# AN INVESTIGATION OF FACTORS CONTRIBUTING TO THE "OVERSELECTIVE" RESPONDING OF MENTALLY RETARDED CHILDREN



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by

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Abstract

Previous research has suggested that normal, mentally retarded, and autistic children with Mental Ages (MAs) of less than 5 or 6 years are more restricted in the number of components they learn when presented with a relevant redundant cue (RRC) discrimination problem than are older MA children. There has been a tendency to attribute the poor performance of the young MA children to limited breadth of attention. However, this assumes that young, as well as old MA children learn the RRC discriminations by attending to the individual cues which form the stimuli. This may not be the case.

In addition to component learning, two alternative learning processes were investigated. In compound learning, the child is assumed to learn the $S^+$ in the RRC task as a unit, i.e. the components are not learned separately. In configurational learning, the child learns a directional response based on the arrangement or configuration of both the stimuli. It has been reported that young MA children are more likely to employ compound and configurational responding than older MA children. It was, therefore, hypothesized that the stimulus overselectivity exhibited by young MA children does not arise from limited breadth of attention, but rather that it results from a type of

learning which does not focus on the individual components which form the stimuli.

In Experiment 1, young MA (mean of 49.2 months) and old MA (78.0 months) mentally retarded boys were trained on a task which could be learned using compounds, configurations, or components. It was found that the younger MA boys made significantly fewer component responses than did the older MA boys. Furthermore, the younger MA boys made significantly more configurational responses to colour than to form or junk stimuli.

In Experiment 2, young (48.6 months) and old (83.8 months) MA mentally retarded boys were presented with a series of successive or simultaneous discriminations. The stimuli were colour-form compounds. For the configurational learner, the successive and simultaneous discriminations should be of equal difficulty to learn, while for the component or compound learner, the successive discrimination should be more difficult. It was found that the young MA retarded boys found the two problems to be equally difficult, as indicated by trials and errors to criterion. In contrast, the older boys found the successive problem more difficult than the simultaneous problem. An examination of the component learning indicated that only the older MA boys in the simultaneous condition exhibited any appreciable amount of component learning. The other groups performed slightly above chance when tested on components.

The results of both experiments suggest that the poor component learning exhibited by young MA children in RRC tasks probably results from these children attending to configurations rather than to components.

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## Introduction

Perhaps the most significant way in which the mentally retarded person differs from the non-retarded person is the difficulty the former encounters when attempting to learn. The retarded person is usually slower at learning discrimination tasks than are non-retarded children, even when matched for MA (e.g. Girardeau, 1959; House and Zeaman, 1958; and Stevenson and Iscoe, 1955).

The ability to discriminate is an important prerequisite to most forms of formal and informal learning. One must be able to discriminate faces or other bodily features to identify and recognize people, to differentiate between shirts and pants to dress oneself, and to discriminate letters to read and words to communicate.

The present paper has as its focus an investigation of the learning of discriminations by mentally retarded children when presented with stimuli which vary on a number of relevant but redundant dimensions.

### Stimulus Overselectivity

O.I. Lovaas and various associates have, over the past decade, built up a literature on a characteristic of discrimination learning which they have termed stimulus overselectivity (Lovaas, Schreibman, Koegel, and Rehm, 1971). Stimulus overselectivity, which Lovaas et al. (1971) compare with selective attention, is often exhibited following discrimination training in which the stimuli to be discriminated are composed of a complex of cues varying on a number of different dimensions. Following the initial training, these dimensions or cues are presented individually, to determine which exert control over the subject's responding. Typically, results have shown that normal children are able to respond to all of the cues when these are presented separately, while autistic and other low functioning children tend to respond to only a limited number of cues, i.e. they are overselective in their responding.

In the Lovaas et al. (1971) study, autistic, mentally retarded, and normal children were trained to bar press for a reward when presented with a stimulus complex consisting of visual, auditory, tactile, and temporal components. Subjects were to withhold responding in the absence of the stimuli. Following training, each of the four components were presented to the subjects separately to determine which of the components would exert control over the child's responding. Their findings showed that on the initial test trials, the normal children responded uniformly to three of the components, while the autistic children responded primarily to only one of the components. The third group, consisting of the mentally retarded children, performed between these two extremes. (None of the children in any of the groups responded to the temporal component.)

Lovaas and Schreibman (1971) in a partial replication of the Lovaas et al. (1971) study demonstrated that autistic children responded primarily to only one component of the stimulus complex (composed of an auditory and a visual component) when these components were presented individually. Normal children were found to respond to both of the individual components.

In both the Lovaas et al. (1971) and Lovaas and Schreibman (1971) studies, no evidence was found for a modality or cue preference which might account for the poorer performance of the autistic (and mentally retarded) children. In addition, following the testing procedure, Lovaas et al. (1971), and Lovaas and Schreibman (1971) found that it was possible to train their overselective children to respond to their previously non-functional modalities, when this training was done for each modality separately. This, therefore, precludes the possibility of sensory limitations or defects creating the effects.

In addition to these findings of overselectivity with between-modality components, overselectivity has also been found within modalities. Koegel and Wilhelm (1973) presented normal and autistic children with a visual simultaneous discrimination task. Subjects were presented with two cards, each of which contained two pictures, and were trained to respond to one of the cards. The pictures were of common objects, such as a horse, girl, bicycle, and tree. As a variation on this task, some subjects were presented with stimuli composed of two solid-red, spatially-separated geometric forms. In the test phase, the subjects were presented with pairs of cards which featured only one of the original cues which made up the $S^+$ and $S^-$. The results indicated that 12 of the 15 autistic children responded at above chance level to only one of the two positive components, while only three of the fifteen normal children exhibited such overselectivity.

Reynolds, Newsom and Lovaas (1974), utilizing auditory stimuli and a successive discrimination procedure, found autistic children to show overselectivity in this modality as well.

Until 1976, Lovaas and his various co-investigators looked at stimulus overselectivity primarily as it related to the autistic child. Indeed, to a certain extent, there was a tendency to consider overselectivity to be a feature of autism, a feature which could explain many of the social, language, behavioral, and learning deficiencies of the autistic child (e.g. Lovaas et al.,1971, Reynolds et al., 1974; Rincover and Koegel, 1975; Schreibman and Lovaas, 1973). It should be recalled, however, that in the Lovaas et al. (1971) study, there was also a mentally retarded group of children who exhibited stimulus overselectivity, although not as severe as that found in the autistic group.

In 1976, the overselective responding of mentally retarded children was once again investigated (Wilhelm & Lovaas). Normal, moderately retarded, and severely retarded children were trained to discriminate between two cards, each of which contained three different pictures. Following training, the children were presented with individual pictures from both the cards to determine how many of the three original cues had gained control over the child's responding. A mean of 3.0, 2.1, and 1.6 of the cues were learned by the normal, moderately retarded, and severely retarded groups respectively. From this study, Wilhelm and Lovaas concluded that stimulus overselectivity was a function of I.Q. or perhaps the MA of the child and was not a feature specific to the autistic child.

## Related Studies

Eimas (1969) presented normal children with simultaneous visual discrimination tasks. The stimuli were colour-form patterns of various sizes and with various borders. The $S^+$ and $S^-$, on different tasks, varied on two, three or four of these characteristics. An example of a task involving only two relevant dimensions would be the discrimination of a red circle from a blue square. When four dimensions were relevant, the stimuli might be a 2-inch red circle without borders and a 1-inch blue square with borders. Following learning to criterion on the original discrimination, Eimas (1969) instituted a test series. Test items were designed so that only one of the original relevant dimensions remained relevant for any given test trial. The other dimensions were made irrelevant for a given trial by introducing novel values for those dimensions. The novel values, when used, were constant both within and between trials. For example, if the original training task was a four-dimension-relevant task just described, Eimas (1969 would test the control the colour dimension had over the child by presenting him with a test trial for which the test stimuli consisted of a 1½-inch red triangle with dashed borders and a 1½-inch blue triangle with dashed borders. To test for size, a 2-inch green triangle with dashed borders and a 1-inch green triangle with dashed borders would be employed. In a similar fashion, tests for form and borders were also presented. If a child's responses on test trials for a dimension were well above the chance level, Eimas assumed that that dimension had acquired control over the child's responding.

Although Eimas reports several findings, the one most germane to our present purposes is that his kingergarten-aged children learned less (i.e. made fewer correct responses) about the relevant dimensions than did 2nd or 4th graders, who performed about equally. Also, on tasks in which three or four dimensions were relevant, the kindergarten children learned fewer of the dimensions than did the 2nd and 4th graders.

Kovattana and Kraemer (1974) used a procedure similar to Eimas (1969). Autistic, mentally retarded, and normal children were trained to discriminate between stimuli which varied simultaneously in form, colour, and size. As in the Eimas (1969) study, following training, the children were tested with trials in which only one of the original dimensions varied for any given trial. In addition, the children also received test trials on which two of the original dimensions varied (i.e. were relevant).

Upon examining the results, Kovattana and Kraemer (1974) found it necessary to divide their autistic group into two smaller groups, verbal autistic and non-verbal autistic, since these two subgroups performed quite differently. The results indicated that the normal and verbal autistic groups made significantly more correct responses on the test trials than did the retarded group, who in turn did better than the non-verbal autistic group.

Schover and Newsom (1976) also employed stimuli which varied on form, colour, and size. Subjects were autistic and normal children of equivalent MAs. Their results indicated no significant differences between the two groups with respect to the amount learned on each dimension. This would support the Wilhelm and Lovaas (1976) belief that stimulus overselectivity is not a characteristic of autism or mental retardation, but rather is related to MA.

In summary, the studies described in this section indicate two things, first that overselectivity is not limited to the autistic/or mentally retarded child, and secondly, that the degree of stimulus overselectivity would appear to be a function of MA.

Mental Age

Table 1 presents the characteristics and performances of subjects in the studies described. Although the majority of the experimenters failed to provide mental age data for their subjects, mental ages can be inferred, to some degree, from the I.Q. and/or behavioral descriptions provided. From such an examination, it becomes apparent that the autistic (and mentally retarded) subjects in the studies have quite consistently been of a lower MA than their normal controls. These findings would support Wilhelm and Lovaas' (1976) and

Schrover and Newsom's (1976) statements that the degree of stimulus overselectivity is related to the MA of the child.

In all of the studies listed in Table 1, with the exception of the Schrover and Newsom (1976) study, the normal control subjects have had MAs and/or CAs of more than 6 years. Furthermore, with the exception of Eimas' (1969) data, these children were able to respond to all of the dimensions or cues presented to them.

In contrast, the majority of the autistic and mentally retarded children had MAs (either as actually given or inferred) of less than 6 years. The only obvious exception to this statement are the populations used by Wilhelm and Lovaas (1976). The implications of this above-below MA 6 year differences for the control and experimental populations will be made clearer in the following sections.

Table 1

Population Characteristics and Group Performance Levels on Stimulus Over-selectivity Tasks for the Studies Described in the Text

| Study | Group | Mean CA[a] | Mean MA[a] | Mean IQ | Cues Learned/ Cues Possible |
|---|---|---|---|---|---|
| Eimas (1969) | Normal Kinder. | 5.4 | 6.2 | 106 | 2/2 2/3 1/4 |
| | Normal 2nd Grade | 7.6 | 8.6 | 113 | 2/2 3/3 2/4 |
| | Normal 4th Grade | 9.5 | 10.6 | 113 | 2/2 3/3 3/4 |
| Koegel & Wilhelm (1973) | Autistic | 9.4 | c | | 1/2 |
| | Normal | 6.3 | | | 2/2 |
| Kovattana & Kraemer (1974) | Verbal Autistic | 9.0 | | | Performed Worst |
| | Non-Verbal Aut. | | | | |
| | MR[b] | 10.0 | | 30-53 | |
| | Normal | 8.2 | | | |
| Lovaas et al. (1971) | Autistic | 7.2 | d | | 1/4 |
| | MR | 8.0 | 3.7 | | 2/4 |
| | Normal | 6.4 | | | 3/4 |
| Lovaas & Schreibman (1971) | Autistic | 10.2 | e | | 1/2 |
| | Normal | 6.8 | | | 2/2 |
| Reynolds et al. (1974) | Autistic | 11.5 | f | | 1/2 |
| | Normal | 6.5 | | | 2/2 |
| Schover & Newsom (1976) | Autistic | 10.2 | 5.5 | 27-70 | Performed Equivalently |
| | Normal | 4.5 | 5.5 | 107-152 | |

Continued...

Table 1 (Continued)

| Study | Group | Mean CA[a] | Mean MA[a] | Mean IQ | Cues learned/ Cues possible |
|---|---|---|---|---|---|
| Wilhelm & Lovaas (1976) | Severely MR | 15.8 | | 39.3 | 1.6/3 |
| | Moderately MR | 14.3 | | 66.1 | 2.1/3 |
| | Normal | 11.1 | | | 3/3 |

[a]Mean MA and CA are in years.

[b]MR = Mentally Retarded

[c]"profoundly retarded"

[d]"extremely regressed"

[e]"behavioral retardation was profound"

[f]Vineland Social Ages ranged from 1.8 to 2.6 years.

## Theoretical Implications

Koegel and Lovaas (1978) have made the comment (in response to a study of overselectivity by Litrownik, McInnis, Wetzel-Pritchard, and Filipelli, 1978) that they are more concerned with the practical implications of overselectivity than with the theoretical issues involved:

> We conclude by suggesting that Litrownik's [et al. 1978] use of the term <u>attention</u> invites many theoretical and measurement problems. We made some effort to avoid these problems by using the term <u>stimulus overselectivity</u>, which has a less theoretical connotation. (p. 564).

Despite this statement, Lovaas and his collaborators, (Koegel and Wilhelm, 1973; Lovaas et al., 1971; Lovaas and Schreibman, 1971; Wilhelm and Lovaas, 1976) as well as Schrover and Newsom (1976), have tended to view overselectivity as resulting from attentional deficits, or a limited breadth of attention.

While attentional deficits or limited breadth of attention may be useful in explaining stimulus overselectivity, the low MAs of the overselective children compared to the non-overselective children as described in the preceeding section suggest other possibilities.

There is evidence in the literature which would indicate that children of mental ages of 6 years and less may solve discrimination problems in a different manner than older MA children (e.g. Tighe, Glick and Cole, 1971; Zeaman and House, 1974; Zeiler, 1964).

Thus, it is possible that young MA children are not overselective due to limited breadth of attention, but may appear to be overselective or deficient in learning because the method they used to solve the discrimination is not adequately tapped by the test trials. In the stimulus overselectivity literature, it is assumed that the children learn about the specific components of the complex stimulus presented them. This assumption may not be correct.

Four sections follow. The first examines the breadth of learning or attention demonstrated by young MA normal and mentally retarded children in match-to-sample tasks. The next two sections present discussions of configurational and compound learning. The fourth section describes the sub-problem analysis literature, which has provided some support for both the configurational and compound learning hypotheses.

## Match to Sample Tasks and Breadth of Attention

Several studies have employed match-to-sample tasks in attempts to investigate the breadth of attention of young normal and mentally retarded children. In a match-to-sample problem a child attempts to choose, from a number of alternatives which are presented simultaneously, the stimulus which matches a sample stimulus. Typically, the sample stimulus is composed of a number of relevant dimensions (e.g. colour, form, size) with each dimension taking on one of two possible values (e.g. red or blue for colour). The alternatives from which the child chooses his match usually represent all the possible combinations of one value from each of the dimensions. For example, with five relevant dimensions, each of which may be one of two values, a total of thirty-two ($2^5$) combinations (or alternatives) are possible. The assumption behind the task is that the breadth of a child's attention will be reflected in how closely the stimulus he chooses from the alternatives matches the sample. Thus, a child whose choices match the sample on only three of five possible dimensions is assumed to have a more restricted breadth of attention than a child whose responses match on four dimensions.

Olson (1971) presented five groups of normal and retarded children (mean MAs of the five groups ranged from 2.5 to 5.7 years) with match-to-sample tasks in which one to eight dimensions were relevant. He found that all the children, including the MA 2.5 year old retarded children, were able to perform at well above chance levels for problems with one or two relevant dimensions. On the three-dimension relevant problem, the performance of the MA 2.5 year old children dropped, but the MA 4.8 to 6.2 year old normal and retarded children were all able to make the match at above chance levels. As more dimensions were made relevant, the performances of all the groups declined.

Ullman (1974) presented normal and retarded children (MA 5.1 to 7.3 years) with a match-to-sample task in which the stimuli could vary on five dimensions. There were 32 alternatives to choose from on each trial. The matches were made under a simultaneous condition and four conditions of delay (0, 10, 20, and 30 seconds) between removal of the cue stimulus and presentation of the choice stimuli. The normal and Educable Mentally Retarded (mean IQ of 64) groups performed equivalently and were able to correctly match a mean of 4.65 cues in the simultaneous condition, and 4.10 cues in the 30-second delay condition. The Trainable Mentally Retarded group (mean IQ of 54) did somewhat poorer, matching 4.2 cues in the simultaneous and 3.2 cues in the 30-second delay condition.

Sivertsen (1976) presented Autistic and normal children (mean Leiter Scale MAs of 5.6 and 5.9 years respectively) with match-to-sample tasks involving one, two, or three relevant cues. Both colour and junk stimuli were used. Although Sivertsen (1976) did not go into depth in her analysis, an examination of her raw data indicated several interesting trends. First, the percentage of subjects in both groups who met criterion for the object tasks was higher than the percentage who solved the colour tasks (76% as opposed to 67%). This was especially true of the normal group. Secondly, both groups did somewhat better on the <u>three</u> cue tasks (75% correct) than on the <u>two</u> cue tasks (67%). These findings are perhaps a result of practice and exposure effects arising from

Sivertsen's procedure, as the colour stimuli were presented before the junk stimuli, and one-and two-relevant-cue tasks were administered before the three-relevant-cue task was given. Nevertheless, Sivertsen's results do show that the majority of the MA 2.5 to 9.4 year old children could attend to three components in the match-to-sample tasks. It is noted, however, that the younger children were those making the majority of the errors.

Litrownik, McInnis, Wetzel-Pritchard, and Filipelli (1978) have compared the match to sample performance of autistic, mentally retarded, and normal children. The mean MAs for the three groups were 3.5, 3.1, and 4.2 years, respectively. The stimuli varied on the four dimensions of form, colour, size, and number of stars contained within the form.

Their results indicated that the autistic and normal children performed equivalently, both groups being able to utilize all four of the dimensions in problem solution at well above chance levels. The retarded group performed slightly more poorly than the other two groups on the colour and form dimensions but were at well above chance levels. Size was correctly matched by the retarded group on about 71% of the trials, just slightly less than the 75% criterion level established by Litrownik et al. (1978) to indicate whether or not a dimension had established control over responding. The retarded group was able to match number correctly on 63% of the trials. A breakdown of the results for each group indicated that 4/7 of the retarded, 5/7 of the normal, and 6/7 of the autistic groups were able to consistently make matches using at least three of the four possible dimensions.

A study carried out by Fisher, Martin, McBane, and Zeaman (Note 1) has come closest to comparing learning of a match-to-sample task with a redundant cue discrimination task. They compared the degree to which the two components of stimuli consisting of relevant redundant cues were learned using two types of stimulus presentation. The <u>standard</u> problem was similar to that used in the stimulus overselectivity literature. That is, two different form-colour stimuli were presented on the training trial, and form and colour were tested separately on the test trials. In the second type of presentation, only the $S^+$ was presented on the "training" trial, i.e. it was a <u>demonstration</u>. This made it somewhat similar to a match-to-sample task with delayed presentation of choice stimuli. As in the standard problem, form and colour were tested separately on the test trials. Retarded subjects in the MA 4 to 6 and MA 8 to 12 year old ranges received a single training trial followed by two test trials, one for form and one for colour.

The MA 8 to 12 year olds were able to respond correctly about 95% of the time to the form and colour tests using the demonstration procedure. The MA 4 to 6 year olds responded correctly about 83% of the time to the form and colour tests on the <u>first</u> test trials, but this dropped to about 73% for the second test trials. This latter performance was just slightly worse than the 75% criterion level established by

Fisher et al. (Note 1) to indicate successful learning. Fisher et al. suggest that this drop on the part of the 4 to 6 year olds might be the result of poor retentive abilities in these children relative to the 8 to 12 year olds.

Both groups performed worse on the standard method than on the demonstration method. The MA 8 to 12 year olds averaged 78% correct while the MA 4 to 6 year olds averaged only about 58% correct. No explanation for the differences in performance between the two types of stimulus presentation is offered in Zeaman's (1973) description of the Fisher et al. (Note 1) study.

The studies reported in this section have indicated that children with MAs as young as 2.6 years are capable of solving match-to-sample problems using at least two different relevant dimensions. By MA 3 years, matching on three dimensions appears possible, and by MA 4 years, four dimensions.

These data would tend not to support the argument that younger children are overselective due to limited breadth of attention. In stimulus overselectivity tasks, children are typically presented with stimuli composed of only two or three relevant cues, yet young MA children fail to learn them all. The match-to-sample studies cited suggest that a majority of young MA children do appear to have a wide enough breadth of attention to learn the few components which are presented in a stimulus overselectivity task. The fact that these children do not learn all of the cues in a stimulus overselectivity task provides evidence for the hypothesis of the present paper, that is, that the younger MA children may be using alternative (non-component) approaches when learning discrimination problems containing a number of relevant but redundant cues.

The reason for the discrepant performances on the match-to-sample and discrimination tasks may lie in the nature of the problems. In the match-to-sample task, the child must attend to the components of the sample stimulus. In contrast, for the relevant redundant cue discrimination task the child must learn to respond differentially to two or more different stimuli. Although the child may learn to do this by learning the relevant components of the $S^+$ stimulus, this does not necessarily appear to be the case, especially for younger children, as was shown in the Fisher et al. (Note 1) study. What is proposed is that the young child does not necessarily learn to solve a redundant cue discrimination task by attending to the components of the $S^+$ (although he would appear capable of doing so) but rather may employ an alternative problem solving method when solving such a task. Possible alternative learning approaches will be presented in subsequent sections.

Components and Configurations

Suppose a child is presented with a red circle and a green circle and is reinforced for choosing the red circle, which always appears on the right. Further suppose that he is also presented with a large blue triangle and a small blue triangle, the large triangle being reinforced and always appearing on the left. The child can learn this problem in two ways. He can learn by responding to components, in which case he would respond to large and to red, or he could learn to respond to configurations, i.e. when circle go to the right, when triangle, go to the left. In less general terms, a configuration is described as a directional response learned "on the basis of the internally undifferentiated configuration established by the two stimuli" (Zeiler, 1964, p. 292).

Zeiler (1964) trained normal children aged 3, 5, and 7 years on the discrimination tasks just described. He then retrained the children with the two original problems plus their spatial alternatives (i.e., red circle on the left, green circle on the right) making a total of four different retraining trials. For half the subjects at each age level, Zeiler reinforced configurational responses during the retraining trials. That is, he reinforced the choice of the right hand triangle when presented with triangles, and the left hand circle when circles were presented, irrespective of their colour or size. The other half of the subjects in each age group were reinforced for making component responses, i.e. red for circles and large for triangles.

The results indicated that the 3 year olds were able to learn the configurational problem faster than the component problems. For the 5-and 7-year olds, the opposite was the case, component learning was faster. Zeiler (1964) concluded that the three-year olds preferred a configurational approach to the problem solving while older children prefer to solve discriminations by using components.

Campione, McGrath, and Rabinowitz (1971) presented four-year olds (range 2.6 to 5.6 years) with training trials similar to those used by Zeiler (1964). Once criterion was met, Campione et al., like Zeiler, presented test trials consisting of the original (training) settings, plus trials in which the positions of the stimuli in each pair were reversed (novel setting). Reinforcement contingencies for the original items remained the same during the test phase. However, for the novel settings, choice of <u>either</u> stimulus was reinforced. This allowed the child to respond configurationally or componently to either of the discriminations. A measure of component responding was obtained by examining the type of response to the novel settings.

Of the 28 subjects, 25 responded in a component fashion to the size pair. However, only one-half (14) of the children used a component solution for the colour pair. Furthermore, 12 subjects who consistently made component responses to both the tasks were found to be significantly older than 7 children who made component responses to size and configuration responses to colour. The mean ages for the two groups were 4.5 and 3.7 years respectively.

Zeiler's (1964) and Campione et al.'s (1971) findings suggest several possibilities with respect to the understanding of stimulus overselectivity. Foremost amoung these possibilities is that the young overselective child has not learned anything at all about the individual components of the stimuli composed of relevant redundant cues but rather has learned something about the configurations which make up the discrimination problem. It is also possible that the child has learned configurations based on only part of the available information.

Obviously, if a child did learn the discrimination by configurations then the testing procedure used in the stimulus overselectivity literature would functionally destroy the configuration. That is, the test stimuli inhibit a configurational response since during testing the stimuli are changed either by the elimination of all but one of the components for any given test trial (as with the junk stimuli of Wilhelm and Lovaas, 1976), or by replacement of attributes of all but one of the relevant dimensions with novel and irrelevant attributes (as with the form-colour-size stimuli employed by Kovattana and Kraemer, 1974).

Components and Compounds

A second alternative explanation for findings of overselectivity is that young children may be learning compounds rather than components. Zeaman and House (1974) describe compounds as "the combination of two or more aspects responded to as a unitary pattern, different from, and independent of, any of the constituent components". (p. 146).[1]

House and Zeaman (1963) and Eimas (1964) have employeed a methodology based on the "miniature" experiments of Estes (1960) to look at the component and compound learning of mentally retarded children. Both the House and Zeaman, and the Eimas studies reported that mentally retarded children were capable of learning both components and compounds when solving two-dimensional problems with both dimensions relevant." Eimas (1964) also reports that his subjects learned compound solutions to the discriminations even though solution was possible solely on the basis of components. Furthermore, he found that compounding of stimuli tended to persist over a number of types of problems, even though in some cases this led to a reduction in reinforcement. (The mental ages of the children in the House and Zeaman study ranged from 4 to 8 years. MAs ranged from 6 to 7.9 in the Eimas study.)

More recently, Zeaman and House (1974) have examined developmental trends in discrimination transfer effects (e.g. intra-dimensional - extra-dimensional shifts; reversal - non-reversal shifts) in light of a compound-component hypothesis. It is their belief that use of compound learning by young children and component learning by older children provides an acceptable means of explaining the developmental changes found in problem solving.

Zeaman and House (1974) do not hold that young children always respond to compounds and older children to components. Rather they believe that there is a developmental trend towards increasing the use of component solutions as compared to compound solutions. Although House and Zeaman (1963) reported that the absolute amount of compounding increases with MA, Zeaman and House (1974) have stated that in relation to the degree of component usage, the relative amount of compounding decreases with age. The probability with which a child uses compounds or components is considered to be dependent upon stimulus conditions and the previous learning of the child (Zeaman and House, 1974).

A final point should be made with respect to Zeaman and House's formulation of compounds. It is their belief that compounds are dimensional and conceptual in nature. That is, compounds may be thought of as dimensions which happen to have two or more properties.

Barnes (1978) has tested some of the implications of the compound-component hypothesis. To do so, he presented MA 5 and MA 10 year old mentally retarded children and adults with two types of problems. Component problems involved the presentation of two forms (e.g. square and circle, square being the reinforced component). The two components were the same colour within trials (e.g. both blue), but ten different colours were used randomly between trials. As Barnes (1978) points out, a compound solution to the task is possible, but improbable, as this would require the learning of ten different compounds, one for each colour. The compound problems involved two sets of stimuli. An example of a compound problem would be a yellow triangle versus a yellow cross and a brown triangle versus a brown cross. For the former set, the yellow triangle may be the $S^+$, and for the latter, the brown cross. Therefore, to learn the problem, the child had to learn a compound of form and colour.

Barnes gave two problems to each of his subjects. One quarter of the subjects in each age group were given one of the following sequences of problems; component-compound, compound-component, component-component, or compound-compound. Barnes' (1978) findings tend to support Zeaman and House's (1974) position. Barnes found that MA 10 year olds made an average of 9 times as many errors in learning the compound problem, when it was presented first, than they made when learning the component problem, when it was presented first. The MA 5 year olds also made more errors in learning the compound as compared to the component problem, but in their case they made only 1.5 times as many errors. Thus, the older children did much poorer on compound problems relative to component problems than did the younger children.

Barnes's (1978) design also permitted an investigation of whether or not a compound could be considered a dimension which simply happened to possess two or more properties. Alternatively, this design could be considered an evaluation of the transfer of compound or component learning strategies across problems. Pairs of problems in which the same strategy was relevant (component-component or compound-compound) were compared with pairs involving different strategies (compound-component or component-compound presentation orders of problems). Barnes's reasoning was that if the different strategies groups took longer to learn the second problem than the same strategies groups, then this would imply that compounds could be considered a dimension of sorts. That is, slower learning of the second problem by the different strategies groups would result because of an unsuccessful attempt to use compound (in the compound-component shift) or component (in the component-compound shift) as mediators in the second problem. In general, the findings indicated that the different strategies groups did take longer to learn the second problem than the same strategies groups at both age levels. This tends to support Barnes' view that a compound is like a dimension in that it is used as a mediator. An exception to the general findings was the compound to component shift for the older children, which was learned approximately as fast as the shifts for the same strategies groups. Barnes attributes this to the fact that "the easiness of the form dimension overrides the difficulty of the [different strategy] shift for those subjects" (p. 77).

Barnes' findings are important for two reasons. First, since the compound learner appears to treat a compound in much the same way he approaches a single dimension, it is unlikely that the compound learner gives individual attention to the components (dimensions) which make up the compound. And secondly, the findings indicate that a preference (in this case artificially imposed by pre-exposure) for a particular learning strategy inhibits learning in a second problem for which an alternative learning strategy is more appropriate.

House (1979) has provided additional support for the compound-component hypothesis. She pretrained mentally retarded subjects (mean MA of 5.8 years, range 4 to 8 years) on either a component or a compound task, similar to those used by Barnes (1978). Following the pretraining the subjects in both groups were presented with a standard problem in which form was relevant and colour irrelevant and variable within settings. For example the stimuli might be a red square versus a blue circle and a blue square versus a red circle, square being the reinforced feature. Following criterion on the standard problem, half of the subjects in both the compound and component pretrained groups were presented with a reversal shift problem. In a reversal shift, the feature which is reinforced following the shift is from the same dimension as the feature reinforced prior to the shift. In the example given above, this would involve shifting the reinforced value from square to circle. The remaining subjects in each group were given an extradimensional shift problem. In the extradimensional shift, the feature reinforced following the shift is from the dimension which was irrelevant prior to the shift. Again referring to the example above, this might involve changing the reinforced value from square to red. House assumed that the pretraining strategy received by the subjects would affect performance on the shift task. She found that the subjects pretrained on the compound problem responded to the shift problems in a manner identical to that commonly found in young MA children, i.e. the extradimensional shift was learned faster than the reversal shift. The opposite was found for the component pretrained group, they learned the reversal shift faster, which is what is typically expected of older MA subjects. That is, the compound pretraining, but not the component pretraining, resulted in discrimination shift performances resembling that typically found in young MA children. This led House to believe that the young MA child is more likely to use compounds than components in discrimination learning.

The implications of the component-compound hypothesis with reference to the stimulus overselectivity literature is obvious. If, during training, the child has learned to respond to compounds of the relevant and redundant dimensions, then the child's performance on the test trials for components is bound to be poor.

Finally, it should be noted that it is also possible to solve the compound problems used in the Barnes (1978) and House (1979) studies by using configurations. This would require the learning of four configurations, as the two compounds each appeared in two different positional arrangements.

Subproblem Analysis

Tighe, Glick, and Cole (1971), Cole (1973) Tighe and Tighe (1972) and Tighe (1973) have applied a procedure termed subproblem analysis to investigate cases in which young children learn a non-reversal shift faster than a reversal shift, while older children learn reversal shifts faster. Figure 1 will best illustrate this procedure. The pre-shift problem features size (large) as the relevant dimension and colour as the irrelevant dimension. In the reversal shift, size is still relevant, but the reinforced value has changed to small. In the non-

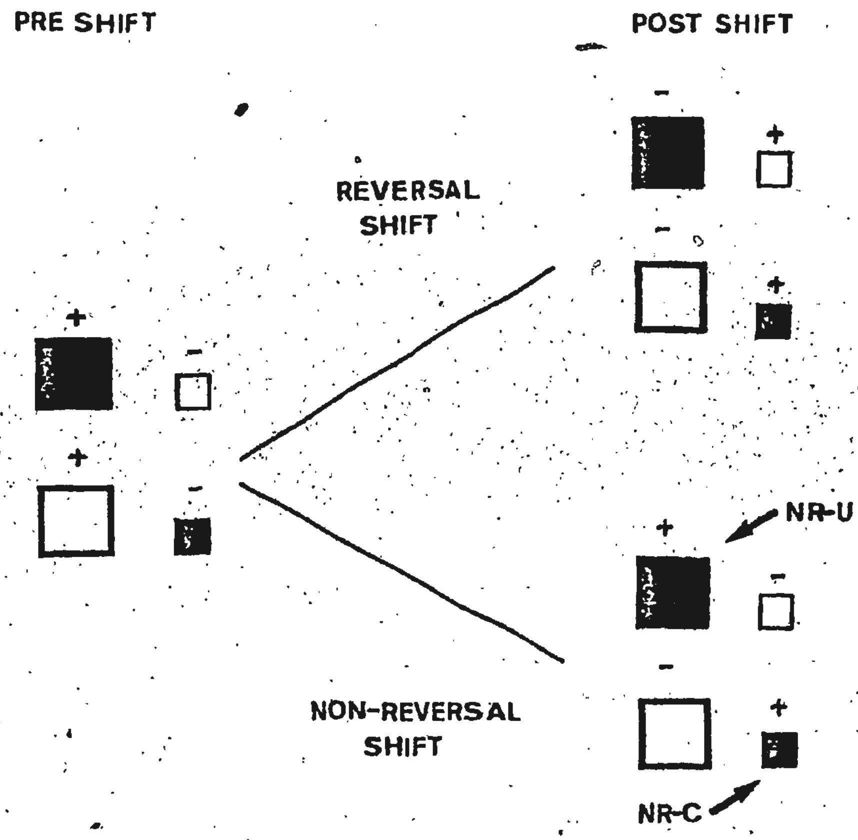


Figure 1. Illustration of the subproblem analysis procedure.

reversal shift, the previously relevant size dimension is now made irrelevant, colour (black) becoming relevant. However, what is important to note is that in the non-reversal shift, the large, black form is a positively reinforced stimulus for both the pre- and post-shift tasks. This will be referred to as the non-reversal, unchanged stimulus (NR-U). In contrast, the small black form was not previously reinforced (NR-C).

Tighe et al. (1971), compared the learning functions of 4 and 10 year olds for the NR-U, NR-C, and reversal shift items following the shift. The ten year olds showed a similar learning function for each of the NR-U, NR-C and reversal shift items. That is, percent correct responses for all three types began at below chance levels before climbing quite rapidly to well above chance levels. For the 4 year olds, similar results were found with the reversal shift and NR-C items. However, for the NR-U items, percent correct remained at well above chance level immediately following the shift, and remained high throughout the post-shift trials. Furthermore, of the 16 subjects in each group, none of the 10 year olds, but half of the 4 year olds made no errors at all on the NR-U item during the post-shift trials.

Tighe (1973), Tighe, Glick, and Cole (1971) and Tighe and Tighe (1972), believe that these findings indicate that while older children tend to see the solutions to the two subproblems as being interdependent, younger children appear to view them as two separate, independent problems. That is, on the post-shift task, the older children saw the two stimulus pairs as being parts of the same problem and "non-reinforcement on [NR-C] , then, caused these older Ss to change response to the [NR-U], even though they had never experienced non-reinforcement on this pair", (Tighe et al. 1971, p. 160). The younger children, however, simply appear to relearn their responses to the NR-C pair, and continued to make their previously learned response to the NR-U pair.

Cole (1973) also employed subproblem analysis in his investigation of reversal and non-reversal shifts made by Mexican children age 4 to 10 years. In addition to the cues typically employed in such studies (e.g. red square versus blue triangle and blue square versus red triangle), Cole also used dimensionless stimuli, that is, stimuli with no common attributes. An example of such stimuli would be a red cross versus a yellow triangle, and a blue square versus a green circle. If the red cross and the blue square were the $S^+$s for their respective pairs, then on the reversal shift, the yellow triangle and the green circle would become the $S^+$s. For non-reversal shifts, only one of the original (pre-shift) $S^+$s would be changed. For example, the non-reversal shift $S^+$s for the above example might be the red cross and the green circle. (Reversal and non-reversal shifts with dimensionless stimuli are also often referred to as pseudo-reversal and pseudo-non-reversal shifts respectively.)

As in the Tighe et al. (1971) study, Cole (1973) looked at the spontaneous shifts on initial trials for the NR-U trials as compared to the NR-C and reversal shift trials. Cole's findings were comparable to those reported by Tighe et al. (1971). That is, the younger children did not spontaneously change their responses to the NR-U items after failing to receive reinforcement for their responses on the NR-C items immediately following the shift. The older children, however, did spontaneously change their responses to the NR-U item. This was true for both the dimensional and the non-dimensional problems, although the effect was significantly stronger for the dimensional problems.

The implications of Cole's (1973) study, as with Tighe et al.'s (1971) study is that younger children tend to see different settings of a problem as independent subproblems, while older children see the two settings as being inter-related.

These findings have been used by Zeaman and House (1974) to support their component-compound hypothesis. They suggest that the compound learner learns the reversal shift slower than the non-reversal shift because the latter requires the learning of only one new compound, while the former requires that two new compounds be learned. However, for the older, component learner, the mediator learned on the original training task will facilitate the reversal shift but retard learning on the non-reversal shift.

The subproblem analysis findings would also support the configuration-component hypothesis in that the reversal shift involves changing the direction of response for four configurations, while the non-reversal shift requires that this be done for only two of the configurations. (There are twice as many configurations as compounds to learn since each positional setting is a different configuration.)

## Summary

It would appear that the young MA child does not necessarily solve discrimination problems by learning about specific components or cues. Rather, it is very possible that they learn by employing either configurations or compounds to solve problems. Consequently, these children would be expected to show poor component learning, as they do not learn to solve the original discrimination by attending to the individual components which make up the stimuli.

However, the fact that a child may learn by using either compounds or configurations does not preclude the possibility that the same child also solves problems using a component approach. This is indicated in the Campione et al. (1971) study in which some children learned a component solution to one dimension and a configurational solution to another; and in the Barnes (1978) study in which the children learned one problem which required a compound solution as well as a second problem which required a component solution.

There is nothing which would suggest that a child cannot learn something about the components of a stimulus while learning the solution by configurational or compound means. This learning, however, would probably be limited to components which are especially salient to the child. This may help to explain why some components are learned, by a compound or configurational learner. It is important to emphasize that component learning may be incomplete not because the child may be incapable of attending to all the cues, but because the process he uses to solve the discrimination does not lend itself to attending to the components of a stimulus on an individual basis.

The present research is directed at examining the possibility that the overselective child is not a child who responds to a restricted number of components because of any specific attentional deficiencies, but rather is a child who simply may learn a discrimination in a manner other than by attending to the particular components of the stimuli.

Although Koegel and Lovaas (1978) would argue that such theoretical work is of less importance than research directed at the more practical implications of stimulus overselectivity, a more solid understanding of the problem is required before adequate training and teaching methods can be developed. Thus, when training developmentally handicapped children, the goal of teaching these children to respond to all the components in a relevant and redundant cue task may have to be preceded by the goal of getting the children to respond to components.

## Experiment I

The first experiment was modeled after that of the Campione et al. (1971) study described earlier. Subjects were trained on discriminations which could be learned using components, compounds, or configurations. Following the training phase, a series of test trials was administered. On some of the test trials, the stimuli were presented in novel arrangements by reversing the position the $S^+$ and $S^-$ had maintained during training. For these novel arrangements, the component and compound learner should be able to shift his responding to the new position of the $S^+$. However, the configurational learner would not be expected to make such a shift as he is not responding to the individual components of the stimuli.

Configurational learning has already been demonstrated in young MA normal children (Campione et al., 1971; Zeiler, 1964). It was expected that similar findings would be demonstrated in young MA mentally retarded children. The hypothesis tested was that young MA retarded children would exhibit less component learning than would older MA retarded children.

The experiment was also designed to examine the degree of configurational learning (if found) that mentally retarded children demonstrate on each of the dimensions of form, colour, and junk. A number of the studies already described (Eimas, 1969; Kovatana and Kramer, 1974; Schrover and Newsom, 1976) have found significantly more learning for form than for colour components. Few of the studies related to the investigation of stimulus overselectivity have compared junk stimuli with form or colour stimuli. However, Koegel and Wilhelm (1973) reported little difference between the overselectivity resulting from junk stimuli as opposed to red-coloured form stimuli. Sivertsen (1976) found that fewer errors were made on match-to-sample tasks with junk stimuli than when colour stimuli were used (although as noted earlier, this may in part have been due to her presentation method). It was predicted that similar tendencies would be demonstrated in the present experiment, that is, that configurational learners would show less configurational responding to form or junk stimuli than to colour stimuli. The rationale behind this hypothesis is that the more salient dimensions are more likely to capture a child's attention to the extent that the individual values of the dimensions are attended to and thus learned in a component manner.

## Method

Subjects The subjects were 12 mentally retarded boys who, during the course of the experiment, were residing in the Dr. William F. Robert's Hospital-School, Saint John, N.B., Canada.

The subjects were selected at random from a pool of children who had been tested by the experimenter with Alpern and Kimberlin's (1970) short form of the Stanford-Binet Intelligence Scale, with the restrictions that the subjects be classified as mentally defective (IQ $<$ 70), and that half of the subjects have Mental Ages (MAs) less than 66 months while the remaining six subjects have MAs greater than 66 months. This resulted in two groups. The Younger MA group had MAs ranging from 40 to 60 months, with a mean of 49.2 months. The Older MA group consisted of six boys with a mean MA of 78.0 months and a range of 72 to 96 months. One of the boys in the Younger MA group was a replacement for a boy who had to be dropped from the experiment as a result of his refusal to continue following the completion of the 2nd of the six sessions. The 12 subjects were distributed among 5 of Hospital-School's 11 units or wards.

MAs, CAs, and IQs of the subjects participating in Experiment I, as well as the group means, can be found in Table 2. Attempts to match the two groups for CA were not entirely satisfactory, $\underline{F}(1, 10) = 4.90$, $\underline{p} < .06$. The MAs for the two groups were significantly different, $\underline{F}(1, 10) =$

Table 2

CAs, MAs, and IQs of subjects participating

in Experiment 1

| Subject | CA | MA | IQ |
|---|---|---|---|
| Younger MA | | | |
| 1 | 138 | 40 | 30 |
| 2 | 127 | 45 | 38 |
| 3 | 106 | 54 | 50 |
| 4 | 112 | 51 | 46 |
| 5 | 200 | 45 | 23 |
| 6 | 120 | 60 | 50 |
| Mean Young | 133.8 | 49.2 | 39.5 |
| Older MA | | | |
| 1 | 154 | 72 | 50 |
| 2 | 166 | 72 | 47 |
| 3 | 150 | 72 | 50 |
| 4 | 181 | 96 | 57 |
| 5 | 197 | 72 | 45 |
| 6 | 164 | 84 | 54 |
| Mean Old | 168.7 | 78.0 | 50.5 |

_Note_. MAs and CAs are in months.

32.53, $p < .001$, as were IQs, $F(1, 10) = 5.01$, $p < .05$. Although the IQs and MAs were confounded in distinguishing between the two groups, the labels Older MA and Younger MA groups will be used here for the sake of convenience.

Design of Experiment Each subject was trained and tested on six different problems. For each problem, the subject was required to learn two discriminations, the stimuli for the discriminations representing two of the dimensions of form, colour, or junk. More specifically, during training, the subject was presented with two pairs of stimuli from different dimensions and had to learn the $S^+$ for each pair. Both pairs were always presented in the same arrangement during training. For one pair, the left-hand stimulus was the $S^+$, for the second pair, the right-hand stimulus. During the test phase, 20 trials were presented, 5 trials for each of the pairs in their training (original arrangement) positions, and 5 trials for each pair with the positions of the $S^+$ and $S^-$ reversed (novel arrangement). The training and testing phases are outlined in Figure 2.

Materials Testing and training stimuli were drawn individually on 75 x 125 mm white index cards. The cards were plastic laminated to prevent wear and facilitate cleaning. Three different dimensions (form, colour and junk),

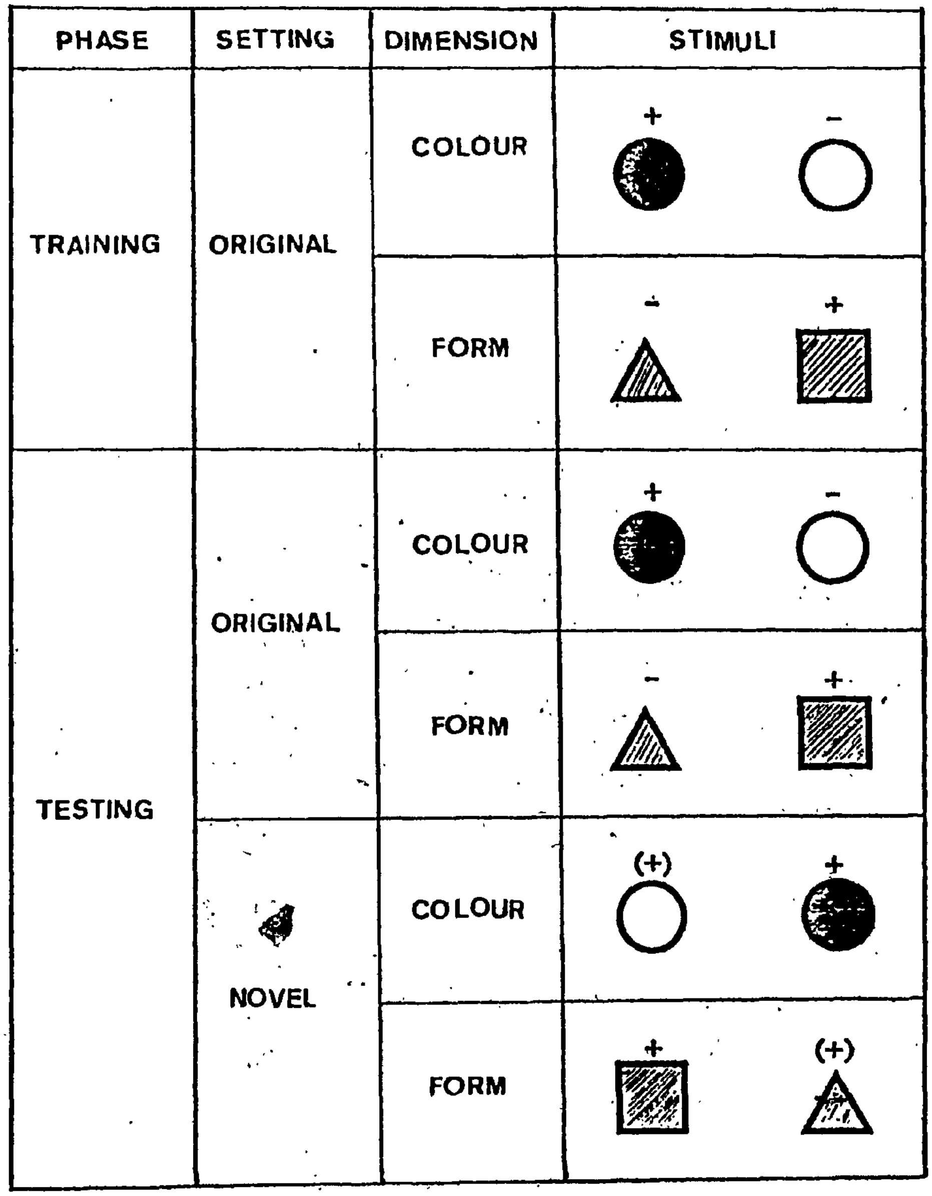


Figure 2. Illustration of the training and testing phases of Experiment 1. (Responses to any of the stimuli in the Novel settings were reinforced. The "+"s not enclosed by parentheses indicate correct component responses.)

were each represented by eight different values. The colours used were grey, turquoise, dark green, tan, dark brown, lime green, dark blue, and yellow. Forms employed were a heart, "X", octagon, six-pointed-star, cross, trapezoid, pentagon, and "Tee". The junk stimuli consisted of black line drawings of a clock, pair of shoes, telephone, jacket, tree, hand, scissors, and dog. Illustrations of the stimuli used appear in the Appendix.

In order to emphasize the differences between the settings irrelevant dimensions were made constant within settings but variable between settings. Thus, all the colour stimuli were small (25 mm in diameter) circles. The forms, which were all outlined with 1.5 mm thick black borders, were coloured purple. They were medium in size (40 x 40 mm). The junk stimuli were all "colourless" black outline drawings. They were large in size (60 mm high, 50 to 65 mm wide, mean width of 58 mm).

The eight values of each of the dimensions were randomly paired to produce four pairs each of form (F), colour (C), and junk (J) stimuli. Then two of the form pairs were randomly assigned to two of the junk pairs. Next, the remaining two form pairs were randomly assigned to two of the colour pairs. Finally, the two remaining junk pairs were assigned at random to the two remaining colour pairs. This resulted in six sets of stimuli, two sets with a form pair and a colour pair, two sets with a form pair and a junk pair, and two sets with a colour pair and a junk pair (see Table 3). When training and testing the subjects, the order in which these sets were presented to the subjects followed a Latin Square design for each group.

Within each stimulus set, there are eight possible arrangements of position and reinforcement of the stimuli as indicated by Table 4. To control for this, each subject was randomly assigned one of the arrangements, with the restriction that each of the arrangements be used at least once with each stimulus set. There was one exception to this rule. On the first session only, the child's response to the first presentation of the first stimulus pair was designated the $S^+$ for that pair. This was done as an attempt to facilitate learning of the task by ensuring that the child receive immediate positive reinforcement for his first response. The $S^+$ for the second pair in the first stimulus set was thus determined by the child's response to the first pair. For example, if he chose the left-hand stimulus in the first pair, then the right-hand stimulus was designated as the $S^+$ for the second pair.

To summarize, during each session, the subjects were

Table 3

Stimulus Sets Used in Experiment 1

| Set | Dimension[a] | Stimuli | |
|---|---|---|---|
| I | C | 1A Grey | 1B Turquoise |
| | F | 2A Heart | 2B "X" |
| II | J | 1A Clock | 1B Shoes |
| | F | 2A Star | 2B Octagon |
| III | C | 1A Dark Green | 1B Tan |
| | J | 2A Telephone | 2B Jacket |
| IV | C | 1A Dark Brown | 1B Lime |
| | F | 2A Trapezoid | 2B Cross |
| V | J | 1A Tree | 1B Hand |
| | F | 2A Pentagon | 2B "Tee" |
| VI | C | 1A Dark Blue | 1B Yellow |
| | J | 2A Scissors | 2B Dog |

Note. The number/letter designations were used to identify individual stimuli within the sets.

[a] F = Form, C = Colour, J = Junk

Table 4

Presentation and Reinforcement Arrangements of Individual Stimulus Sets, Using Stimulus Set I as an Example, Experiment 1

| Order | Arrangements | |
|---|---|---|
| | Left | Right |
| 1 | 1A Grey$^{+}$ | 1B Turquoise$^{-}$ |
| | 2A Heart$^{-}$ | 2B "X"$^{+}$ |
| 2 | 1A Grey$^{-}$ | 1B Turquoise$^{+}$ |
| | 2A Heart$^{+}$ | 2B "X"$^{-}$ |
| 3 | 1A Grey$^{+}$ | 1B Turquoise$^{-}$ |
| | 2B "X"$^{-}$ | 2A Heart$^{+}$ |
| 4 | 1A Grey$^{-}$ | 1B Turquoise$^{+}$ |
| | 2B "X"$^{+}$ | 2A Heart$^{-}$ |
| 5 | 1B Turquoise$^{+}$ | 1A Grey$^{-}$ |
| | 2A Heart$^{-}$ | 2B "X"$^{+}$ |
| 6 | 1B Turquoise$^{-}$ | 1A Grey$^{+}$ |
| | 2A Heart$^{+}$ | 2B "X"$^{-}$ |
| 7 | 1B Turquoise$^{+}$ | 1A Grey$^{-}$ |
| | 2B "X"$^{-}$ | 2A Heart$^{+}$ |
| 8 | 1B Turquoise$^{-}$ | 1A Grey$^{+}$ |
| | 2B "X"$^{+}$ | 2A Heart$^{-}$ |

*Note.* Reinforced stimuli are marked with a "+". Non-reinforced stimuli are marked with a "-".

presented with a stimulus set consisting of two pairs of stimuli representing different dimensions. The order in which the two pairs in each set were presented during a session followed a 100 item sequence derived from Fellows (1967). A different presentation sequence was constructed for each of the six stimulus sets.

Procedure Each subject was seen individually in the large semi-partitioned bedroom which was a part of the unit in which he resided. The layouts of the bedrooms were all similar. The bedrooms were chosen for testing as they provided a familiar and non-threatening environment for each child. As the bedrooms are generally not used during the day, they were also quiet and private. A standard school room desk, with a surface of 45 X 60 cm and a height of 75 cm, and two chairs were set up in a corner of each of the bedrooms. A third chair, situated to the side of the experimenter, and out of the direct view of the child, was used to store stimulus cards not being used on a particular trial.

During the first session, the Younger MA children were given the following instructions:

> We are going to play a game. I am going to show you some cards. The cards are going to have different colours and pictures on them. Each time I show you the cards, I want you to point to the one you think is correct, the one

which is right. If you are right, I'll give you a raisin (bit of chocolate, etc.). At first you might have to guess, but after a while you will be able to tell which are right ones. Try hard and see if you can tell me which is the right one every time.

The first trial then began with the placing of the stimuli on the table in front of the child. The two cards were placed approximately 3 cm apart. If the child did not respond within a few seconds, he was urged to "Show me the good one" or "Show me the one which is right". On initial trials only, subjects were sometimes urged to guess.

On trials to which the younger children responded correctly, they were immediately reinforced verbally (i.e. "Good" or "Correct") and with a small bit of edible reinforcement. Raisins, bits of chocolate, candied cereals, and cheese flavored snacks were all used as reinforcers, depending on the preference of the child. When the subject made an incorrect response, the subject was simply told "No", or "Wrong". Immediately after each response, the cards were withdrawn and the cards for the next trial were presented. The intertrial intervals were thus self-paced.

Instructions and procedures for the Older MA children were basically the same with the exception that they did not receive edible reinforcers for making correct responses. Without exception, all of the Older MA children enjoyed participating in the "game" and the use of tangible reinforcers was found to be unnecessary to maintain their interest or co-operation. The Older MA children were, however, on two occasions given a candy bar for "helping with the game".

During each session, training continued until the child reached a criterion of five correct responses in each of two consecutive blocks of five trials, successive blocks beginning with trials 1, 6, 11, etc.. This allowed for up to 275 trials before the probability of reaching criterion by chance exceeded .05 (Bogartz, 1965). A maximum of 100 training trials were administered during any given day. If a child failed to reach criterion after 100 trials, the training was terminated for the day but resumed the following day. No child required more than two sessions to reach criterion.

To ensure that each child learned each problem, upon the first error following trials 25, 50, 75, etc. the correct responses were demonstrated to the child by placing both pairs of stimuli on the table in front of the child and saying:

When you see these two cards (pointing to the first pair) then this is the correct one to point to (indicating the $S^+$). When you see these two things (pointing to the second pair), then this is the one you should point to (indicating the $S^+$ of the second pair).

Immediately after reaching criterion, the twenty trial test series began. The children were not informed about the test trials and hence did not know when they would begin. The experimenter attempted to make the transition from the training phase to the test phase as smooth as possible. During the test phase, responses to the stimuli in their original (training) arrangements were reinforced or non-reinforced using the same contingencies of the training phase. However, for the novel spatial arrangements, responses to either of the stimuli in each pair were reinforced. Thus, for the novel spatial arrangements the child was reinforced for responding in either a component or configurational manner.

Each of the six problems in Experiment I were administered on different days for each subject. With one exception, sessions were held on successive days. One of the boys in the Older MA group was unavailable for testing for one day between sessions 2 and 3. Testing for each child took place at approximately ($\pm$ one hour) the same time each day.

Results and Discussions

Trials and Errors to Criterion Dunlap and Duffy's (1974) transformation procedures were used to minimize the marked skew which was found in both the Trials to Criterion (excluding the criterion run) and Errors to Criterion data. The transformation formula used for the Trials to Criterion data was $\underline{Y} = (X + 1)^{0.150}$, where $\underline{X}$ represents the original score and $\underline{Y}$ its transformation. For Errors to Criterion, $\underline{Y} = (\underline{X} + 1)^{-0.181}$. Since zeroes were present in the raw data, Dunlap and Duffy's procedure required that a one (1) be added to all the raw scores prior to calculating the appropriate value for the transformation.

An Age x Session analysis of variance for the Errors to Criterion data indicated a significant Age effect, $\underline{F}(1, 10) = 6.649$, $\underline{p} = 0.026$, while the Age effect for the Trials to Criterion data approached significance, $\underline{F}(1, 10) = 3.949$, $\underline{p} = .073$. Not unexpectedly, it was the Older MA group who made fewer errors and took less trials: 2.9 and 11.3 respectively, compared to means of 8.2 errors and 24.9 trials by the Younger MA children. The main effect of Session, and the Age x Session interaction were non-significant for both Trials and Errors to Criterion.

Correlations between the number of special training trials (i.e. demonstration of the correct responses on the first error following trials 25, 50, and 75) given for each problem and the number of Trials and Errors to Criterion were calculated for both this and the second experiment. The correlation with Trials exceeded .92 in both experiments, while the correlation with

Errors exceeded .85. For this reason, further analysis of the special training trials was deemed unnecessary.

Test Trials A four-way (Age x Setting x Dimension x Session) analysis was performed on the test trial data. The two levels of Age, the only between subject variable, were Young and Old MA. There were also two levels of setting. The Original Settings were the settings or arrangements in which the material had always been presented during the training phase. The Novel Settings, used only during the test phase, featured the $S^+$ and the $S^-$ for each stimulus pair in positions which were the reverse of the original positions. The five test trials for each of the two stimulus pairs in the original setting were scored for correct responses. The five test trials for each stimulus pair in the Novel settings were scored for component (or compound) responses. Thus, low scores for the Novel settings reflects configurational learning.

The three levels of Dimension were Form, Colour and Junk. Although subjects were seen for six different sessions or problems, each of the three dimensions were presented only four times. The four levels of Session, therefore, indicate the temporal order in which tests for a given dimension occurred.

The results of the analysis are shown in Table 5. The significant Sessions effect reflects a slight decrease in the mean number of component responses from the first session to the final three sessions, $F(3, 30) = 3.208$, $p = .036$. Means for

Table 5

Summary Table from the Four-Way (Age x Setting x Dimension x Session) Analysis of Variance of the Test Trial Data, Experiment 1

| Source | df | MS | F | p |
|---|---|---|---|---|
| Age (A) | 1 | 74.01 | 17.83 | 0.002 |
| Error | 10 | 4.15 | | |
| Setting (Sg) | 1 | 42.01 | 29.28 | 0.000* |
| A x Sg | 1 | 34.72 | 24.20 | 0.000* |
| Error | 10 | 1.44 | | |
| Dimension (D) | 2 | 4.84 | 3.07 | 0.067 |
| A x D | 2 | 1.88 | 1.19 | 0.324 |
| Error | 20 | 1.57 | | |
| Sg x D | 2 | 6.21 | 7.73 | 0.004 |
| A x Sg x D | 2 | 3.71 | 4.62 | 0.022 |
| Error | 20 | 0.80 | | |
| Session (Sn) | 3 | 2.08 | 3.21 | 0.036 |
| A x Sn | 3 | 1.28 | 1.98 | 0.138 |
| Error | 30 | 0.65 | | |
| Sg x Sn | 3 | 1.32 | 1.71 | 0.186 |
| A x Sg x Sn | 3 | 1.03 | 1.33 | 0.283 |
| Error | 30 | 0.77 | | |

Continued

Table 5 (Continued)

| Source | df | MS | F | p |
|---|---|---|---|---|
| D x Sn | 6 | 0.85 | 0.63 | 0.707 |
| A x D x Sn | 6 | 0.58 | 0.43 | 0.858 |
| Error | 60 | 1.35 | | |
| Sg x D x Sn | 6 | 0.84 | 0.52 | 0.794 |
| A x Sg x D x Sn | 6 | 0.28 | 0.17 | 0.981 |
| Error | 60 | 1.62 | | |

*$p < .001$

sessions 1 to 4 were 4.361, 4.028, 3.986, and 4.069 respectively. The lack of any significant interactions involving Sessions suggests that the slight decrease is not related to any manipulated variable.

The remaining significant results are all lower order to the three way interaction of Age x Setting x Dimension, and so discussion will be limited to this interaction, $F(2, 20) = 4.620$, $p = .022$. The means of the twelve cells making up this interaction are plotted in Figure 3. As is evident by inspection of the graph, follow-up F tests indicated that the performance of the Young MA boys for the Novel setting was significantly different from each of the other age-setting combinations, all $Fs(1, 10) > 25.0$, $p < .01$. The other age-setting combinations did not differ from each other, all Fs being less than 1.0. In addition, it is only within the Young MA group for the Novel setting that significant differences were found across the dimensions, $F(2, 20) = 9.08$, $p < .01$. Scheffé's multiple comparison test indicated that performance on the Colour Dimension for this group differed significantly from that of the Form or Junk stimuli, $S^2 (2, 20) = 10.44$ and 16.25 respectively, $p < .05$. Performances on the Form and Junk stimuli did not differ significantly.

These data clearly support the hypothesis that younger MA mentally retarded children utilize configurational responding to a greater degree in solving discrimination problems than

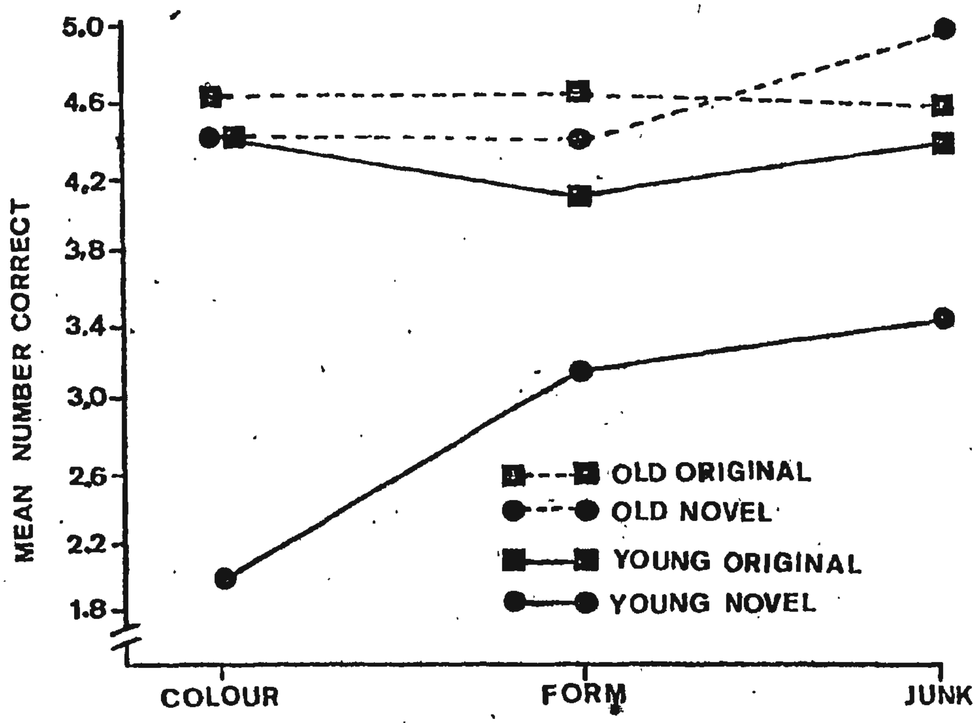


Figure 3. Mean number of correct (component) responses made by the Younger and Older MA groups to the Novel and Original settings of the colour, form, and junk stimuli, Experiment 1.

do older MA retarded children. In addition, the possibility of compound learning by the younger children can be ruled out in the present experiment. While the responding of the older MA group may be accounted for by either component or compound learning, the former is the more likely, as Barnes (1978) found his older MA group (MA range 7-13 years) to perform better on component than compound tasks. Finally, the data for the configurational learners across the dimensions agrees with the expected finding of less configurational learning on form and junk stimuli than on the less salient colour stimuli.

## Experiment 2

In the second experiment, the learning of successive and simultaneous discriminations of stimuli with two relevant and redundant components was investigated. (Figure 4 provides an illustration of the simultaneous and successive discrimination procedures.) In the successive discrimination condition, subjects were presented with two different form-colour stimuli in each session. For any given trial however, the pair of stimuli which were presented were identical, and so the child was required to learn a directional response. For example, on some trials, the child might be presented with two identical black circles, the one on the left being the $S^+$. On other trials, two identical white squares might be presented, the right-hand one being the $S^+$ for this pair. Thus, for each of the subproblems, the child had to learn a directional response based on form and/or colour. This is a configurational problem requiring responses of the type: "When black and/or circles, go left, and when white and/or squares, go right". A solution to the problem based on compounds or the individual components is impossible.[2]

In the simultaneous discrimination procedure, the subject must form a discrimination between the black circle and the white square when these are presented on the same

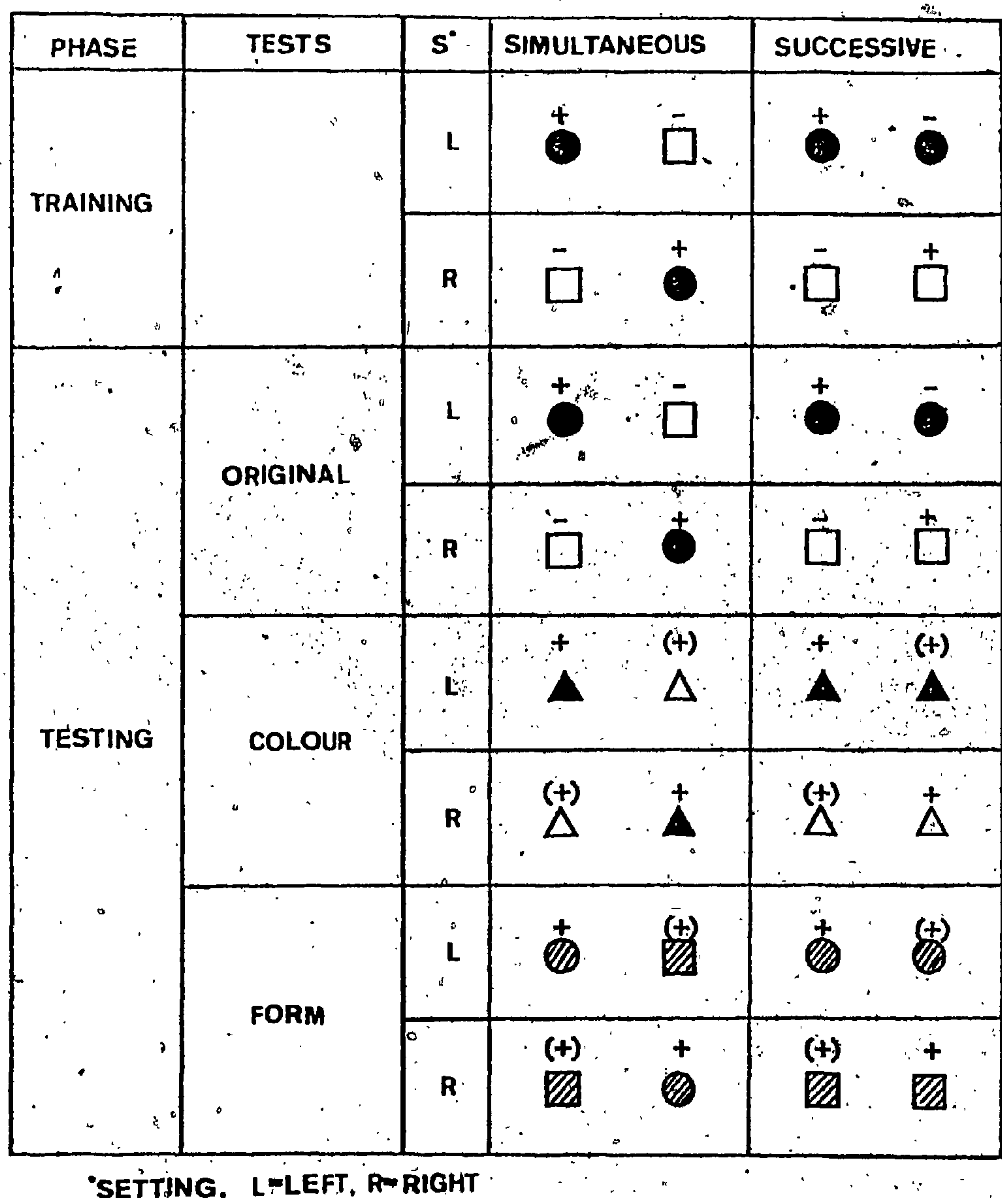


Figure 4. Illustration of the training and testing phases of the simultaneous and successive discrimination procedures used in Experiment 2. (Responses to any of the stimuli in the colour and form tests were reinforced. The "+"s not enclosed by parentheses indicate correct component responses.)

trial, the left-right positions of the stimuli being varied over trials. Only one of the stimuli, the black circle for example, is correct, regardless of its position. For the component learner, this task should be simpler than the successive discrimination, since by attending to the reinforced values of form and/or colour, the problem may be solved quickly. Similarily, the compound learner, by attending to the form-colour compound, should be able to learn the discrimination with little difficulty. However, for the configurational learner, the simultaneous task should be as difficult to learn as the successive problem since the former, like the latter, contains two configurations. In the simultaneous condition, the configurational learner must learn to go left when black circle is to the left of the white square, and to go right when the black circle is to the right of white square.

Before stating the first hypothesis of the second experiment, it is appropriate to briefly examine previous studies which have compared successive and simultaneous methods of discrimination. A number of studies, including those of Jeffrey (1961), Lipsitt (1961, Exp. 2), and Spiker and Lubker (1965), have found that the simultaneous condition results in performance superior to that of the successive problem. However, a number of variables have been identified which can make the successive problem as easy or easier to learn than the simultaneous problem. These include moving the locus of response away from the stimuli themselves (e.g. Lipsitt, 1961, Exp. 1); presenting the different settings of the discrimination in blocks rather than on a random basis (Lubker, 1967); manipulating the similarity of irrelevant components of the stimuli (Price & Spiker, 1967); and manipulating the degree of similarity between the stimuli themselves (Loess & Duncan, 1952). A difficulty with these findings is that the majority of such studies have used subjects with MAs of 60 or more months, extending upwards to college level students. Thus, little is known of the performance of the younger MA (less than 60 months) child, although a configurational approach would suggest that younger children would have relatively less difficulty with the successive problem than would the older MA child. In the present experiment, the use of stimuli which differed in both colour and form should have helped to reduce the difficulty of the successive problem for both the older and younger MA child.

The first hypothesis was that older MA children would find the successive problem more difficult to learn than the simultaneous problem, whereas younger MA retarded children would demonstrate less discrepancy in the rates at which they learned the two problems. If found, this would provide additional support for the evidence of non-component learning exhibited by the young MA subjects of Experiment I. To test this prediction, Trials to Criterion and Errors to Criterion data from the first session only were examined. Due to expected transfer effects, especially by the older MA children, an analysis over all four sessions would be less sensitive.

In addition to examining the relative difficulties encountered by the two age groups in learning the two types of discriminations, the problems were examined with respect to the learning of the form and colour components. To accomplish this, three types of test trials were presented in a random order. The first type were re-presentations of the original (training) settings. These served as a check on the original learning. The form components were tested by making the colour component irrelevant by replacing it with a novel colour. To test the learning of colour components, the colours with the form component made irrelevant were presented. Figure 4 illustrates the training and testing phases of Experiment 2.

Non-component learners would be expected to do poorly on the tests for form and colour. Hence the second hypothesis was that there would be little if any learning of the individual components by younger MA children in either training condition. (As mentioned in the introduction, some component learning could occur in the younger children if certain values of the form or colour dimensions were salient to the children.) Third, it was predicted that the older MA children in the Simultaneous condition would demonstrate more component learning than the younger MA children would in either training condition. Fourth, it was predicted that the older MA mentally retarded children would exhibit poorer component learning in the successive condition than in the simultaneous condition, as the former problem requires that the child learn the discrimination in a non-component manner.

Method

Subjects Twenty mentally retarded males, all of whom were residing in the Dr. William F. Robert's Hospital-School, Saint, John, N.B., Canada, participated in the second Experiment. Eleven of the twelve boys from the first experiment took part in the second experiment. The twelfth boy was unavailable for the second experiment as he had been discharged from the Hospital-School.

Ten boys made up the Older MA subjects. Their MAs ranged from 72 to 108 months with a mean of 83.8 months. The 10 Younger MA boys had MAs ranging from 36 to 60 months with a mean of 48.6 months. The Older and Younger MA groups were subdivided into the two experimental (Successive and Simultaneous) groups, resulting in five subjects in each condition. Assignment to groups was as random as possible given the stipulations that 1) subjects who participated in Experiment I be devided as evenly as possible amoung the four groups, and 2) that the attempt be made to match groups on the basis of CA.

Mean CAs, MAs, and IQs for the groups are shown in Table 6. Reliable Stanford-Binet IQs and MAs were not avail-

Table 6

Mean CAs, MAs, and IQs of the Four Groups in

Experiment 2

| Group | CA | MA | IQ |
|---|---|---|---|
| Young-Successive | 164.8<br>(105-235) | 50.2<br>(45-54) | 33.8<br>(22-50) |
| Young-Simultaneous | 151.4<br>(128-178) | 47.0<br>(36-60) | 32.4<br>(21-42) |
| Old-Successive | 172.2<br>(151-194) | 86.0<br>(72-102) | 52.0<br>(44-57) |
| Old-Simultaneous | 171.0<br>(154-178) | 81.6<br>(72-108) | 52.2<br>(45-69) |

_Note._ There were five subjects in each group. CAs and MAs are in months. Numbers in parenthesis are ranges.

able for three of the younger MA children, due to the limited verbal abilities of these children. In these cases, MAs for these children were obtained from recently administered Vineland Social Maturity Scales. IQs for these children were calculated using the formula: IQ = (MA/CA) x 100. This formula was also used to calculate IQs for those children tested with Alpern and Kimberlain's (1970) short form of the Stanford-Binet Intelligence Scale for whom the Stanford-Binet's Revised (1972) IQ Tables did not provide IQs due to extremes in CAs and MAs.

Two-way (MA Group x Problem) analyses of variance were performed on the CAs, MAs, and IQs. The results of these analyses are given in Table 7. The Younger MA and Older MA subjects differed significantly for both MA and IQ. Differences between subjects in the Simultaneous and Successive conditions were non-significant. All of the groups were equivalent on the basis of CA. Although MA and IQ are confounded in differentiating between the Younger MA and Older MA groups, the labels Younger MA and Older MA will be used for the sake of convenience.

Materials The eight colours and eight forms used in Experiment I were randomly paired to produce eight different form-colour compounds. The eight compounds were then randomly paired to yield four different stimulus sets, as shown in Table 8.

Table 7

Summary Tables from the Two-Way (Age x Problem) Analyses of Variance Performed on the CAs, MAs, and IQs of Subjects in Experiment 2

| Source | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|
| | | MA | | |
| Problem (P) | 1 | 72.2 | 0.55 | 0.527 |
| Age (A) | 1 | 6195.2 | 47.61 | 0.000* |
| P x A | 1 | 1.8 | 0.01 | 0.904 |
| Error | 16 | 130.1 | | |
| | | CA | | |
| P | 1 | 266.5 | 0.24 | 0.628 |
| A | 1 | 911.3 | 0.86 | 0.630 |
| P x A | 1 | 186.1 | 0.18 | 0.683 |
| Error | 16 | 1057.8 | | |
| | | IQ | | |
| P | 1 | 1.8 | 0.02 | 0.884 |
| A | 1 | 1805.0 | 20.07 | 0.000* |
| P x A | 1 | 3.2 | 0.04 | 0.847 |
| Error | 16 | 89.9 | | |

*$p < .001$

Table 8

The Stimulus Sets Used in Experiment 2

| Set | Compound I | Compound II |
|---|---|---|
| I | Turquoise-Pentagon | Dark-Brown-"X" |
| II | Dark-Blue-Trapezoid | Light-Green-Star |
| III | Tan-Cross | Dark-Green-Octagon |
| IV | Grey-Heart | Yellow-"Tee" |

Each of the stimulus compounds were drawn separately on 75 X 125 mm white index cards. The cards were laminated with clear plastic to prevent wear and facilitate cleaning. The forms measured 35 X 35 mm with 1.5 mm thick black borders. They were each solidly coloured with their assigned colours. With the exception of differences in colour and size, the forms were identical to those employed in Experiment 1 (see Appendix).

The testing phase of the sessions required that each of the form components of the training compounds be presented with colour irrelevant. Also, colour had to be presented with form irrelevant. Form-relevant, colour-irrelevant stimuli were identical to the testing stimuli with the exception that the form test-items were all coloured the novel and irrelevant colour purple. The colour-relevant, form-irrelevant stimuli were solidly coloured 3[illegible] mm diameter circles.

As in Experiment 1, presentation orders and reinforced stimuli were balanced as much as possible.

<u>Procedure</u> The experimental setting, criterion level, instructions, and reinforcement contingencies of Experiment 2 were identical to those of Experiment 1. There were only four sessions for each subject in Experiment 2, one session for each stimulus set. A total of thirty test trials were administered following training on each of the four problems. Five test

trials were presented for each of the two settings of the original (training) stimuli and their form and colour components (see Figure 4). Responses to the original stimuli during the testing phase were reinforced using the same contingencies present during the training phase. However, responses to <u>any</u> of the stimuli in the form and colour component tests were reinforced.

As in the first experiment, sessions were held on successive days. There were three exceptions to this. One boy was unavailable for testing for one day between his second and third sessions, another boy for one day between his third and fourth. The third boy was unavailable for two days between his second and third sessions.

## Results and Discussion

<u>Trials and Errors to Criterion</u> Two-way (Age x Problem) analyses of variance were performed on the Trials to Criterion (excluding the criterion run) and Errors to Criterion data obtained from the first problem administered to each child (see Table 9). In contrast to the first experiment, untransformed scores were used for these data as the skew was not excessive.

For both the Trials to Criterion and Errors to Criterion analyses, the main effect of Problem was significant, $F(1, 16) = 11.633$ and $6.277$ respectively, $p < .05$. Mean Trials to Criterion for the Simultaneous and Successive

Table 9

Summary Tables from the Two-Way (Age x Problem) Analyses of Variance Performed on the Trials to Criterion and Errors to Criterion Data for the First Session Only, Experiment 2

| Source | df | MS | F | p |
|---|---|---|---|---|
| Trials to Criterion | | | | |
| Problem (P) | 1 | 2101.25 | 11.633 | 0.004 |
| Age (A) | 1 | 101.25 | 0.561 | 0.529 |
| P x A | 1 | 2101.25 | 11.633 | 0.004 |
| Error | 16 | 180.63 | | |
| Errors to Criterion | | | | |
| P | 1 | 145.80 | 6.277 | 0.023 |
| A | 1 | 0.80 | 0.034 | 0.849 |
| P x A | 1 | 156.80 | 6.751 | 0.018 |
| Error | 16 | 23.23 | | |

conditions were 11.0 and 31.5 respectively, mean Errors to Criterion were 3.8 and 9.2 respectively. The Age effect was non-significant. The Age x Problem interactions were significant for both Trials and Errors to Criterion, $F(1, 16)$ = 11.633 and 6.751 respectively, $p < .05$. The interactions were plotted in Figures 5 and 6.

As predicted, the Young MA children performed better on the Successive discrimination relative to the Simultaneous discrimination than did the Older MA children. In fact, the Young MA children's performance on the two types of discrimination was equivalent, while the older MA children took about 14 times as many trials and made about 10 times as many errors in learning the Successive as opposed to the Simultaneous problem. These findings indicate that the Younger MA children appear to be using a configurational approach when solving discriminations involving relevant and redundant cues.

An attempt was made to analyze the Trials and Errors to Criterion data across all four sessions. As in Experiment 1, Dunlap and Duffy's (1974) procedure was used in an endeavor to minimize the marked skew but the data were too variable to allow for a satisfactory transformation. The skew may have in part been due to the improvement over sessions of the Older Successive group. By the final session they were able to learn the discrimination in only 9 trials, while making a mean of only two errors. Consequently, Age x Problem analyses were performed using subjects' mean Trials and mean Errors to

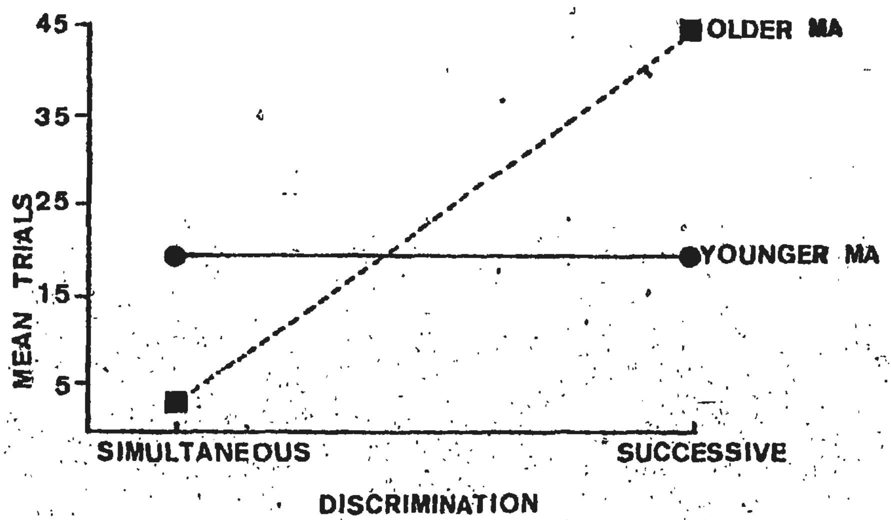


Figure 5. Mean number of Trials required by each group in Experiment 2 to reach criterion on the first session.

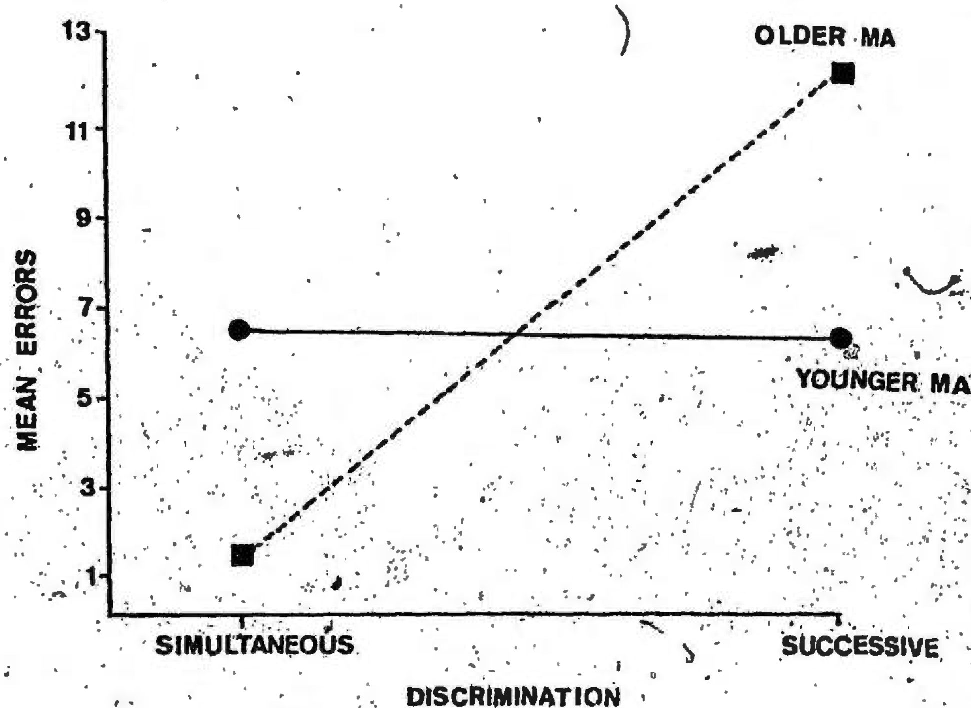


Figure 6. Mean number of Errors made by each group in Experiment 2 prior to reaching criterion on the first session.

Criterion across the four problems. A $\underline{Y} = \underline{X}^{0.383}$ transformation was used for the Trials data, while for Errors to Criterion, $\underline{Y} = \underline{X}^{0.215}$. The overall analysis was consistent with the analysis of the first session only. The Younger MA children performed almost equivalently on the Simultaneous and Successive problems while the Older MA children found the Simultaneous problem to be easier than the Successive problem. Although the main effect of Problem and the Age x Problem interaction for the overall analysis were not significant, probability levels did fall below 0.10 for both the Trials and Errors to Criterion data. In contrast to the analyses of the first session, the <u>overall</u> Age effect was significant for both the Trials and Errors to Criterion data, $\underline{F}(1, 16) = 7.33$ and 6.63 respectively, $\underline{p} < .05$. Averaged over the four sessions, the Older group took 11.9 trials and made 3.3 errors in meeting criterion for each session, while the Younger MA children averaged 27.6 Trials and 8.9 errors.

<u>Test Trials</u> A four-way (Problem x Age x Dimension x Session) analysis of variance was performed on the data obtained from the test trials. The two levels of problem were the Simultaneous and Successive discrimination conditions. The two levels of Age, the second between subjects variable,

were Young MA and Old MA. The three Dimension levels were Original (i.e. the training compound), and the Colour and Form components. There were four levels of Session. For each combination of Dimension and Session, a subject received 10 test trials and his score was the number of correct (component) responses made. The results of the four-way analysis of variance are presented in Table 10.

Two of the interactions, Age x Dimension x Session, and Problem x Session, reached significance. An inspection of the cell means upon which the former interaction was based revealed no obvious trends (see Table 11). The Problem x Session interaction, plotted in Figure 7, indicated an improvement over sessions for the Successive problem. The reasons for the drop and partial recovery of performance on the third and fourth sessions of the Simultaneous problem are unknown.

The main effect of problem was significant; there was a mean of 7.61 correct responses to the compounds and components of the Simultaneous problem and an average of 6.46 correct responses to the Successive discrimination, $F(1, 16) = 5.477$, $p = .031$. The main effect of Dimension was highly significant $F(2, 32) = 29.196$, $p < .001$. An examination of the means showed averages of 8.32, 6.61, and 6.18 correct responses to the Original (compound), Form, and Colour tests respectively. A follow up using Scheffé's

Table 10

Summary Table from the Four-Way (Problem x Age x Dimension x Session) Analysis of Variance of the Test Trial Data, Experiment 2

| Source | df | MS | F | p |
|---|---|---|---|---|
| Problem (P) | 1 | 79.35 | 5.47 | 0.031 |
| Age (A) | 1 | 40.02 | 2.76 | 0.113 |
| P x A | 1 | 13.07 | 0.90 | 0.641 |
| Error | 16 | 14.49 | | |
| Dimension (D) | 2 | 102.00 | 29.20 | 0.000* |
| P x D | 2 | 0.49 | 0.14 | 0.870 |
| A x D | 2 | 8.55 | 2.45 | 0.101 |
| P x A x D | 2 | 2.80 | 0.80 | 0.539 |
| Error | 32 | 3.49 | | |
| Session (S) | 3 | 1.30 | 0.53 | 0.665 |
| P x S | 3 | 12.49 | 5.13 | 0.004 |
| A x S | 3 | 0.89 | 0.37 | 0.780 |
| P x A x S | 3 | 3.08 | 1.26 | 0.297 |
| Error | 48 | 2.43 | | |
| D x S | 6 | 3.24 | 1.39 | 0.226 |
| P x D x S | 6 | 1.63 | 0.70 | 0.653 |
| A x D x S | 6 | 5.93 | 2.54 | 0.025 |
| P x A x D x S | 6 | 1.52 | 0.65 | 0.693 |
| Error | 96 | 2.33 | | |

*$p < .001$

Table 11

Cell Means of the Age x Dimension x Session Interaction for the Test Trial Data of Experiment 2

| Group | Dimension | | |
|---|---|---|---|
| Session | Original | Colour | Form |
| Young | | | |
| 1 | 7.8 | 6.4 | 5.6 |
| 2 | 8.7 | 5.5 | 5.8 |
| 3 | 8.8 | 5.7 | 5.3 |
| 4 | 7.7 | 5.3 | 6.9 |
| Old | | | |
| 1 | 7.9 | 6.7 | 7.7 |
| 2 | 8.2 | 7.6 | 7.2 |
| 3 | 8.3 | 5.6 | 7.3 |
| 4 | 9.1 | 6.6 | 7.1 |

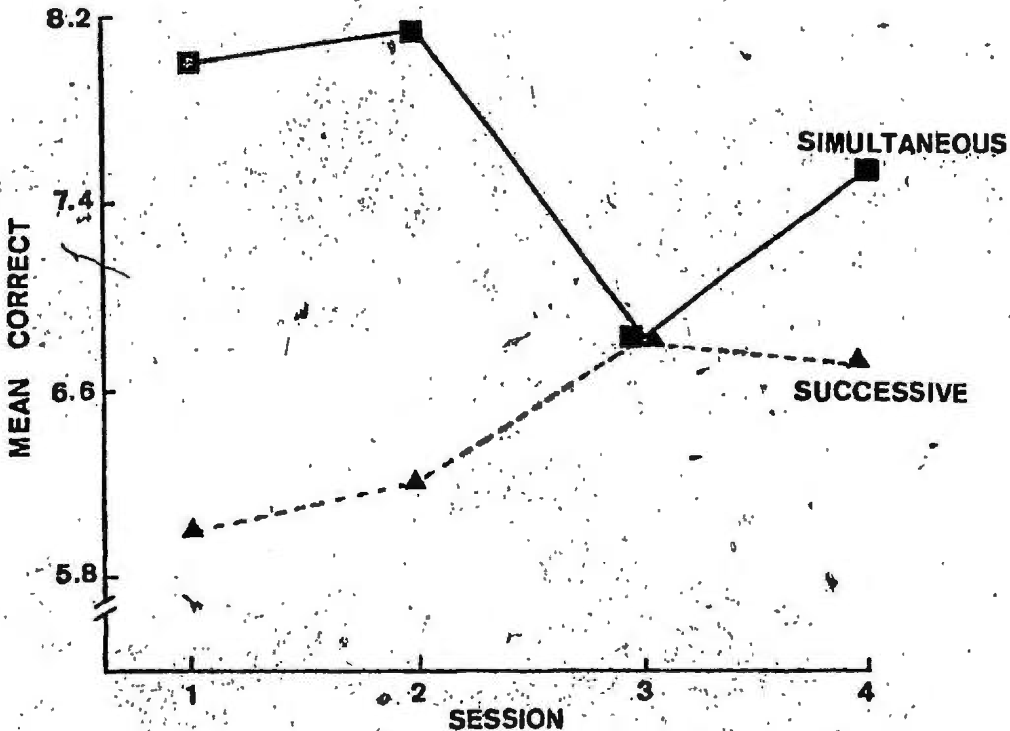


Figure 7. Mean number of correct responses given in the Successive and Simultaneous discrimination conditions across the four sessions of Experiment 2.

multiple comparison test indicated that performance on the Original test trials differed significantly from that of the Form and Colour tests, $S^2$ (2, 32) = 52.28 and 33.05 respectively, $p < .01$. An inspection of Figure 8 indicated that there was a tendency for the Form components to be better learned than the Colour components. In contrast to Experiment I, this was not found to be significant, possibly because the component learning of all but the Older MA group in the Simultaneous condition was so poor.

Cell means for the four groups on the three types of test trials are plotted in Figure 8. An inspection of this graph indicated that the performances for all groups on the test trial presentations of the Original (compound) stimuli were well above chance levels. Only the Older MA subjects in the Simultaneous condition showed any appreciable amount of learning on the transfer tests. The near floor level performances of the remaining three groups, plus the variability in cell means probably accounts for the non-significance of the Age x Problem x Dimension interaction, $F(2, 32) = 0.803$, $p = .539$.

A number of statistical tests were conducted to evaluate the transfer predictions. The total number of correct responses to the Form and Colour transfer tests, averaged across the four sessions for each subject, served as the dependent variable

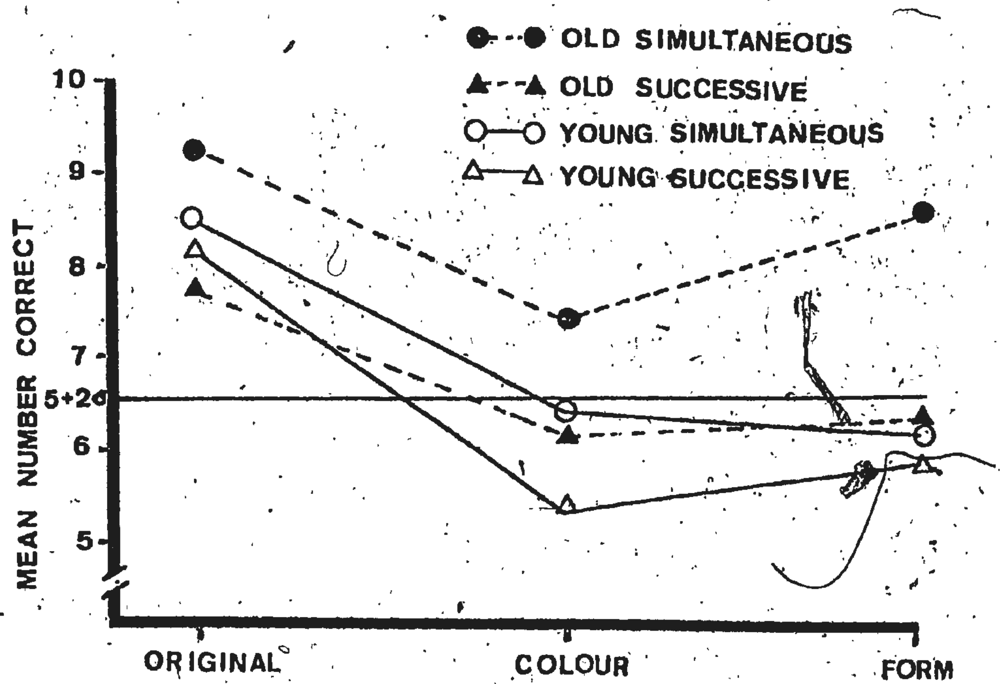


Figure 8. Mean number of correct responses made to the Original, Colour, and Form tests by each of the four groups in Experiment 2. (Note that points above the $5 + 2\sigma$ line are significantly different from chance level, which is a mean score of 5.)

for these tests. Consistent with expectations, the Younger MA Successive and Simultaneous groups did not differ significantly on the transfer tests, where they performed at near chance levels. The Younger MA subjects (collapsed across the Simultaneous and Successive problems) performed significantly poorer than the Older MA group in the Simultaneous condition, $t(13) = 2.298$, $p < .05$. These findings supported the second and third hypotheses by indicating that regardless of the problem type, component learning by the Younger MA children was poor, and inferior to that of the Older MA group in the Simultaneous condition.

The fourth hypothesis predicted that the Older MA children in the Successive condition would learn less about the components which made up the stimuli than would the Older MA children in the Simultaneous condition, as the Successive problem forces the child to learn the problem in a non-component manner. Support for this hypothesis was found in the significant difference between these groups on the transfer tasks, $t(8) = 2.36$, $p < .05$. The poor component learning exhibited by the Older MA group in the Successive condition nicely demonstrates that little component learning may be shown by children when configurations are used to solve discriminations, whether this is by choice, or in the case of the Older MA group in the Successive condition, by necessity.

## Conclusions and Implications

The results of both experiments have indicated that younger MA (range 36 to 60 months) mentally retarded children are less likely to employ a component approach to solving discrimination problems than are older MA (range 72-108 months) retarded children. In addition, the findings of both experiments would tend not to support a compound learning hypothesis. The compound learning approach suggests that younger MA children solve discriminations by attending to the stimulus as a whole rather than by giving attention to the individual components which make up the stimulus. Had the Younger MA children in Experiment 1 learned the reinforced stimulus as a compound during the training phase, then they should have continued to respond to the compound when it was presented in the novel position during the testing phase, as the compound itself had not changed. This was not the case and so the arguement for configurational learning was supported. In Experiment 2, it was possible to learn the Simultaneous problems using compounds, but compound solutions to the Successive problems were impossible. If young MA children preferred to solve problems using compounds, then, like the component learner, faster learning would be expected in the Simultaneous condition than in the Successive condition, as in the latter condition the compound learner (and the component learner) would have to learn using a non-preferred strategy (i.e. configurations). Instead, the Younger MA children in the Simultaneous and Successive conditions learned at the same rate, thus supporting the configurational hypothesis. This allows for a reinterpretation of findings of compound learning in terms of configurational learning. The Barnes' (1978) study described earlier provides a convenient example. Barnes' compound problem required the learning of two different compounds, each of which was presented in two different arrangements. Alternatively, in the light of the present findings, this problem may have been solved by the learning of the four configurations. Configurational learners, like Barnes' younger MA (5 years) subjects, would also find the component problem difficult to solve using their preferred strategy (configurations), and would thus show better learning for the "compound" problems. (The component problem would be difficult to learn by configurations since the use of ten "irrelevant" colours plus the two positional settings of the relevant form components combine to produce a total of twenty different configurations.)

Instead of attempting to interpret compound learning in terms of configurational learning, it may be more relevant to view compound learning as a transitional stage between the very rigid learning involved in configurations and the more abstract learning found in components. Developmentally, the child in the configurational stage may advance to compounds by abandoning his attention to positional features while retaining his focus on the stimulus as a whole. Subsequently, by learning to differentiate the components of the compound stimuli, the child may move on to component learning.

In the studies described early in the introduction, young MA normal and developmentally handicapped children were found to learn fewer of the components which made up the stimulus complex than did older MA children, even though both age groups did learn to respond to the complex. The present experiments have found that younger MA mentally retarded children tend to solve discrimination problems by using configurations. By learning redundant cue discrimination problems in a configurational manner, the child's attention is not focused on the individual components of the stimulus complex, and so learning of components is poor. As discussed previously, some component learning does appear to occur, but this seems limited to dimensions or cues which are especially salient to the child.

The confounding of IQ and MA in differentiating the Younger and Older MA children in the present experiments may limit the generalizability of the findings, although this confounding was also noted in many of the studies described in the introduction. Two of the studies, however, would suggest that IQ is a less important variable than MA (Eimas, 1969; Schover & Newsom, 1976). Eimas (1969) found that younger (CA 5.4 years) non-retarded children responded to fewer cues than did older (CA 9.5 years) non-retarded children, although these children had equivalent IQs. In the Schover and Newsom (1976) study, groups were matched for MA (5.5 years) but differed in IQ. These autistic (IQ 27-70) and normal children (IQ 107-152) children showed no difference in the degree of component learning they exhibited. Thus, differences in MAs, but not IQs, appear to lead to differences in "overselectivity".

The findings of the present experiments help to explain some of the problems young MA mentally retarded children experience in learning. Poor generalization would be expected of the configurational learner as learning is restricted to a particular arrangement or arrangements of the stimuli. This difficulty may be enhanced by the nature of the stimuli. For example, training colours is impossible without a form dimension of some type. If a particular form is taken by a child to be a part of the configuration, then the learning of a colour would in fact be the learning of a form-colour combination. This would suggest that special steps be taken to teach a particular stimulus (e.g. the colour red) to a child who prefers to learn by using configurations. These steps would involve constantly changing all the irrelevant dimensions associated with the stimuli (e.g. form, size, etc.) as well as constantly changing the colour from which red is being discriminated. Thus, by attempting to eliminate all the conditions under which configurational learning can occur, the child would be forced to learn by attending to the desired component, i.e. red. The component problems used by Barnes (1978) and House (1979) provide a good example of a procedure which might be used to focus a child's attention on components rather than compounds or configurations.

The suggestion to vary what are obviously potentially relevant stimuli (i.e. characteristics of the training stimuli presented to the child) to ensure the learning and generalization of a particular cue or cues could be extended to include characteristics of the training setting itself. For example, the overall configuration established by a child could include such incidental characteristics as the table used in training, the room, lighting, teacher, etc.. Rincover and Koegel (1975) have found that for some autistic children, such characteristics do become important parts of the stimulus, and generalization is poor in their absence. Thus, continuously altering the environment during training as well as the irrelevant stimulus characteristics may lead to better transfer of learning in the low functioning child.

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Footnotes

[1]Spiker (1963) and Medin (1975) have both offered theoretical analyses of discrimination learning in which position is treated as a dimension that could be part of a stimulus compound. In comparison with most of the discrimination learning models, these treatments place a much greater emphasis on the context in which a cue appears. Therefore, these theorists can handle some of the configuration data described above. We chose not to treat these models in detail in the text for two reasons. First, without some modifications, it does not appear that either of the models can handle the data obtained in Experiment 2. Second, for our purposes of exposition, it is useful not to blur the distinction between compounds (which do not include position) and configurations.

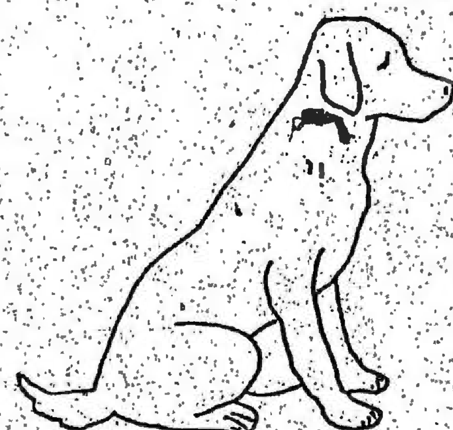
[2]This statement is true only if position does not enter a compound (consistent with the assumption we are making in this paper). The reader is referred to papers by House (1968), Medin (1975), and Spiker (1963) for the alternative viewpoint.

## Appendix

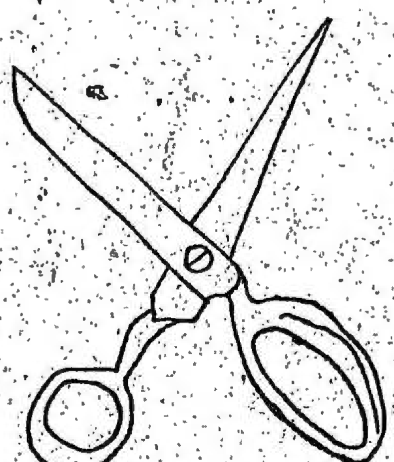
Illustrations of the stimuli. Refer to text for colour and size.

Junk Stimuli

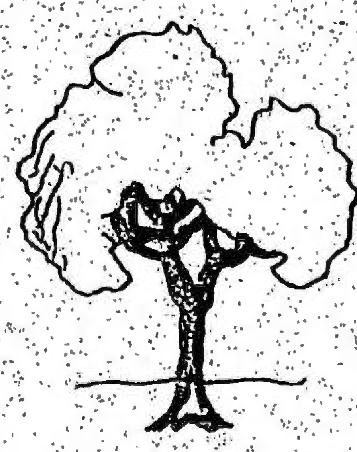
Hand$^{W}$



Dog$^{S-B}$



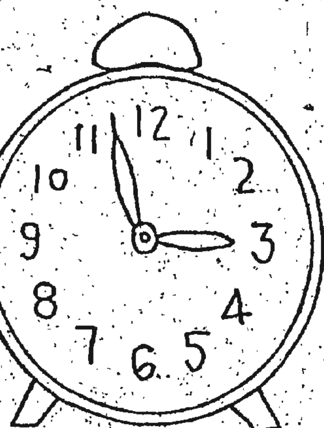
Scissors$^{W}$



Tree$^{S-B}$

Appendix (Continued)

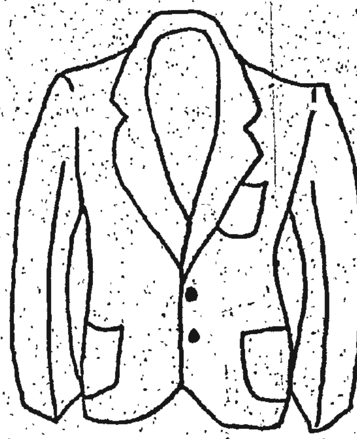
Junk Stimuli (Continued)



Clock[S-B]

Telephone[W]

Shoes[S-B]



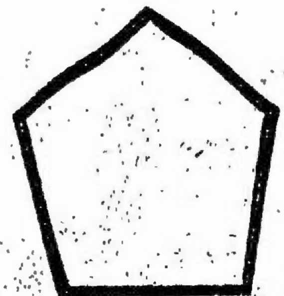
Jacket[S-B]

[S-B]Stimulus adapted from a test item used in the Stanford Binet Intelligence Scale, published by Houghton Mifflin Company, Boston, 1973.

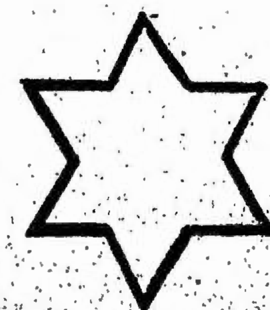
[W]Stimulus adapted from a test item of the Picture Completion subtest of the Wechsler Intelligence Scale for Children -Revised, published by The Psychological Corporation, New York, 1974.

Appendix (Continued)

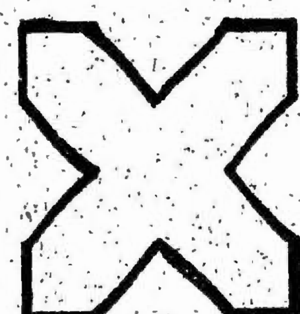
Form Stimuli



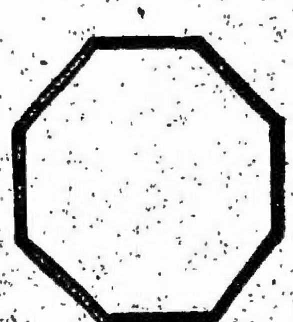
Pentagon



Star



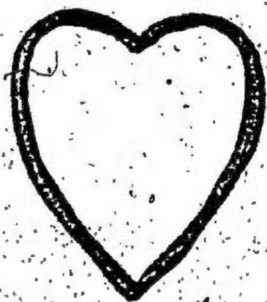
"X"



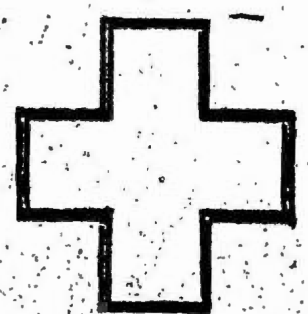
Octagon

Appendix (Continued)

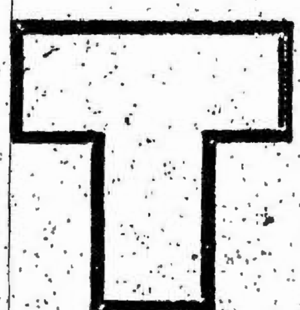
Form Stimuli (Continued)



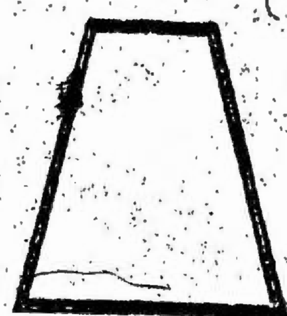
Heart



Cross



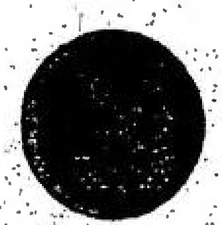
"Tee"



Trapezoid

Appendix (Continued)

Colour Stimuli



This circle illustrates the colour stimuli of Experiment 1 and the colour-component test stimuli of Experiment 2. As illustrated, the circles were solidly coloured, with the colour itself defining the circle's borders. The coloured circles used in Experiment 2 were larger than that shown. Felt-tipped markers, with the brand name "Buffalo" were used to colour the circles (and the forms). See text for the colours used.