged elements and did not attend to reversed elements. Response topographies recorded during presentations of the conflict com-

TABLE 3
RESPONSE TOPOGRAPHIES FOR CONFLICT COMPOUND COMPOSED OF FOUR UNCHANGED SYMBOLS AND TWO REVERSED SYMBOLS

	Percentage chosen during reinforced trials when compound criterion accuracy was achieved	
Subject	Unchanged symbols	Reversed symbols
1	100	0
2	100	0
3	6	94
4	94	6
5[a]	100	0
6	89	11

[a] Percentages for Subject 5 were calculated from fewer reinforced trials as compared to the other subjects due to recording malfunction.

pound supported these test results as shown in Table 3. With the exception of Subject 3, the children selectively touched only unchanged symbols in the training compound on most reinforced trials when criterion accuracy was achieved.

Whether the children selectively attended to clover vs. milk symbols or selectively ignored them depended on previous conditioning histories. If the prior reinforcement history of this symbol pair was maintained while simultaneously reversed for remaining symbol pairs, clover vs. milk exclusively controlled responding in the compound discrimination. Conversely, if the prior reinforcement history was reversed for this symbol pair, while simultaneously maintained for other symbol pairs, the children's responding was not controlled by clover vs. milk in the S+ and S− compounds.

Transfer Compound: Two Reversed Symbols and Four Novel Symbols

The majority of children continued to selectively not respond to the reversed symbol pair when it appeared in a novel compound (Compound D in Fig. 2). After unchanged components were withdrawn and novel symbols introduced, four of the six children achieved low percent agreement scores for only reversed symbols during the subsequent test (Fig. 4). The reversed symbols continued to produce zero or near zero agreement with the compound's reinforcement contingencies for Subjects 3, 5, and 6. In contrast, these children achieved high agreement scores for both novel symbol pairs. While Subject 1 selectively did not respond to reversed symbols when he learned the transfer compound task, original stimulus control was disrupted after novel symbols appeared as revealed by near chance agreement for the reversed symbols.

Subjects 2 and 4, in opposition to the other children, did not selectively ignore reversed symbols after novel symbols were introduced in the compound discrimination. Both children achieved greater than 90% agreement with the compound's contingencies during reversed-symbol test trials. Reversing prior reinforcement histories of individual symbols resulted in a new stimulus control topography for these children when unchanged symbols were removed. Subjects 2 and 4 differed, however, in their response to the novel components.

The presence of unchanged components was not a requirement for selective ignoring of reversed components to occur. Reversing prior reinforcement histories of some symbols was sufficient for preventing most children from responding to these features when they learned the compound discrimination, although remaining components were novel. Greater variability in test performance was also noted following acquisition of partially pretrained compounds. Four different patterns of responding occurred. Identical test performance was observed, in contrast, if each component was separately trained and some prior reinforcement histories remained unchanged while reversed for other components in the compound.

Novel Compounds

When compounds composed of all novel symbols were given to the six children (Compounds E and F in Fig. 2), variable test performance occurred both within and across children. Only Subjects 3 and 5 responded uniformly to each compound discrimination where none of the symbols had been previously trained (Fig. 5). These children attended to all of the individual components when criterion accuracy was achieved. The remaining four children responded inconsistently to the novel compound tasks (Fig. 5). Subjects 1 and 2 attended to each individual component in one of the novel compound discriminations. Only two components controlled their responding in agreement with the compound's contingencies when the second novel discrimination was learned. Subject 6 also attended to each separate symbol in one novel compound task but selectively attended to only the middle symbols in the second compound task. Subject 4 achieved high agreement scores for two components of one novel compound. After the second compound discrimination was acquired, none of the individual symbols controlled her responding.

DISCUSSION

Manipulating prior reinforcement histories of separate components effectively controlled how young children attended to complex training cues. The children always selectively responded to stimulus components whose prior reinforcement history was unchanged in training compounds while simultaneously not responding to stimulus components with reversed prior reinforcement histories. These results confirm earlier investigations

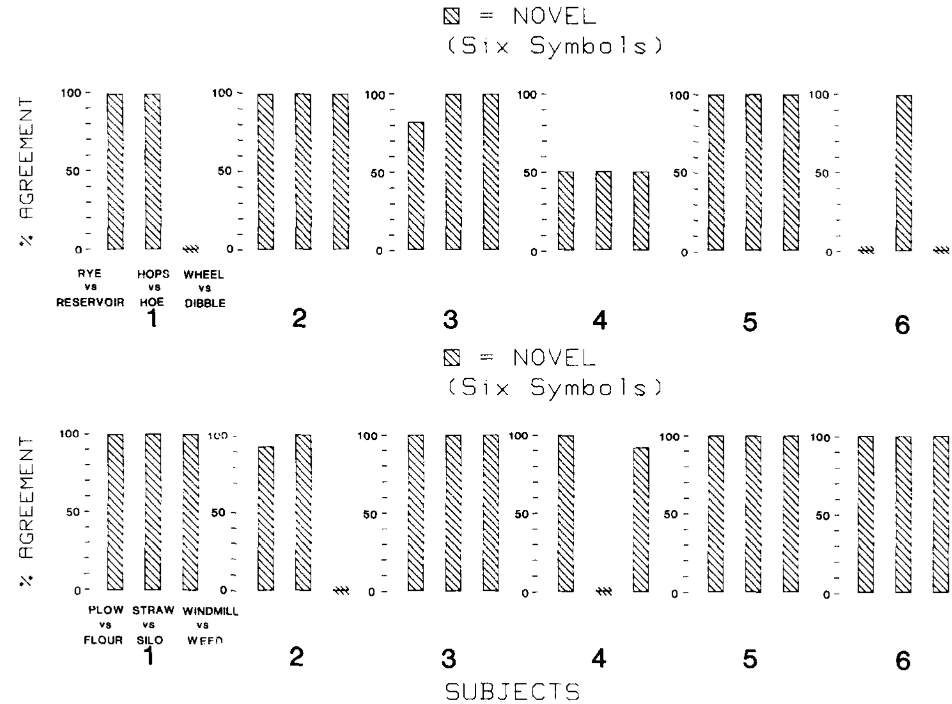

FIG. 5. Percentage agreement of responses during stimulus–element test trials with the reinforcement contingencies of the compound stimuli (Compounds E and F in Fig. 2). During the test, three symbol pairs (one S+ symbol and one S− symbol occupying the same positions in the stimulus compounds) were presented simultaneously for 12 trials each in a mixed sequence. Slashed bars indicate all of the symbols in the stimulus compounds were novel. The top symbols denoted for Subject 1 were positive and the bottom symbols were negative in the compound discriminations.

and extend the effects of this manipulation to young children. Past studies revealed prior reinforcement contingencies determined how developmentally disabled adults (Huguenin & Touchette, 1980) and developmentally disabled adolescents (Tomiser et al., 1983) attended to compound cues. In the present study, normal children participated and prior conditioning histories specified which stimulus features controlled their responding. Previous reinforcement histories were also a determining factor of the attention of children when stimulus elements were not superimposed upon each other in the compounds as was true in earlier investigations (Huguenin & Touchette, 1980; Ray, 1969; Tomiser et al., 1983). One limitation in the data reported is the number of probe stimuli employed to assess stimulus control. Stimulus components occupying the same positions in S+ and S− compounds were presented simultaneously during testing. A more thorough assessment technique would have utilized all possible combinations of S+ and S− elements. This procedure was not chosen, however, because of changes in subject performance which can occur with prolonged testing (e.g., Schreibman, Koegel, & Craig, 1977). In addition, previous pilot research demonstrated that conclusions based on test results from stimuli occupying the same spatial locations were corroborated when all possible combinations of S+ and S− stimuli were administered.

Multiple stimulus control tests administered by computer technology confirmed the reliable effect of the experimental manipulation for each child. In one assessment procedure, unchanged and reversed symbols were presented individually following acquisition of conflict compounds. Only symbols with unchanged prior reinforcement histories controlled responding in agreement with the conflict compound's contingencies indicating selective attention to these symbols in the compound. When response topographies were analyzed, this interpretation was confirmed. With one exception, the children touched unchanged symbols and did not touch reversed symbols in conflict compounds on most reinforced trials when criterion accuracy was achieved. Confirmation across different stimulus control tests substantiates the robustness of the effect of prior training histories in controlling which stimulus features children attend to. It indicates the test results were not contaminated by testing variables which could not be discounted if only one stimulus control assessment was provided. Past studies have shown the importance of multiple tests in accurately assessing stimulus control (Fields, 1985; Huguenin & Touchette, 1980; Newman & Benefield, 1968; Wilkie & Masson, 1976). More than one procedure is seldom employed, however, when assessing attention in children because of equipment and recording limitations. Microcomputers may prove to be practical devices for obtaining valid perceptual data.

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 if alternative controlling relations were concurrently reinforced. This was a representative finding for each of the children. In contrast, we discovered for severely retarded adults of comparable mental age, reversing prior contingencies sometimes disrupted controlling relations associated with extinction (Huguenin & Touchette, 1980). Loss of stimulus control or a reversal of original discriminations were observed. Discrepant performance has been reported in other stimulus control investigations of developmentally disabled students (e.g., Bailey, 1981; Tomiser et al., 1983). Presenting compounds whose components have conflicting prior reinforcement histories may prove to be an effective diagnostic technique for identifying neurologically impaired children with attentional deficits.

Selective attention to unchanged symbols was not maintained for any of the six children if reversed symbols were removed and novel symbols substituted. Presenting symbols with reversed prior contingencies was necessary for only unchanged components to control their behavior. Simply pretraining some individual stimuli and maintaining their contingencies in the compound failed to produce selective attention to unchanged elements. Novel components also acquired control. This finding disagrees with some animal studies where pretraining individual components prevented novel features of training compounds from acquiring stimulus control (Fields, 1978; Fields et al., 1976; Johnson, 1970; Johnson & Cumming, 1968; Mackintosh, 1965; Miles, 1970; Schusterman, 1967; vom Saal & Jenkins, 1970). Although partial pretaining sometimes determined what portions of complex cues lower organisms responded to, manipulating prior reinforcement histories of each component was a prerequisite for controlling the attention of young children. Total pretraining can ensure children attend to relevant features of educational tasks and, thus, facilitates skill acquisition.

In contrast to a lack of transfer of selective attention to unchanged stimuli in novel compounds, selective ignoring of reversed symbols did generalize for most children. When unchanged symbols were removed and novel symbols were substituted, four children persisted in selectively not responding to the reversed symbol pair following acquisition of the transfer compound task. Many studies have reported that teaching students to attend to critical features of educational stimuli reduces errors (e.g., Dixon, 1981; Dowler et al., 1984; Wolfe & Cuvo, 1978), and the effects of this training often generalizes (Guralnick, 1975; Halle et al., 1979; Meador, 1984; Welch & Pear, 1980). Few studies have examined the transfer effects of teaching children not to respond to designated stimulus components. My results indicate such an approach may have educational applications, since selective ignoring of target stimuli did continue to occur for most children in transfer conditions. Instructing children as to which stimulus features to avoid may be effective in preventing them from coming under the control of irrelevant features of educational materials that follow.

Even though most children did not respond to reversed symbols when they learned a transfer compound discrimination, the stimulus–response relation paired with a reversal of its prior contingencies was disrupted in some cases. Two children reversed the original discrimination, whereas chance responding was displayed by a third child during reversed-symbol test trials. When alternative stimulus–response relations were available with unchanged reinforcement histories, reversing the prior contingencies of a controlling relation decreased its frequency without producing any alteration. Each child always displayed the original discrimination during reversed-symbol test trials that followed compound training. Availability of alternative responses determines the influence of extinction on simple operants (Holz, Azrin, & Ayllon, 1963; Leitenberg, Rawson, & Mulick, 1975; Mulick, Leitenberg, & Rawson, 1976; Rawson & Leitenberg, 1973). Although effects of extinction on controlling stimulus–response relations have been examined using different paradigms (Cohen, 1969; Nevin, 1967; Powell, 1973; Ray, 1969; Stoddard & Sidman, 1971; Terrace, 1966; Wilkie, 1973), this investigation suggests availability of alternative relations is an important variable in children.

The consistency in how children attended to complex cues was affected by the amount of stimulus pretraining. If each component was previously conditioned and prior contingencies either reversed or unchanged, all children responded to the same stimulus features in the compound. If compounds were presented containing some novel components, variable test performance was noted. These results support earlier findings where total pretraining also generated the same attentional pattern to compound stimuli across subjects which did not occur when only partial pretraining was provided (Huguenin, 1985). In addition, children did not attend consistently to compounds composed of all novel components. Other investigators have reported that nondisabled children often attend to each component of compounds containing all untrained cues (Bailey, 1981; Koegel & Wilhelm, 1973; Lovaas & Schreibman, 1971; Wilhelm & Lovaas, 1976). Although some of the children in this study responded in this fashion, it was not observed in every instance. Instead, variability within subjects occurred, as the majority of children produced differing test results when the novel compound condition was repeated. It is difficult to predict how young children will attend to complex displays if some or all of the stimulus components are not previously conditioned. Pretraining each individual component of compound training cues is the most reliable procedure for controlling the attention of young children.

APPENDIX

Number of Trials to Acquisition for Each Subject in the Different Experimental Procedures

	Subjects					
	1	2	3	4	5	6
Single symbol training	30	30	30	30	30	30
Single symbol training	30	30	30	30	30	30
Conflict compound Clover–Milk unchanged Four reversed symbols	20	20	20	20	20	20
Conflict compound Clover–Milk reversed Four unchanged symbols	26	20	20	69	24	20

APPENDIX—Continued

	Subjects					
	1	2	3	4	5	6
Transfer compound Clover–Milk unchanged Four novel symbols	20	20	20	20	20	20
Transfer compound Clover–Milk reversed Four novel symbols	35	25	20	55	20	20
Novel compound Six novel symbols	20	20	23	20	20	20
Novel compound Six novel symbols	23	20	20	20	20	20

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. *Journal of Experimental Child Psychology*, **39**, 55–71.

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

Cohen, L. R. (1969). Generalization during acquisition, extinction, and transfer of matching with an adjustable comparison. *Journal of the Experimental Analysis of Behavior*, **12**, 463–474.

Dixon, L. S. (1981). A functional analysis of photo–object matching skills of severely retarded adolescents. *Journal of Applied Behavior Analysis*, **14**, 465–478.

Doran, J., & Holland, J. G. (1979). Control of stimulus features during fading. *Journal of the Experimental Analysis of Behavior*, **31**, 177–187.

Dowler, D. L., Walls, R. T., Haught, P. A., & Zawlocki, R. J. (1984). Effects of preference, prompt, and task agreement on the discrimination learning of mentally retarded adults. *American Journal of Mental Deficiency*, **88**, 428–434.

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

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

Fields, L. (1978). Fading and errorless transfer in successive discriminations. *Journal of the Experimental Analysis of Behavior*, **30**, 123–128.

Fields, L. (1979). Acquisition of stimulus control while introducing new stimuli in fading. *Journal of the Experimental Analysis of Behavior*, **32**, 121–127.

Fields, L. (1981). Early and late introduction or probes and stimulus control acquisition in fading. *Journal of the Experimental Analysis of Behavior*, **36**, 363–370.

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

Fields, L., Bruno, V., & Keller, K. (1976). The stages of acquisition in stimulus fading. *Journal of the Experimental Analysis of Behavior*, **26**, 295–300.

Guralnick, M. J. (1975). Effects of distinctive-feature training and instructional technique on letter and form discrimination. *Americqan Journal of Mental Deficiency*, **80**, 202–207.

Halle, J. W., Marshall, A. M., & Spradlin, J. E. (1979). Time delay: A technique to increase language use and facilitate generalization in retarded children. *Journal of Applied Behavior Analysis*, **12**, 431–439.

Hassett, J. (1984). Computers in the classroom. *Psychology Today*, **18**, 22–28.

Holz, W. C., Azrin, N. H., & Ayllon, T. (1963). Elimination of behavior of mental patients by response produced extinction. *Journal of the Experimental Analysis of Behavior*, **6**, 407–412.

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

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

Johnson, D. F. (1970). Determiners of selective stimulus control in the pigeon. *Journal of Comparative and Physiological Psychology*, **70**, 298–307.

Johnson, D. F., & Cumming, W. (1968). Some determiners of attention. *Journal of the Experimental Analysis of Behavior*, **11**, 157–166.

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

Krupski, A. (1981). An interactional approach to the study of attention problems in children with learning handicaps. *Exceptional Education Quarterly*, **2**, 1–11.

Leitenberg, H., Rawson, R. A., & Mulick, J. A. (1975). Extinction and reinforcement of alternative behavior. *Journal of Comparative and Physiological Psychology*, **88**, 640–652.

Lepper, M. R. (1985). Microcomputers in education: Motivational and social issues. *American Psychologist*, **40**, 1–18.

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

Mackintosh, N. J. (1965). The effect of attention on the slope of generalization gradients. *British Journal of Psychology*, **56**, 87–93.

Meador, D. M. (1984). Effects of color on visual discrimination of geometric symbols by severely and profoundly mentally retarded individuals. *American Journal of Mental Deficiency*, **89**, 275–286.

Miles, C. G. (1970). Blocking the acquisition of control by an auditory stimulus with pretraining on brightness. *Psychonomic Science*, **19**, 133–134.

Mulick, J. A., Leitenberg, H., & Rawson, R. A. (1976). Alternative response training, differential reinforcement of other behavior, and extinction in squirrel monkeys. *Journal of Experimental Analysis of Behavior*, **25**, 311–320.

Nevin, J. A. (1967). Effects of reinforcement scheduling on simultaneous discrimination performance. *Journal of the Experimental Analysis of Behavior*, **10**, 251–260.

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

Powell, R. W. (1973). Effects of stimulus control and deprivation upon discriminative responding. *Journal of the Experimental Analysis of Behavior*, **19**, 351–360.

Ray, B. A. (1969). Selective attention: The effects of combining stimuli which control incompatible behavior. *Journal of the Experimental Analysis of Behavior*, **12**, 539–550.

Rawson, R. A., & Leitenberg, H. (1973). Reinforced alternative behavior during punishment and extinction with rats. *Journal of Comparative and Physiological Psychology*, **85**, 593–600.

Rincover, A., & Koegel, R. L. (1975). Setting generality and stimulus control in autistic children. *Journal of Applied Behavior Analysis*, **8**, 235–246.

Schreibman, L. (1975). Effects of within-stimulus and extra-stimulus prompting on discrimination learning in autistic children. *Journal of Applied Behavior Analysis*, **8**, 91–112.

Schreibman, L., Koegel, R. L., & Craig, M. S. (1977). Reducing stimulus overselectivity in autistic children. *Journal of Abnormal Child Psychology*, **5**, 425–436.

Schusterman, R. J. (1967). Attention shift and errorless reversal learning by the California sea lion. *Science*, **156**, 833–835.

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

Stoddard, L. T., & Sidman, M. (1971). The removal and restoration of stimulus control. *Journal of the Experimental Analysis of Behavior*, **16**, 143–154.

Terrace, H. S. (1966). Stimulus control. In W. K., Honig (Ed.), *Operant behavior: Areas of research and application* (pp. 271–344). New York: Appleton–Century.

Tomiser, J. M., Hollis, V. H., & Monaco, G. E. (1983). Haptic attention and visual transfer by mentally retarded and nonretarded individuals. *American Journal of Mental Deficiency*, **87**, 448–455.

Touchette, P. E. (1968). The effects of graduated stimulus change on the acquisition of a simple discrimination in severely retarded boys. *Journal of the Experimental Analysis of Behavior*, **11**, 39–48.

vom Saal, W., & Jenkins, H. M. (1970). Blocking the development of stimulus control. *Learning and Motivation*, **1**, 52–64.

Welch, S. J., & Pear, J. J. (1980). Generalization of naming responses to objects in the natural environment as a function of training stimulus modality with retarded children. *Journal of Applied Behavior Analysis*, **13**, 629–643.

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

Wilkie, D. M. (1973). Attention and "visual field dependency" in the pigeon. *Journal of the Experimental Analysis of Behavior*, **20**, 7–15.

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

Williams, B. A. (1982). On the failure and facilitation of conditional discrimination. *Journal of the Experimental Analysis of Behavior*, **38**, 265–280.

Wolfe, V. F., & Cuvo, A. J. (1978). Effects of within-stimulus and extra-stimulus prompting on letter discrimination by mentally retarded persons. *American Journal of Mental Deficiency*, **83**, 297–303.

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.

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