DISCRIMINATION AND GENERALIZATION IN AUTISTIC CHILDREN

by

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ABSTRACT

The present study examined stimulus control in autistic children. A matching-to-sample procedure was employed in all experiments. In the first part of Experiment I, autistic and control subjects were trained to discriminate between a vertical line and a line tilted at an angle of 33 degrees from vertical. Following training, subjects were given a generalization test to determine the degree of dimensional control by line tilt. In the second part of Experiment I, subjects were trained to discriminate between a vertical line and lines tilted progressively closer to vertical. Experiment II was also a test for the degree of dimensional control by the line tilt. In Experiment I, the autistic subjects took a greater number of trials than the controls to reach the criterion of 24 consecutive correct trials. However, the difference in the number of trials taken by the two groups was not large. There was also little difference between the autistic and control subjects in part two of Experiment I. All of the autistic subjects successfully discriminated between a vertical line and a 2 degree line tilt to a criterion of eight consecutive correct trials. In the generalization tests in Experiments I and II, there was little difference between the autistic and control subjects in dimensional stimulus control.

In Experiment III, the autistic subjects were examined for acquisition of a multidimensional discrimination. Both autistic and control subjects were trained to match a standard stimulus with one of four comparison stimuli that were varied in shape and in the presence and absence of a star within the shape. The autistic subjects took a greater number of trials than the controls to reach the criterion of eight consecutive correct trials. However, the difference between the autistic and control subjects in the number of trials taken to reach criterion was not large.

In summary, the study found little difference between autistic and control subjects in the acquisition of simple or multidimensional discrimination. As well, there was little difference between the autistics and the controls in dimensional stimulus control. The results of the study suggest that the autistic child's problem is not one of stimulus selectivity.

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CHAPTER I: INTRODUCTION

Diagnostic Criteria of Early Childhood Autism

Early infantile (or childhood) autism was first distinguished and labeled in an article published by Kanner in 1943. Several investigators (*e.g.*, Rutter, 1968; Mahler, 1961; Creak, 1961; Rimland, 1964) have since then reported similar characteristics describing early childhood autism. The literature reviewed by Ward and Hanford (1968) suggests that the main characteristic features of the autistic child are as follows. First, the onset of the syndrome occurs at a very early age. The child is often described as being extremely aloof from the earliest months of life. He avoids eye-to-eye contact, avoids physical contact even with his parents, displays limited variations in facial expressions and is unresponsive to visual and auditory stimuli. As well, difficulty in interacting with other children is a prominent and long-lasting characteristic of autistic children. Generally, their behavior suggests an apparent lack of the ability to be socially reinforced.

Another commonly cited characteristic of the autistic child is the lack of verbal interaction with others. The child's speech is limited, never developing to a level appropriate for his age. The child incorrectly uses personal pronouns. Echolalia (repeating words just said to the child) is frequently observed. Although words ure uttered, spontaneous conversation does not take place. In some cases, speech is completely absent.

The autistic child is often described as having an obsessive desire for the maintenance of sameness. For example, the child, having started to arrange blocks in a particular pattern, may persist to do so even after the blocks have been disarranged. The tendency to maintain sameness on the part of the autistic child leads to a marked limitation in the variety of spontaneous activity in the child's behavioral repertoire. In addition, there is a tendency for the child to engage in stereotypic behavior such as rocking and spinning.

Lack of apparent neurological dysfunction is another major characteristic of early childhood autism. In most of the cases of autism described in the literature, there is no evidence of any observable neurological dysfunction or sensory deficit. Early childhood autism is most intriguing in view of the child's normal responses to sensory stimuli in the absence of any apparent physiological deficit.

Stimulus Control in Autistic Children

In defining stimulus control, Hearst, Besley and Farthing (1970) have proposed that a clear distinction be made between two types of stimulus control: stimulus *control by a specific stimulus*, and *dimensional stimulus control* which is behavioral control by different values along a specific dimension of a particular stimulus. Specific stimulus control is behavioral control by the presence *vs* absence of a specific stimulus which produces a directional effect on responding that "acts in opposition to the normal level of response strength prevailing under the experimental conditions." (Hearst et al, 1970, p. 375). An excitatory stimulus is a stimulus that develops the capacity to increase responding above the level occurring when that stimulus is absent. An inhibitory stimulus is a stimulus which develops the capacity to decrease responding below the level occurring when that stimulus is absent. The term excitatory dimensional control is applied when new stimulus values that lie at progressively greater distances along a specific dimension from an excitatory stimulus, produce a graded decremental effect of responding. The term inhibitory dimensional control is used when stimulus values that lie at progressively greater distances along a specific dimension from an inhibitory stimulus, produce a graded incremental effect on responding.

Hearst et al's definition of stimulus control makes clear the relationship between stimulus control and the traditional concepts of discrimination and generalization. Specific stimulus control is analogous to discrimination, while dimensional stimulus control is like stimulus generalization. There is an advantage in using the term stimulus control in description rather than the term discrimination and generalization because stimulus control merely describes empirical observations. Discrimination and generalization, on the other hand, describe processes and are often used as explanatory concepts. While the terms discrimination and generalization are used in this paper, they refer to specific stimulus control and dimensional control respectively.

The experiment by Jenkins and Harrison (1960) provides a good illustration of both excitatory control by a specific stimulus and excitatory dimensional control. Pigeons were reinforced for pecking in the presence of 1000 cps tone on a variable interval (VI) 20 seconds schedule of reinforcement. This nondifferential procedure failed to produce either specific excitatory control or dimensional excitatory control. The generalization gradient was flat for all values along the auditory frequency dimension. As well, there was no difference in response strength when the tone was present as compared to when it was absent. Another group of pigeons was given differential reinforcement: the 1000 cps tone was correlated with VI 20 seconds schedule of reinforcement and absence of tone was correlated with nonreinforcement. The subsequently obtained generalization gradient indicated that both specific excitatory control and dimensional excitatory control had been established. Response strength in the presence of the tone was above the level occurring when the tone was absent, indicating specific excitatory control. Other tonal frequencies that lie at progressively greater distances from the 1000 cps tone produced a graded decremental effect on responding, indicating that dimensional excitatory control had also been established. The literature concerning the establishment of stimulus control and the variables which affect stimulus control has been reviewed by Terrace (1966) and Nevin (1973).

One of the characteristic features of many children diagnosed as autistic is their unresponsivity to visual as well as auditory stimuli in the absence of any observable sensory deficit. As a result of this, a great deal of research has been done on discrimination learning in autistic children. In general, the data suggest that there is impaired visual discrimination in autistic children.

Hermelin and O'Connor (1965, Expt. 1) tested twenty children between the ages of 7 years and 14 years 6 months, all of whom had been diagnosed as autistic according to the Creak (1961) behavioral diagnostic list. Half of the children were residents in a hospital for childhood psychotics and the rest came from four different mental deficiency institutions. On the basis of their scores on the Peabody Vocabulary Test, which is a test requiring the child to identify an object from a display of four adjacent pictures, the subjects were subdivided into two groups of ten, one group consisting of those who had obtained a minimum verbal score of Mental Age (M.A.) 2 years 6 months and another group consisting of children whose scores were below M.A. 2 years 6 months. It was assumed that this subdivision reflected the level of the children's verbal behavior. The autistic children were tested for intra-dimension discrimination on four dimensions: albedo, size, shape and direction. For each of the dimensions, two examples of the stimuli were presented. Thus, subjects were presented with a black and white square and a black and white apple for albedo; a large and small circle and a large and small ball for size; a triangle with straight and curved sides and toy houses with roofs of the same shape for shape; and a vertical and horizontal line and a man standing or lying, for direction. The stimulus cards were placed over boxes, and the "correct" box had a candy hidden under it. The subject was rewarded with the candy if he pointed to or lifted the correct box.

The results indicated that children who scored higher in the verbal test did better on all intra-dimension discrimination tasks than children who had low scores. However, Hermelin and O'Connor suggested that the difference between the two groups of subjects was not simply due to the fact that the relevant cues could be named by the speaking group. Many of them could not name the relevant cue. It is possible that the verbal instructions given were too difficult for the nonspeaking autistic children to follow, or alternatively, they may have been unable to discriminate between stimuli.

There was also a significant difference in the ease with which subjects acquired the different intra-dimension discrimination. All subjects took the least number of trials to acquire discrimination of size. An increasing number of trials were taken to acquire discrimination for the dimensions of albedo, shape and direction. It is unfortunate that the authors did not include a group of normal children, or preferably, several groups of normal children of different age groups as controls. It is possible that the autistic children are comparable to young normal children in their ability to acquire intra-dimensional discrimination. Without a control group, one cannot be sure if the difficulty in discriminating shape, and especially direction, is a unique and specific problem of autistic children.

A more significant problem perhaps, is that in many of the studies conducted by Hermelin and O'Connor, subjects were not presented with a standard stimulus which indicated the correct stimulus. Successful discrimination was dependent not only on the subject's ability to detect differences between stimuli presented, but also on his ability to recall the consequences of his previous response. As such, the validity of these studies of simple discrimination ability is questionable. Over and Over (1967) have pointed out that experimental results such as those of Rudel and Teuber (1963), in which young children were found to have difficulties in discriminating between oblique lines, may not have been due to poor discrimination ability. Rather, it may have been caused by the subject's inability to remember from trial to trial what the correct stimulus was. This criticism also applies to the results obtained by Hermelin and O'Connor.

Over and Over (1967) presented two lines to 16 subjects between the ages of 5 years 6 months and 6 years and 6 months. Under the "detection" condition, the two lines were of the same orientation on half of the trials, and were differently oriented on the other half of the trials. The child was required to judge whether the lines were of the same or different orientation. Under the "recognition" condition the two lines always differed in orientation. The child was told that selecting one of the lines would always be "right" and selecting the other would be "wrong", and that his task was to indicate the "right" line on each trial. It was found that while only one subject failed to detect differences between the lines, seven out of sixteen subjects failed to select the "right" line on the recognition task. It is important to keep this result in mind in the investigation of "discrimination ability".

Notwithstanding the above criticisms, Hermelin and O'Conner have obtained some interesting findings. In another experiment (1965, Expt. II) subjects were required to solve three discrimination problems. All subjects were presented with two cardboard boxes. By lifting the "correct" box they would find a candy. In task A the boxes were at different heights from the table at which the subject was seated. One box was on the table while the other box, a short distance away from the first one, was on a small stand 12 inches above the top of the table. For half of the subjects the "correct" box was the one on the table, and for the other half of the subjects, it was the one on the stand. In task B the boxes were at the same height but one box had an arrow painted on it, pointing either up or down for different subjects. The correct box in this case was the one with the arrow. In task C the boxes were again at the same height but this time both boxes had an arrow. The arrows were pointing in opposite directions, one pointed vertically upward and the other downward. The consistent choice of either the upward or downward pointing arrow was reinforced. Presumably task A could be solved if subjects utilized the kinesthetic or visuo-spatial cues provided. Task B could be solved by distinguishing between the total amount of light reflected from the surface of the the two stimulus objects, or simply by distinguishing between the presence or absence of the arrow. The third task required subjects to perceive differing orientations of otherwise identical figures.

The subjects were twenty autistic children and ten subnormals. The autistic children were the same as those who had participated in the previous study (Hermelin and O'Connor, 1965, Expt. I). None of the subnormal controls had any positive scores on any of the items of Creak's (1961) diagnostic list for autistic children. The subnormals were selected from four different mental institutions and were matched with the autistic subjects on the scores obtained on the Peabody Vocabulary Test.

An analysis of variance comparing the autistic speaking, autistic nonspeaking and subnormal children showed a highly significant interaction between groups and treatments. The subnormal children showed no difference in the number of trials needed to reach criteria in any of the three problems. For the speaking autistic children, a significantly greater number of trials was needed to reach the criterion on task C than on task A but task B did not differ significantly from either A or C. The nonspeaking autistic children required an increasing number of trials to reach criterion from tasks A through C. They showed no difference from the other groups in learning task A, but all ten subjects failed to learn task C in sixty trials. In any case, the difference between the speaking autistic children and the subnormals was statistically nonsignificant. There was a marked and highly significant difference between the nonspeaking autistic children and the other two groups in both tasks B and C. The authors point out, however, that although inability to discriminate between stimuli of differing orientations is associated with the absence of speech, a causal relationship should not be assumed. For a further discussion on the language hypothesis of autism, refer to the Appendix.

In an attempt to explain the above findings, Hermelin and O'Connor propose that there is a tendency for autistic children to rely heavily on information from proximal receptors, i.e., kinesthetic cues. When the boxes were in different positions, discrimination was facilitated by the upward or straight ahead reaching movements. When these kinesthetic cues were eliminated and success on the task depended solely on visual cues, the performance of the autistic children dropped markedly and in some cases discrimination was never acquired. This was evident in task C.

It is possible that the above results were obtained simply because of the difficulty autistic children have in discriminating directional cues, and not because of their tendency to utilize tactual and motor cues at the expense of visual and auditory cues. In the previous study (Hermelin and O'Connor, 1965, Expt. I), it was shown that autistic children had difficulty discriminating between a horizontal and vertical line and a standing and lying man. Similarly, in task C (Hermelin and O'Connor, 1965, Expt. II), the stimuli consisted of inversely oriented figures: an arrow pointing upward or downward. However, the findings of another study (Frith and Hermelin, 1969) also seem to suggest that the strategies most efficiently used by autistic children are those based on immediate feedback from kinesthetic cues. The procedure involved in the study, however, was considerably different from the procedure of the experiments mentioned above. The subjects were presented with more of a problem - solving situation rather than a simple discrimination task. The subjects were given five sets of cards, each set containing six cards, and they were required to arrange each set of cards in the proper order. All cards had pictures printed on them so that their vertical orientation was apparent. Cards in set A and A' had straight edges and the correct arrangement of these sets would allow for a continuous line to form through the set. Sets B and B' also had lines on each segment which could be arranged in such a way as to form an unbroken line through each set. In addition, they had jigsaw-puzzle type edges, each segment interlocking with the adjacent one. Set C resembled B and B' in that it had interlocking edges but it did not have a line running through it.

In order for the child to arrange the cards in the predetermined order, it was necessary for him to adopt different kinds of strategy according to the type of information or cues provided. An exclusive use of visual cues would be the optimal strategy for sets A and A'. Sets B and B' had the same visual cues as in the previous set although the child could also rely on the tactile feedback of the interlocking edges of the adjacent cards. A minimum of visual information was given in set C, as the child had only immediate kinesthetic feedback to depend on. According to the authors, the matching of the interlocking edges was too difficult for the child to rely on visual scanning of the edges. Thus, while a strategy of using visual cues could have played a role in all tasks, they were maximized in set A and minimized in set C.

The subjects were 20 autistic, 20 subnormal and 20 normal children. The autistic children were selected according to psychiatric diagnosis, which in all cases included onset before two years of age, absence or impairment of speech, and "stereotyped and manneristic" behavior. All the subnormal children had I.Q.'s below 50 and were free from autistic symptoms. The children from all three groups were matched on their level of performance on the Frostig Test of Visual Perception. This test required the child to draw a pencil line between two printed lines and to connect dots with a straight line. The ages of the children were between six and fifteen years for the autistic group, fourteen years to seventeen years seven months for the subnormal group and three years and nine months to six years and six months for the normal group.

The results indicated that, with the exception of the autistic children who scored very low on the Frostig Test of Visual Perception, all of the children performed best on the task depending most clearly on a visual strategy (set A), and worst on the task which provided minimal visual information (set C). In contrast, the autistic children who scored very low on the Frostig Test, performed better on set C than on set A, although the difference was not significant. The provision of visual information did not seem to have any facilitating effect on the performance of the more regressed autistic children. The authors, however, did not indicate the number of errors made by the respective groups on set C. While the autistic children who scored very low on the Frostig Test may have done better on set C than on sets A or B, it is possible that the number of errors they made on set C was higher than the number of errors made by the other groups on the same set. If this was the case, it would be erroneous to infer a predominance of proximal receptors in autistic children. Rather, the results could be a reflection of the general "low level of cognitive function" in the autistic subjects, especially since the tendency to rely on motor and tactile cues was found only in the more regressed autistic children.

There is some evidence which suggests that the impaired visual discrimination of autistic children is accompanied by an inability to attend to stimuli for an extended period of time. Hermelin and O'Connor (1967) have examined the visual activity and fixation times of autistic children as compared to that of normal and subnormal children. The procedure was one in which the subject was required to place his head in a viewing box. His responses to visual stimuli displayed in the box were then observed. The measures taken were the total fixation time on any one display and the amount of change in the direction of fixation. It was argued that differences in fixation time could possibly lead to a differential amount of information yielded for the dimensions of (a) identity, (b) size, (c) colour, (d) brightness, (e) pattern, (f) complexity, and (g) meaningfulness. For each dimension, a pair of cards was presented, _e.g._, two white cards for identity; two blue cards of different sizes; a red and black card; _etc_. Perceptual activity was measured by comparing visual inspection time for the two simultaneously presented displays.

The autistic subjects were chosen from two hospitals and a special school, and each subject had been diagnosed by psychiatrists according to the criteria developed by Creak (1961). Half of the subjects had no speech and none of them had any obvious sensory or motor defects. The normal children were from a nursery school in London, while the subnormals were chosen from a mental deficiency hospital. The mean ages for the three groups were: 5 years 4 months for the control (range 4 years and 3 months to 6 years and 1 month); 14 years 4 months for the subnormals (range 10 years and 9 months to 17 years and 7 months); and 11 years 4 months for the autistic children (range 7 years to 18 years and 11 months).

Hermelin and O'Connor found that non-directed gazing increased within each 30 second period for all groups, but the autistic group had lower fixation scores than the other two groups. While the normals made frequent brief glances at the display cards, the subnormal and autistic children achieved their fixation scores by uninterrupted fixation, although the autistic children looked at each card for a briefer time period than the subnormals. In terms of perceptual activity, then, there seems to be differences between autistic and children in the other two groups, but the relationship is unclear. Visual inspection time is not a reliable indicator of the individual's ability to perceive differences. While differences in visual inspection time usually indicate that the individual has perceived differences between stimuli, one cannot infer that differences were not perceived by the individual when the visual inspection time for two different stimuli are the same. For size, brightness and complexity, the scores within pairs of stimuli were the same. However, this does not mean that differences were not perceived as the autistic children were able to acquire size and brightness discrimination in studies when an operant response was required (Hermelin and O'Conner, 1965).

The hypothesis that there is a predominance of proximal receptors over distance receptors in autistic children was incorporated by Hermelin and O'Connor into the larger theoretical framework of hierarchical organization of sensory channels. This theory suggests that information via certain sensory channels may be responded to more readily than data provided from other channels. The concept of hierarchical structure of sensory systems has been connected with the developmental process in young children. Some investigators of normal children (Birch, 1962; Zaporozhets, 1961) have formed the hypothesis of a gradual developmental change from proximal to distance receptor dominance. The concept of relative sensory dominance has also been used for investigating responses to environmental stimulation in schizophrenic children (Goldfarb, 1956). Goldfarb suggested that schizophrenic children make contact with their environment through proximal rather than distance receptor channels. In adopting the concept of hierarchical sensory organization in their investigation of autistic children, Hermelin and O'Connor(1964) suggest that there is a retardation of developmental processes in autistic children at the stage of proximal receptor dominance.

Hermelin and O'Connor (1964) conducted an experiment in order to establish the relative responsiveness of autistic children to stimuli in different sensory modalities. Visual, auditory, and tactile stimuli were used. Subjects were tested individually while seated at a table opposite the experimenter with the apparatus on the table between them. Lights were placed on either end of the display panel and buzzers were mounted behind the screen out of sight of the subject. The lights and buzzers were controlled by the experimenter. For the tactile stimulus, pieces of string were lightly tied around the subject's ankles. The experimenter, by pulling the ends of the string, could give a light tug on either ankle.

Initially, stimuli were presented singly, in succession. Subjects were trained to lift the lid of a box on the same side from which the stimulus came. Inside the correct box was a candy. In the following experimental session, pairs of stimuli were presented simultaneously with each coming from a different direction. For example, a light might appear on the left and the sound of the buzzer from the right, or any combination of the three different stimuli counterbalancing for position. During these trials there was no incorrect response; there was a candy in both the right and left boxes. It was assumed that the subject's choice of boxes over trials would reveal his preferred modality, thus demonstrating his relative responsiveness to the three different sensory modalities.

The subjects were a group of ten subnormal children and a group of ten autistic children matched for chronological age, sex and, as far as possible, I.Q. The mean age of the autistic and the control group was 12 years, ranging from 8 years 6 months to 16 years. The mean I.Q. for the autistic children was 40 points ranging from 28 to 55 points, and that for controls was 43 points with a range from 30 to 56. No child was selected for the autistic group unless he had at least three of the symptoms listed by Creak (1961). It should be noted that children with evidence of central nervous system damage were included in both the experimental and control groups, although there was no difference in the frequency of such clinical signs between the groups.

Hermelin and O'Connor found that most subjects, irrespective of diagnostic criteria, responded to light whenever a visual stimulus was a component in the combination of signals. However, when sound was combined with a tactile stimulus, most subnormals responded to sound, while the autistic children responded to the tug at the ankle. When only auditory and visual stimuli at differing intensities were used, all groups showed an increase in sound oriented responses for the loud noise/soft light combination, but the scores of the autistic children remained more evenly distributed under all modality and intensity combinations than those of subnormals. This result was taken as evidence that the responses of autistic children are determined more by the positioning of the stimulus source either to the right or left, than by different intensities or different stimulus modalities. There is, however, little justification for this conclusion as it is highly possible that the results are an artifact of the design used. It was assumed that the lights, the buzzer and the tug at the ankle were the salient cues in the experiment. However, for some of the subjects, the relationship between the particular box chosen and the candy that was found in it, may have been the determining factor. As there were no incorrect responses, some subjects may have persisted in responding to the same box throughout the experimental session regardless of the intensity or modality of the stimuli combination presented. Thus, motivation and/or susceptibility to conditioning may have been the factors involved, rather than the predominance of position responses in autistic children. More important, perhaps, is the finding that the relative dominance of the visual channel seems to have been equally established in the autistic as well as in the subnormal children. If indeed the proximal receptors are dominant in autistic children as Hermelin and O'Connor claimed, then autistic children should have responded more to the tactile stimulus than to either visual or auditory stimuli.

Briefly, the work of Hermelin and O'Connor can be summarized as follows. The longer time spent in undirected gazing by autistic subjects (Hermelin and O'Connor, 1967), suggests that they "attend" to a stimulus display for a shorter time than normal. Presumably, this could mean that autistics gain less information from the same stimulus than normals. However, whether or not the 1965 experiments indicate impaired visual discrimination is questionable as there was no standard stimulus with which the choice stimuli could be compared across trials; poor performance could be due to poor recall of the correct stimulus rather than an inability to discriminate differences between stimuli. Poor performance of autistic children in tasks involving primarily visual cues (Frith and Hermelin, 1969) is not sufficient evidence of their dependence on tactile and motor cues. As the subjects were described as having a "low level of cognitive functioning", it is reasonable to assume that trial-and-error is their favoured strategy. Assuming that a trial-and-error strategy is used for all sets of cards, the probability of making errors in arranging cards with straight edges (set A, maximum visual cues) would be greater than in other sets simply because each segment in set A would fit adjacent to every other segment in the set. Finally, the results of the 1964 study (Hermelin and O'Connor) failed to support the hypothesis of proximal receptor dominance. The relative dominance of the visual channels seemed to have been equally established in the autistics as well as in the subnormals.

While Hermelin and O'Connor and associates have attempted to explain the apparent unresponsivity of autistic children to visual and auditory stimuli in terms of a sensory hierarchical theory characterized by a predominance of the motor-kinesthetic system over that of the visuo-auditory mechanism, Lovaas and his associates (Lovaas, Schriebman, Koegel and Rehm, 1971) have argued in favour of a selective attention hypothesis. They proposed that the problem with autistic children is one of stimulus selectivity. Contrary to the findings of Hermelin and O'Connor (1964, 1965), their data have failed to support the notion that any one modality is impaired in autistic children, or that a particular modality is the "preferred" modality.

The germinal ideas underlying attention theories of discrimination learning were expressed by Lashley and Kechevsky during the 1930's. According to Lashley, during discrimination learning "a definite attribute of the stimulus is 'abstracted' and forms the basis of reaction" (Lashley, 1938, p. 81). Since Lashley, most attention theories of discrimination assume that learning occurs in two stages. For example, Zeaman and House (1963) theorized that discrimination learning requires first a central mediating response identified with attention to the relevant stimulus dimension, and, second, an instrumental response of approach to the appropriate value. All attentional theories assume that the various attributes of objects are not equally attended to. Some dimensions are vastly more salient than others, and those dimensions tend to dominate performance. Selective attention refers to the process in which an organism, when presented with multiple, redundant cues, attends to or comes under the control of, only a portion of the available stimuli (Terrace, 1966; Trabasso and Bower, 1968).

There is general agreement that individual subjects in animal experiments often attend to only one of the relevant cues. The selected cue, however, may be different for different subjects of classes of subjects (Jones, 1954; Reynolds, 1961; Sutherland and Holgate, 1966). Reynolds (1961), for example, trained pigeons on a successive discrimination in which a white triangle on red background was associated with reinforcement, and a white circle on a green background was associated with extinction. After training, the components of the stimuli were presented seperately during an extinction session. The results indicated that both aspects of the stimulus associated with extinction acquired control over not responding; neither pigeon responded to either the green background or the white circle. Different aspects of the stimulus associated with reinforcement acquired control over responding in different subjects. One pigeon responded only when the red background was presented, and the other responded only when the white triangle was presented.

It should be noted that selective attention is not always of the idiosyncratic type demonstrated in Reynolds' (1961) study. There is also systematic selective attention which has been associated with the notion of an "attending hierachy". For example, Newman (1965) found that when the stimulus associated with reinforcement is a vertical line on red background and the stimulus associated with extinction is a horizontal line on a green background, pigeons always responded to the colour rather than the line orientation. As well, it should be noted that selective attention does not always occur with redundant stimuli. Butter (1963) for example, reinforced pigeons for responding to a band of light whose wavelength and orientation could be simulataneously varied. During training the light was 550 mu and in a vertical position. In the subsequent generalization test, Butter found that the responses of pigeons had been brought under the control of both the **wavelength** and **orientation.**

In an attempt to explain stimulus selectivity, Sutherland and Mackintosh have developed a model which incorporates the idea of a stimulus analysing mechanism (Sutherland, 1963; Mackintosh, 1965). According to this account, in acquiring discrimination a subject has to learn to switch-in the appropriate stimulus analyser and then to attach the appropriate instrumental response to the outputs from this analyser. The stimulus that the subject responds to is determined by the reinforcement contingencies. Alternatively, stimulus selectivity may be explained by Rescorla and Wagner's (1972) theory of stimulus blocking. Stimulus blocking is the result of the differential rate of learning of different cues in a complex stimulus. If the rate of learning of one cue is faster than the rate of learning of the other cues, the faster learned cue blocks the learning of other cues. While both the analyzer theory and the stimulus blocking theory can account for the Newman type of result, and the Butter type of result, neither can apparently handle the Reynolds type of result.

According to Lovaas, the failure of cognitive, social and emotional development in autistic children is due to deficiencies in attentional mechanism. This inference was made on the basis of the results obtained from the following experiment. Lovaas, Berberich, Perloff and Schaeffer (1966) presented both verbal and visual cues to mute autistic children to facilitate their verbal training. The child could clearly see the teacher's face when she pronounced the various sounds, such as "mm" which has auditory and visual cues quite distinct from "ah". When the visual cues associated with the sound were removed, as when the teacher purposely covered her face, the child's performance showed a marked decline. The distinction was made between "nominal" stimulus which consisted of the total set of the available elements, and "functional" stimulus which is that part of the total stimulus which actually controlled behavior. The authors' explanation of the marked decline in the child's performance following the removal of the visual cues was that the visual cues comprised the functional component of the stimulus and consequently, in its absence, performance could not be maintained at the same high level.

In another study (Lovaas, Schriebman, Koegel and Rehm, 1971) subjects were reinforced for responding in the presence of a stimulus display and were not reinforced for responding in the absence of the display. The experimental set-up was very similar to that of Hermelin and O'Connor's 1964 experiment. The subject was seated in front of a table, on which a box, with a 3 inch bar protruding from its front, had been placed. The box dispensed a candy each time the bar was pressed. Sound equipment and one-way vision screens connected the experimental room to an observation room from which the experimenter controlled the various experimental procedures. Three kinds of stimuli were employed: a visual stimulus, which consisted of a 150 W red floodlight mounted on the ceiling behind the subject; an auditory stimulus, consisting of white noise fed from a tape recorder into a speaker above the subject; and a tactile stimulus applied by forcing air into a blood pressure cuff fastened around the subject's left calf. Subjects were trained to press the bar whenever the stimulus complex was presented. When the subject failed to give any evidence of decreased rate of responding during the interval between stimulus complex presentations, the experimenter would deliver a loud "no" over the intercom contingent on such a response. After the child had been brought under the control of the stimulus complex, components of the stimulus complex were presented singly to assess which aspects of the stimulus complex had acquired control over the child's behavior. The subjects were made up of a group of autistic children, a group of retardates, and another of normal children. The mean chronological age was 7 years 2 months (range 4 to 10 years) for the autistic group, 8 years (range 7 to 10 years) for the retarded group, and 6 years 4 months (range 6 to 7 years 6 months) for the normal group.

In general, there was a great deal of variability in the acquisition of the discrimination. It was reported that the normal subjects learned to respond to the stimulus complex and not to respond in its absence within a matter of minutes. The retarded subjects required, on the average, less than 30 minutes of training, while the autistic group required twice as many sessions as the retardates. In the second part of the experiment there were significant differences between groups in the number of stimulus components which produced responding. A statistical analysis of the data indicated that the autistics responded primarily to one stimulus, retardates to two and normals to all three components. The normals gave no evidence of a preference among the cues, or that they were selectively attending to some cues and not to others. Of the five autistic children tested, two responded primarily to visual cues and three to auditory stimuli. It should be noted that the responses of the autistic children were weakest, and in one case totally absent, for the tactile stimulus. These observations are the opposite of the findings of Hermelin and O'Connor, and are in direct contradiction to their hypothesis of a predominance of proximal receptors in autistic children. If indeed there was a predominance of proximal receptors in autistic children, as Hermelin and O'Connor had hypothesized, then the autistic children in Lovaas *et al*'s study (1971) should have responded primarily to the tactile stimulus.

The generalizability of Lovaas *et al*'s findings are somewhat limited as the autistic children in the study were extremely regressed. Four of the subjects were mute and gave only sporadic responses to the most elementary commands, *e.g.*, "sit down", "come here". Three had early histories of suspected deafness, were inpatients, and, in all likelihood, faced permanent hospitalization. Two of the subjects were not toilet trained and could not dress themselves. Different results may have been obtained had the autistic children been less regressed.

Lovaas *et al* interpreted their results in terms of nominal and functional cues (*i.e.*, selective attention). They suggested that the autistic child's problem is "stimulus overselectivity", or the tendency to attend to only a small portion of a stimulus complex, and because he is reinforced for responding to it, the subject does not broaden his learning to other relevant cues.

Traditionally, the term stimulus selectivity is used to refer to the tendency to attend to or come under the control of only a portion of the stimulus array available, when the stimuli are multidimensional as in Reynolds' (1961) study, or when the stimuli are multimodal as in the study by Lavaas et al (1971). The concept of stimulus selectivity can be broadened to include steep generalization or dimensional gradients and the ability to discriminate between stimuli that lie close together on a specific dimension. Steep dimensional control gradients would be produced if a subject responds to a very small range of stimulus values that lie along a particular dimension, with maximum response strength occurring at that stimulus previously associated with reinforcement. Fine discriminations would indicate that the subject is being selective to the stimulus responded to. If the problem with autistic children is stimulus selectivity, then one would expect them to be able to discriminate small differences between stimuli, and that in a generalization test, the subsequent gradients produced would be steep.

It is possible that the autistic child's obsessive desire to maintain sameness is due to extreme stimulus-selectivity or stimulus control. For example it has been observed by the present writer that in teaching the autistic child self-care skills, for example, tying shoelaces, it was necessary to adhere to the exact sequence of steps. Any change in the sequence of steps resulted in the child not completing the task. In the study by Lovaas et al (1971), the autistic child's differential response to the stimulus complex and elements of the stimulus presented seperately could be viewed as evidence of sharper stimulus control in these subjects compared to the normal subjects. In Hermelin and O'Connor's study (1964), it was shown that the autistic children were unresponsive to the sound/light combination and instead persistently responded to the same box under which he found a candy. It is not unreasonable to argue that the child's behavior had been brought under the control of the box rather than the signals. It should be noted that while selective attention or stimulus control is an important and necessary asset in coping with the numerable and complex stimuli that an individual is confronted with daily, the tendency to the extreme is undesirable. It is possible that extreme stimulus selectivity or stimulus control might contribute importantly to the autistic child's failure in the acquisition of new behavioral topography, and, as such, it has significant implications for the type of remedial program he should receive for the learning of new skills.

Purpose of Present Research

The purpose of the present study was to provide additional data on stimulus control in autistic children. During training in Experiment I, both autistic and normal children were examined for their rate of acquisition of stimulus control. Subjects were presented with a vertical line and a line tilted at angle of 33 degrees from the vertical and were reinforced for responding to the vertical line. The number of trials taken to reach criterion were recorded. It should be noted that in Hermelin and O'Connor's (1965) experiment, the autistic subjects had great difficulty in discriminating between a vertical and horizontal line.

Following training in Experiment I, and in Experiment II, subjects were given a generalization test to determine the degree of control by the line tilt. The subsequent generalization gradients provided data on dimensional stimulus control in autistic children. Most of the studies on discrimination learning in autistic children have neglected to look at dimensional control in autistic children. As well, in part two of Experiment I, subjects were trained to discriminate between a vertical line and lines tilted progressively closer to the vertical. If the autistic child's problem is "stimulus overselectivity" as Lovaas _et al_ have suggested, then stimulus control by line tilt may be greater in autistic than in control subjects, _i.e._, the autistic subjects may be controlled by deviations of line orientations from the vertical to a greater degree than the control subjects.

Experiment III was designed to test if autistic children can learn a multidimensional discrimination. Autistic and control subjects were trained to choose,from four comparison stimuli that differed both in shape and in the presence or absence of a star within it, one stimulus that matched the standard stimulus. The autistic subjects in Lovaas _et al_'s study (1971) had great difficulty in acquiring discrimination of the complex stimulus. For example, one autistic child was run for a total of 5 sessions a week for three months and still responded less than 80 percent of the time to complex stimulus. While Lovaas _et al_ interpreted the data in terms of stimulus selectivity, it is possible that the results were produced as a result of the autistic subjects failure to learn multidimensional discrimination.

CHAPTER II: EXPERIMENTS

Three experiments were conducted to examine stimulus control in autistics. In all three experiments a matching-to-sample procedure (Stoddard, 1968) was employed and the same subjects were used. The purpose of Experiments I and II was to examine dimensional control by line tilt after line tilt discrimination training. The purpose of Experiment III was to examine acquisition of multidimensional discrimination.

Experiment I

Subjects were trained on a matching-to-sample procedure to discriminate between a vertical line and a line tilted at 33 degrees from the vertical. They were then given a generalization test to determine the degree of control by line tilt. Following the generalization test, subjects were trained to discriminate between a vertical line and a line tilted progressively closer to the vertical.

Method

Subjects

The subjects were 6 to 9 year old boys. Three of the subjects were autistic, and four were control subjects.

Autistic Subjects

Subjects for the autistic group were from Laurel House which is located in Vancouver at 1896 West 15th Avenue. Laurel House is a government-subsidized home for children with behavior disorders. It accomodates about twelve to fifteen children. Most of the children are in residence, while others are on a day program. There are twelve members on the staff, including the secretary and the cook. Each staff member is responsible for only three children during a work session. Behavior modification procedures (cf. Ayllon and Azrin, 1968) are used. Special attention is devoted to the improvement of verbal behavior. Activities such as skating, swimming and an afternoon at the gym are included in the program. The type of reinforcement used varies for different children, but social reinforcement is used extensively. A child is given a six month trial period on the program and if, during this trial period no change is observed, therapy is discontinued and the child is returned to his home.

In comparison with some of the descriptions of autistic children in the literature, the three autistic subjects chosen for the study generally did not possess extremely severe behavior disorders. However, they had all been diagnosed as autistic by two or more psychiatrists, did not suffer any sort of physical handicap or sensory deficit and had all been toilet trained. Their ages were, SA 1:5 years 11 months; SA 2:9 years; SA 3:8 years 4 months. (The abbreviation SA will be used to refer to the subjects in the autistic group). Only SA 3 was a resident at the house.

Information about the subjects' verbal, perceptual, motor and social behavior was obtained from the therapists in charge, who had in turn obtained the information from a questionnaire taken from a study by Wing (1968) on the handicaps of autistic children.

Verbal Behavior: All three boys spoke intelligibly. They spoke in sentences of three words or longer and followed simple instructions given in short sentences. SA 1 and SA 2 articulated words very clearly, but SA 3 sometimes tended to produce distorted sounds; for example, he would say "boar" instead of "ball". SA 1 and SA 3 sometimes engaged in echolalic speech. All three rarely initiated or took an active part in conversation.

Visual and Perceptual Behavior: It was difficult to achieve eye-contact with SA 1 and SA 2. All three subjects could place different objects into their appropriate cutouts in a board, a task very similar to the Sequin Form Board utilized by Hermelin and O'Connor (1965) in their research. The subjects responded correctly to the words up-down, in-out, and over-under. However, they seemed to have difficulty in left-right orientation.

Motor Behavior: Abnormal body movements were evident in SA 1 and SA 2. SA 1 frequently walked on tip-toes and often ran around and around in a circle. SA 2 frequently held his hands near his eyes, twisting and turning his fingers. He would sometimes injure himself by scratching and picking at his hands and legs. SA 3 seemed to display less abnormal body movements although he tended to get overly upset when not allowed his own way. For example, he would loudly protest if he was not allowed to continue colouring his book. Other abnormal body movements of all three subjects were repeated grimacing when excited and, as in the case of SA 1 and SA 3, frequently flinching unexpectedly.

Work and Social Behavior: The children's behavior was characterized by a distant and aloof manner; interaction with other children whether at work or play, was absent. All activities such as colouring, cutting up shapes from paper, putting away toys in a box, *etc*., had to be supervised by an adult, although this was more marked in SA 1 and SA 2 than SA 3.

The above children were chosen for this study because they met with the diagnostic criteria of early childhood autism as defined in the previous chapter. They were also chosen because they could follow simple instructions.

Control Subjects

The subjects for the control group were children from a parochial school, The Holy Trinity Elementary School, in North Vancouver. They were four boys, two from Grade Two, and two from Grade Three. Their ages were: SC 1:8 years 7 months; SC 2:8 years 8 months; SC 3:8 years 9 months; SC 4: 8 years 8 months. (The abbreviation SC will be used to refer to the subjects in the control group.) The subjects in the control group were free from all diagnostic characteristics of autistic children, and did not have any physical handicap or sensory deficit. They were rated by their teachers as average students.

Stimuli

Subjects received training and test trials on a matching-to-sample procedure. The stimuli consisted of lines of different orientation. The lines were approximately 56 mm long by .5 mm wide and were drawn with a black felt pen on white cards 22.5 cm by 30.3 cm. The standard stimulus (vertical line) was drawn on the upper half of all cards. The two comparison stimuli were drawn on the lower half of all cards. The comparison stimuli always consisted of a vertical line (which matched the standard) and a line tilted from the vertical. To preclude position discrimination, the position of the vertical and tilted lines were counterbalanced. The tilted line randomly appeared on the right-hand side of the card 50 percent of the time and on the left side 50 percent of the time.

The comparison stimuli of all training cards consisted of a vertical line and a line tilted 33 degrees from the vertical. When position and direction of tilt were counterbalanced there were four training cards; tilt in the clockwise direction on the right side of the card; tilt in counterclockwise direction on the right side of the card; tilt in clockwise direction on the left side of the card; tilt in counterclockwise direction on the left side of the card.

The test cards had, in addition to the vertical standard and vertical comparison, one of ten different line tilts: 1^{o}, 2^{o}, 4^{o}, 6^{o}, 9^{o}, 12^{o}, 15^{o}, 21^{o}, 27^{o}, and 33^{o}. Position and direction of tilt were counterbalanced.

The cards were presented on a wooden board that was raised towards the subject at an angle of 30 degrees from the table.

Procedure

All subjects were individually tested by the same experimenter (J.A.). The control subjects were tested at the school they were attending; the subjects in the autistic group were tested at Laurel House.

On entering the room, the subject was seated at a small table so that he was directly facing the stimulus cards with the standard stimulus at eye-level. The experimenter was seated to his left. The experimenter told the subject that he was going to play a game and that the subject would receive a marble if he was correct. However, the experimenter explained that because there were not enough marbles, the subject would sometimes not receive a marble even though he was correct, but that he was not to worry, because the experimenter was keeping track of his responses by recording them on paper. The subject was also informed that a marble would be withdrawn for every incorrect response (cf. Winer, 1962).

The reinforcers were brightly coloured marbles. A clear plastic container was placed near the subject in a position where he could clearly see it. At the beginning of a session, the experimenter and the subject together counted ten marbles and placed them into the plastic container. The subject was then shown a matchbox toy and told that if he earned sufficient number of marbles he could have the toy in exchange for the marbles at the end of the session. During the second training session, the experimenter informed the subject that the number of marbles he had at the end of the session would determine the type of toy he could obtain. If he obtained a great number of marbles at the end of the session he was entitled to a more attractive toy.

All subjects were reinforced for choosing the vertical comparison. The instructions to the subjects were: "Touch the line that is like the line above.". Reinforcement was presented only when the subject had placed his whole hand on the comparison stimulus or when he had one or more of his fingers touching it. When the subject failed to touch either of the lines, the experimenter repeated the instructions until he did.

Each subject received two training sessions and three test sessions. The sessions were conducted on different days with not more than three days intervening between two sessions. Training started with a continuous reinforcement (CRF) schedule on which the subject received a marble for every correct response. The subject lost a marble for every incorrect response. After 12 consecutive correct trials, the schedule was gradually shifted to fixed ratio 2 (FR2), fixed ratio 3 (FR3) and fixed ratio 4 (FR4). Each shift from one schedule to another was preceded by 12 consecutive correct trials. On the FR2 schedule, the subject was reinforced for every second consecutive correct response. Similarly, on the FR3 schedule, the subject was reinforced for every third consecutive correct response, and on FR4, reinforcement was presented for every fourth consecutive correct response. An incorrect response was always followed by the withdrawal of a marble. On the unreinforced trials the subject's response was recorded and the next trial initiated. Sometimes the subject questioned the experimenter as to why he had not received a marble. The subject would then be reminded that even though he was correct, he would not always receive a marble because there were not enough marbles, but that he was not to worry, because the experimenter was keeping record of his responses. Otherwise, verbal interactions were kept to a minimum, although the experimenter would, on occasion, repeat the words "Touch the line that is like the line above", when it seemed that the subject was not attending to the task. The duration of the intertrial interval was approximately 10 seconds.

The training session terminated when the subject had reached a criterion of 20 to 24 consecutive correct trials on the FR4 schedule or after 40 minutes, whichever came first. After two training sessions, test sessions commenced. Prior to all test sessions, subjects received a brief training session to ensure that their responses would be maintained by the FR4 schedule. The session started with a CRF schedule which was followed by FR2 and FR3 schedules. Each shift was preceded by four consecutive correct trials. After 6 consecutive trials on the FR3 schedule, the FR4 schedule was introduced and maintained until the subject had achieved 12 correct trials. The test cards were then presented.

Fifty-three cards were presented during test sessions. Thirteen were training cards (vertical and 33 degree line tilt comparison stimuli), and forty were test cards which had as one comparison a line tilt that more closely approached vertical. During testing, an attempt was made to maintain the same schedule that was used during training. The trials were presented in blocks of four. Each block consisted of the presentation of three test cards followed by a training card. There were, altogether, twelve such blocks; the last and thirteenth block of trials consisted of the presentation of four test cards followed by a training card. The last card of every block was the critical card for reinforcement. If the subject responded correctly on this trial (i.e., chose the vertical comparison), he received a marble. An incorrect response to this card resulted in the loss of a marble.

The subject's responses to each test stimulus card were recorded. Subjects did not receive marbles for correct responses to the test cards. If a subject questioned the experimenter about not being reinforced on these trials, the experimenter would repeat that there were not enough marbles and hence the subject would not receive a marble for every correct response. Incorrect responses to the test cards did not result in the withdrawal of marbles. Except for pre-arranging for a training card to appear at the end of every block, the order of test card presentation was random.

Following the third test session, subjects were presented with a different training task. The aim of the task was to determine the number of trials necessary for a subject to discriminate between a vertical line and a tilted line to a criterion of 8 consecutive correct trials. As in the first part of the experiment, subjects were presented with the standard stimulus (vertical line), a vertical comparison line, and a comparison line tilted from the vertical either 12^{o}, 9^{o}, 6^{o}, 5^{o}, 4^{o}, 3^{o}, 2^{o}, or 1^{o}. Position and direction of tilt were counterbalanced and the four cards for each line tilt made up a set. This task is different from the previous task in that a particular line tilt was presented repeatedly to the subject until a criterion of 8 consecutive correct trials was reached or after 28 presentations of that line tilt had been made.

The first set of cards presented was the one with the vertical and 12° comparison line. The subject was reinforced for choosing the vertical comparison. For every correct response, the subject received a marble. Every incorrect response was followed by the withdrawal of a marble. When the subject had reached the criterion of 8 consecutive correct trials, the experimenter proceeded to present the next set of cards, that is, those with the vertical and the 9° comparison. The procedure was then repeated. The procedure was also repeated for the 6°, 5°, 4°, 3°, 2° and 1° comparison line tilts in that order. If the subject failed to reach criterion after 28 presentations of a particular line tilt, the experimenter proceeded to present the next set of cards.

Results

Table I shows the number of trials taken by subjects to reach **criterion of 24 consecutive correct** trials on the FR4 schedule during training in the first part of Experiment I. As can be seen in Table I, the autistic subjects took a greater number of trials to reach the criterion of 24 consecutive correct responses on the FR4 schedule during training, than did the control subjects. The least number of trials needed to complete a training session was 60 trials. Each shift from schedules CRF to FR2 and FR3 had to be proceeded by 12 consecutive correct trials, and the criterion for the FR4 schedule was 24 consecutive correct trials. Subjects SA 1, SA 2 and SA 3 in the autistic group took 82, 78 and 67 trials respectively. The average number of trials for the group was 75.67 trials. All of the control subjects with the exception of SC 1, took only 60

Table I

Number of trials taken by subjects to reach criterion of twenty four consecutive correct trails on the FR4 schedule during training in the first part of Experiment I. The minimum number of trials needed to complete a training session was 60.

Group	Number of trials to criterion
Autistic Group	
SA 1	82
SA 2	78
SA 3	67
Control Group	
SC 1	62
SC 2	60
SC 3	60
SC 4	60

trials to reach criterion during training. SC 1 made two errors at the beginning of the training session and acquired after 62 trials. The average number of trials taken by the control subjects to acquire criterion was 60.5.

In the test for the degree of control by the line tilt, little difference was found between autistic and control subjects. The tendency to choose the tilted line rather than the vertical line on the test cards, was greater for the control subjects than the autistic subjects (see Fig. 1). Figure 1 shows the number of responses made by autistic and control subjects to the various line tilts during test for stimulus control in Experiment I. The average number of times that the non-vertical line tilt was chosen during the presentation of test cards was 11 for the control group and 9.33 for the autistic group (see Fig. 2). This was calculated from Figure 2 which shows the total number of responses to the non-vertical comparison line tilts made by autistic and control subjects. None of the autistics chose line tilts greater than 4^{o}. However, SC 3 of the control group chose the tilted line when presented with a vertical and 9^{o} line tilt.

In the second part of Experiment I, subjects were required to discriminate between a vertical and tilted line to a criterion of 8 consecutive correct trials. Again, there was little difference between the autistic and control subjects (see Table II). Table II shows the number of trials taken by subjects to reach criterion in Experiment I part two. As can be seen in Table II, two of the autistics and three of the controls failed to reach criterion of 8 consecutive trials when presented with a vertical

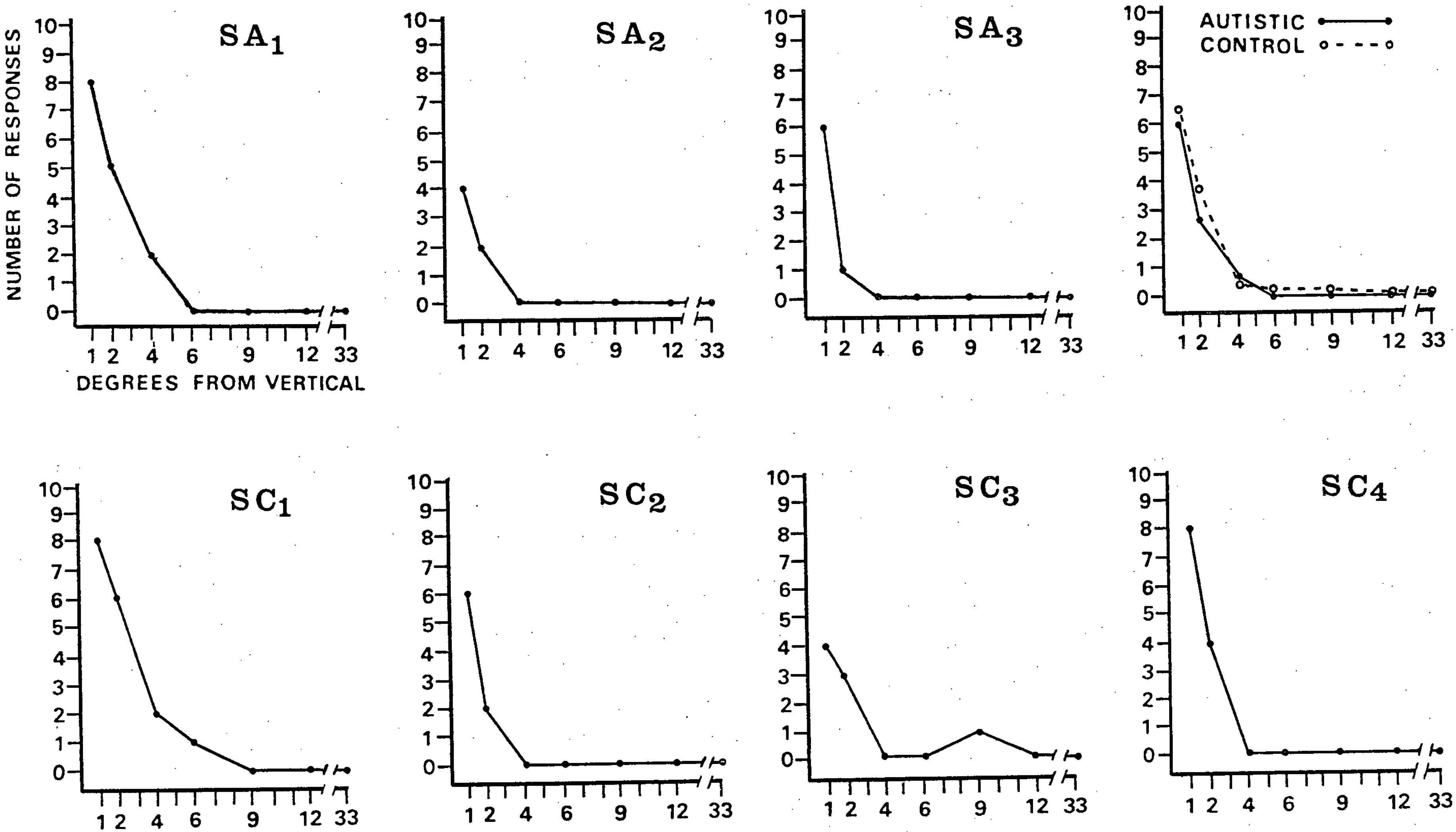

Figure 1: Number of responses made by autistic and control subjects to the various line tilts during test for stimulus control in Experiment I. The top right-hand panel gives the average number of responses to the line tilt made by each group.

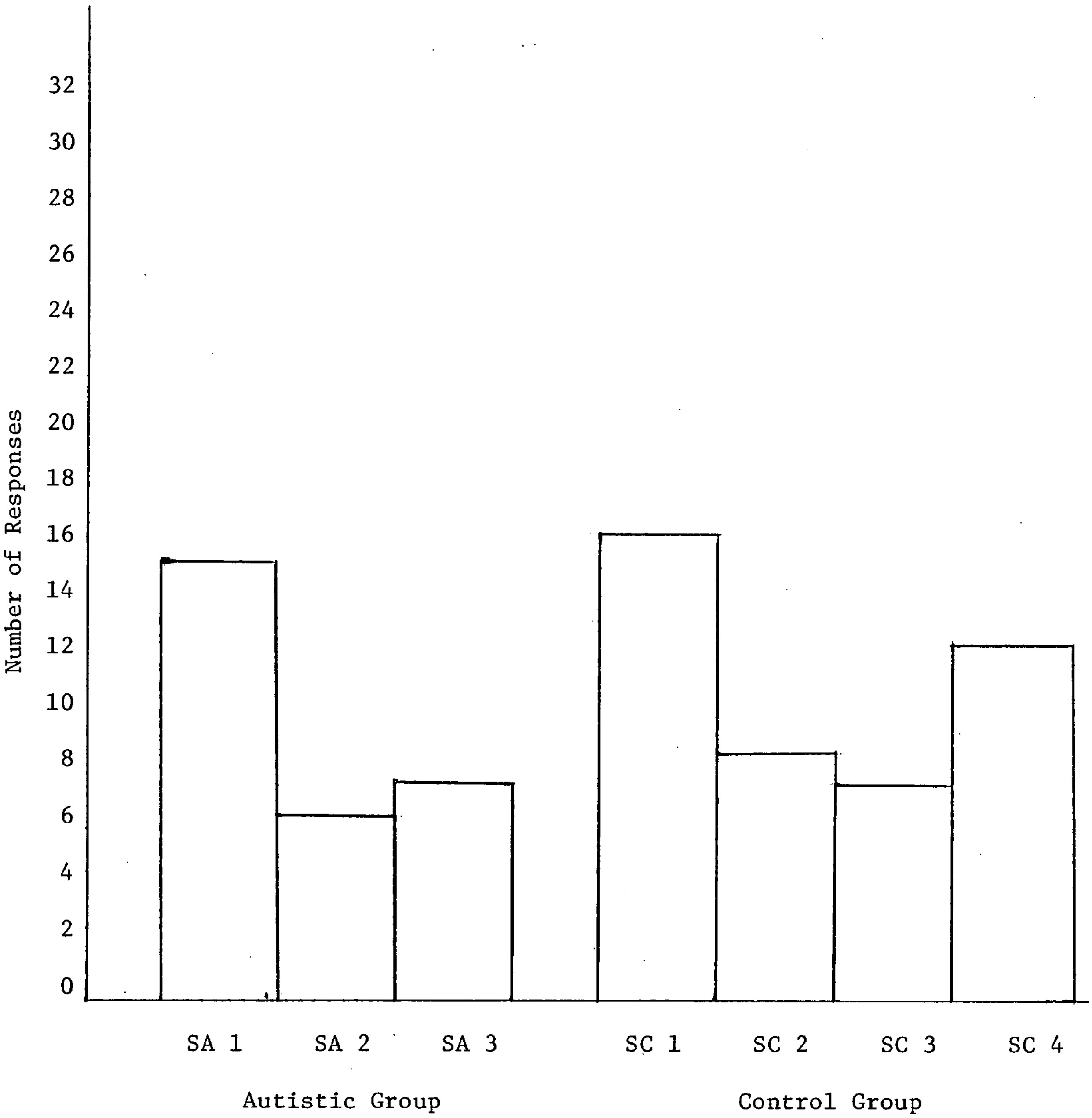

Figure 2: Total number of responses to non-vertical comparison line tilts made by autistic and control subjects in Experiment I, part 1.

Table II

Number of trials taken by subjects to reach criterion of eight consecutive correct trials in Experiment I part two. The symbol * indicates that subject did not reach criterion.

Group	Line Tilt (degrees from vertical)							
	12	9	6	5	4	3	2	1
Autistic Group								
SA 1	8	8	8	8	8	16	13	*
SA 2	8	8	8	8	8	8	16	26
SA 3	8	8	8	8	8	8	16	*
Control Group								
SC 1	8	8	8	14	9	12	24	*
SC 2	8	8	8	8	8	28	*	14
SC 3	8	8	8	8	8	8	8	*
SC 4	8	8	8	8	8	8	17	*

and 1^{o} line tilt. Only SC 2 of the control group failed to reach criterion when presented with a vertical line and a 2^{o} line tilt. All other subjects reached criterion on the 2^{o} line tilt, although the number of trials needed to reach criterion varied considerably between subjects. This was especially so for the control group. For example, SC 3 took only 8 trials to reach criterion while SC 1 took 28 trials to reach criterion. For line tilts greater than 3^{o}, none of the autistic subjects took more than the minimum number of trials to reach criterion, i.e., 8 trials. However, in the case of the control group, SC 1 took 9 trials to reach criterion on the 4^{o} line tilt, and 14 trials on the 5^{o} line tilt.

Discussion

The only apparent difference between the autistic and control subjects found in Experiment I was the number of trials taken to reach criterion of 24 consecutive correct trials on the FR 4 schedule during training. Although the autistic subjects needed more trials than the controls to reach criterion, this difference was not extremely large. Also, this difference was not replicated the second part of Experiment I, in which subjects were required to discriminate between a vertical and a tilted line to a criterion of 8 consecutive correct trials.

In the subsequent test for the degree of control by the line tilt, there was no apparent difference between the two groups. It is possible that the task in Experiment I was too simple to detect any differences in dimensional stimulus control between the groups. Given the length of the lines in Experiment I, even a 2^{o} line tilt showed a noticeable displacement from the vertical. However, a shorter line that is tilted at the same angle from the vertical would show less spatial displacement from the top of the vertical, thus making it more difficult to detect differences between comparison stimuli. Differences between the autistic and control subjects in dimensional control by line tilt might show up more clearly if differences between the vertical lines and the tilted lines were made smaller. Thus, in Experiment II, the lines were shortened. In addition, the angle of the line tilts was varied at smaller intervals. For the line tilts less than 4^{o}, the angle of the tilts was varied at $1/2^{o}$ intervals.

Experiment II

The general procedure was the same as that in Experiment I, part one, with the exception that the standard and comparison stimuli consisted of shorter lines and the angle of the tilted comparison was varied at smaller intervals during the dimensional control test.

Method

Stimuli

The stimuli were basically the same as those in Experiment I. They consisted of lines of different orientations drawn with a black felt pen on 22.5 cm by 30.3 cm white cards. The lines were 19 mm long by .5 mm wide. The standard stimulus (vertical line) was drawn on the upper half of all cards. The comparison stimuli were drawn on the lower half of the cards.

The comparison stimuli of all training cards consisted of a vertical line and a line tilted at 33^o from the vertical. Position and direction of tilt were counterbalanced.

The test cards, had, in addition to the vertical standard and vertical comparison, one of 11 different line tilts: 0.5^o, 1.0^o, 1.5^o, 2.0^o, 2.5^o, 3.0^o, 3.5^o, 4.0^o, 5.0^o, 6.0^o and 15^o. Position and direction of tilt were counterbalanced on different cards.

Procedure

The general procedure was the same as that in Experiment I, part one. Prior to each test session, subjects received a brief training session (refer to Experiment I) which terminated when the subjects had achieved 12 consecutive correct trials (trials on which the vertical comparison was selected) on the FR4 schedule. The same instructions used in Experiment I, were given to the subjects. All subjects were reinforced for choosing the vertical line. Reinforcement was only presented when the subject had placed his whole hand on, or when he had one or more of his fingers touching the correct stimulus.

Each subject received three test sessions. The first test session was conducted not more than three days after the last session in Experiment I. The sessions were conducted at intervals of three days or less.

Fifty-nine cards were presented during the test sessions. Fifteen were training cards (vertical and 33^{o} line tilt comparisons) and 44 were test cards. The cards were presented in 14 blocks of four cards each. Each block consisted of three test cards and a training card. The last and fifteenth block consisted of only 3 cards; the first two were test cards and the last card was a training card. The order of test card presentations was randomly arranged with the exception that a training card appeared at the end of every block. If the subject responded correctly to the last card of a block, he received a marble. An incorrect response to a training card led to withdrawal of a marble. The subject was not reinforced for correct responses to the test cards, neither did he lose a marble for responding incorrectly.

Results

There was again little difference between the autistic group and the control group, as can be seen in Figure 3 which shows the number of responses made by autistic and control subjects to the various line tilts during test for stimulus control in Experiment II. However, the tendency to choose the non-vertical line tilt rather than the vertical line was slightly greater for the autistic group than the control group. The average number of times that the non-vertical line tilt was chosen during the presentation of the test cards was 21 for the controls and 23 for the autistics. There was more variability among the control subjects (range: control 14-31; autistics 20-27; see Figure 4). The total number of responses to non-vertical line tilts made by autistic and control subjects in Experiment II, is shown in Figure 4. None of the autistic subjects responded

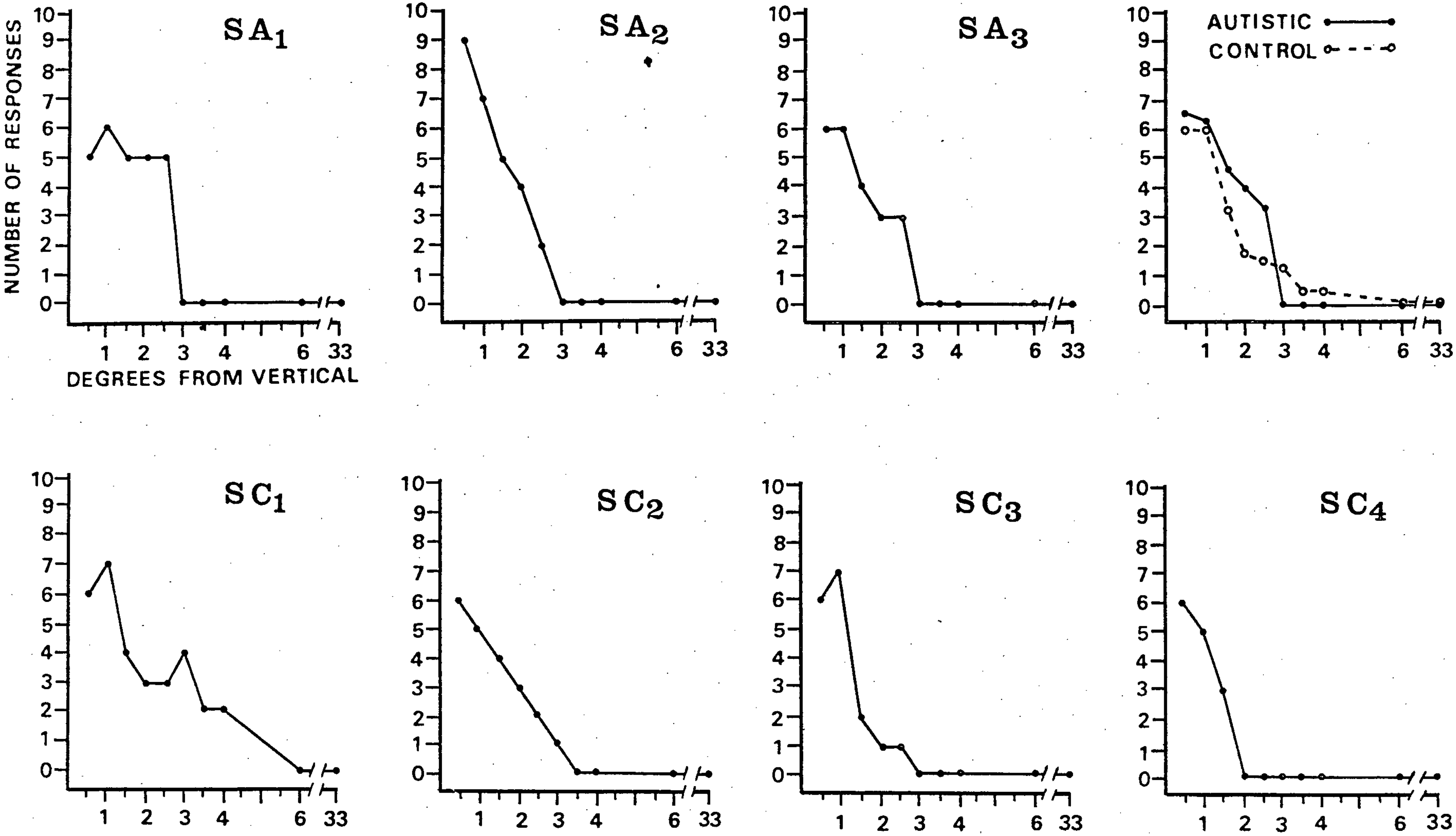

Figure 3: Number of responses made by autistic and control subjects to the various line tilts during test for stimulus control in Experiment II. The top-right hand panel gives the average number of responses to the line tilt made by each group.

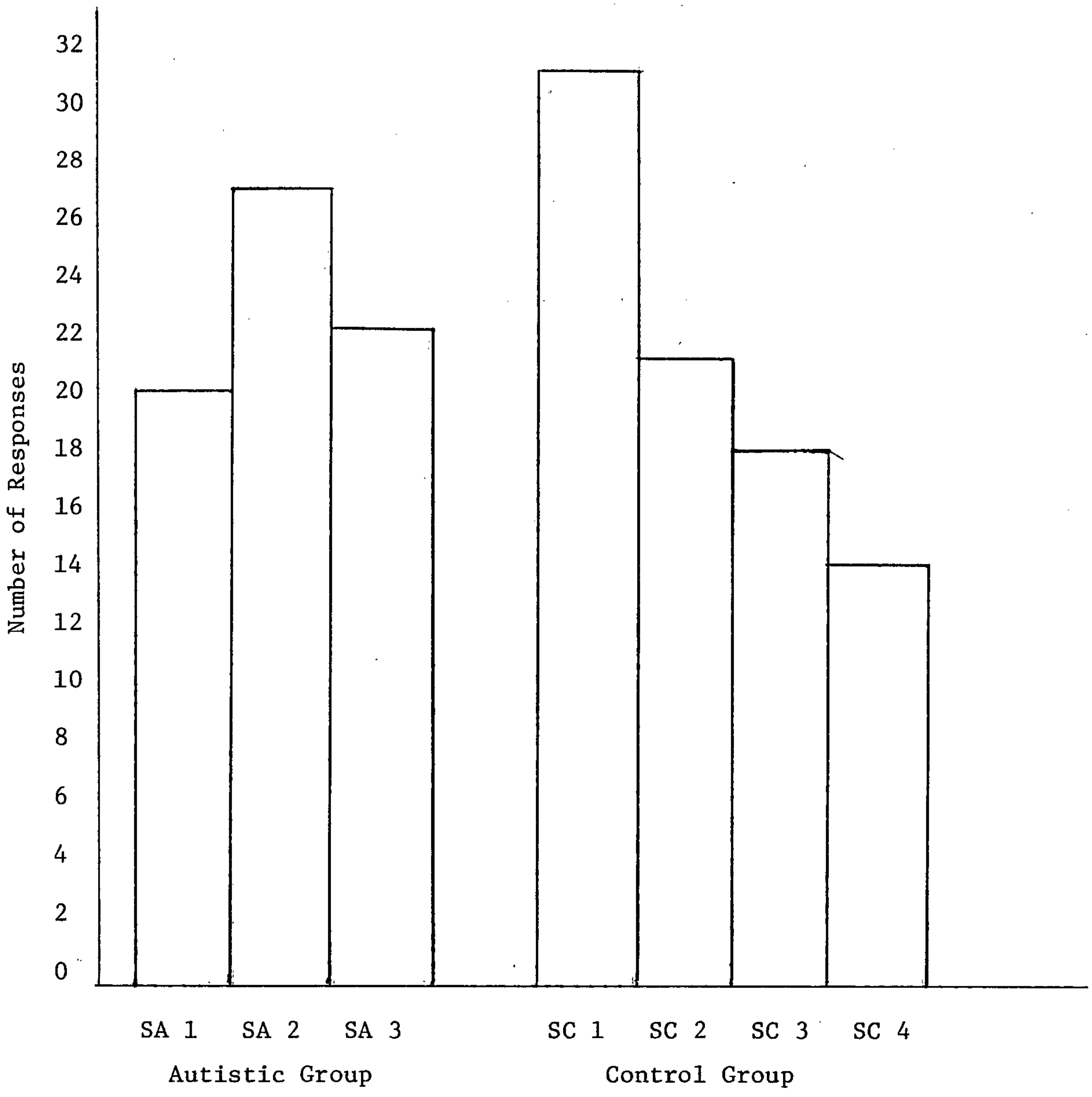

Figure 4: Total number of responses to non-vertical comparison line tilts made by autistic and control subjects in Experiment II.

to the tilted line when the angle of the tilt was greater than 2.5° from the vertical. In the case of the control group, SC 1 responded to the 4° line tilt, and SC 2 responded to the 3° line tilt (see Figure 3). None of the control subjects responded to the tilted line when the angle of the tilt was greater than 4°.

It is noteworthy that subjects in both groups made a greater number of responses to the tilted line during generalization tests of Experiment II, than during the generalization tests of Experiment I. This result suggests that the differences in line orientations in Experiment II were in fact more difficult to detect than the differences in line orientations in Experiment I.

Discussion

The results of Experiment II also failed to demonstrate greater stimulus control in autistic subjects than in control subjects. The results of Experiments I and II which show that autistic children are controlled by line orientations to the same extent as normal children, is inconsistent with Hermelin and O'Connor's notion that autistic children are particularly unresponsive to visual stimuli. The question may be raised as to whether autistic children would do as well as control children when the task involves discriminating differences between stimuli that are varied along two dimensions instead of just one. If autistic children tend to be controlled by only one aspect of a stimulus, then they would have great difficulty in learning a multidimensional discrimination task.

In the third experiment, subjects were presented with a task in which they had to match the standard stimulus with one of four stimuli that varied in shape as well as in the presence or absence of a star within the shape. It should be pointed out that the stimuli in Experiment III did not constitute a dimension like the line orientations of Experiments I and II. As such, Experiment III cannot be considered a test of dimensional stimulus control. Rather, it was a test of the subject's ability to discriminate between four stimuli that varied along two dimensions.

Experiment III

Subjects were trained to match a standard stimulus with one of four comparison stimuli that varied in shape and in the presence or absence of a star within the shape. The number of trials needed to reach criterion of 8 consecutive correct responses was recorded.

Method

Stimuli

The stimuli consisted of two different shapes, an elipse and an oblong spheroid, which is a circle that has been flattened at the poles. As well, the stimuli were differentiated by the presence or absence of a black star. Thus, there were four stimuli: Two elipses, one with a star and one without; and two oblong spheroids, one with a star and one without a star. With the aid of plastic templates, the shapes were drawn with a black felt pen on 22. 5 cm by 30.3 cm white cards. Both the elipses and the oblong spheroids were approximately 29 mm long. The heights of the elipse and the oblong spheroid were 17 mm and 12 mm respectively. Using a roll of deca-dry symbols, a star was transferred to the centre of the appropriate shapes.

Unlike in Experiments I and II, one particular stimulus was not always the standard stimulus. The four stimuli were rotated so that each stimulus became the standard stimulus twice. The standard stimulus was drawn on the top half of the cards.

The four comparison stimuli were drawn on the lower half of the cards, at equally spaced intervals of 1.5 cm leaving a margin of 3 cm on either side of the card. The sequential arrangement of the four comparison stimuli was randomized with the exception that the comparison stimulus that matched the standard stimulus never appeared in the same position more than twice. The order of the presentation of the eight cards was randomized.

Procedure

As this experiment was conducted 10 days after the last session of Experiment II, all subjects were given a brief training session (see Experiment I), to refamiliarize them with the matching-to-sample procedure The training cards of Experiment I were used. Subjects were trained to discriminate between a vertical line and a line tilted at 33^{o} from the vertical, to a criterion of 12 consecutive correct trials on the FR4 schedule.

The experimenter then informed the subjects that they were going to play a game that was similar to that which they had played previously. The experimenter explained that the subjects would receive a marble everytime they responded correctly, and that each time they responded incorrectly, they would lose a marble. At the end of the experiment, they could exchange the marbles for matchbox toyes.

All subjects were reinforced for choosing the stimulus that matched the standard stimulus. The instructions to the subjects were: "Touch the object that is like the one above.". When the subject had one or more of their fingers touching the correct comparison stimuli, they were given a marble. If a wrong comparison stimulus was chosen, the experimenter withdrew a marble from the plastic container that had been placed on the table near the subject. The session was terminated when the subject had made 8 consecutive correct responses.

Results

The autistic subjects in general took a greater number of trials to reach criterion of 8 consecutive correct responses than the normal subjects. The number of trials taken by subjects to reach criterion of 8 consecutive correct trials in Experiment III is shown in Table III. Three of the control subjects reached criterion in 8 trials, which was the minimum number of trials needed. SC 1 took 9 trials to reach criterion. Of the autistic subjects, only SA 2 reached criterion in 8 trials. SA 1 took 20 trials, and SA 3, 13 trials to reach criterion.

Table III

Number of trials taken by subjects to reach criterion of eight consecutive correct trials in Experiment III.

Group	Number of trials to criterion
Autistic Group	
SA 1	20
SA 2	8
SA 3	13
Control Group	
SC 1	9
SC 2	8
SC 3	8
SC 4	8

Discussion

The results of Experiment III suggest that autistic children have difficulty in discriminating between multidimensional stimuli. However, the difference between the autistic subjects and the control subjects in the number of trials taken to reach the criterion of 8 consecutive correct trials, was not large.

It could be argued that this is evidence that the responses of autistic children tend to be brought under the control of only one aspect of the stimuli. However, if the responses of the autistic children were under the control of only one aspect of the stimuli, none of the autistic subjects would have reached criterion, since it was necessary to attend to both the shape of the stimuli and the presence or absence of the star within it, in order to respond correctly to all eight cards. Alternatively, the greater number of errors made by the autistic children compared to the normal children, could be attributed to the greater number of comparison stimuli made available to the subjects. The findings of a study by Hermelin and O'Connor (1967) suggest that autistic children attend to a stimulus display for shorter times than normal children. It is possible that when a large amount of stimuli are presented, autistic children take a longer time than normal children to gain the same amount of information from the stimulus display.

Chapter III: DISCUSSION

The results of Experiment I and II failed to show any great differences between the autistic and the control subjects. In the test for the degree of control by the line tilt the difference between the autistics and the controls were very slight. The only apparent difference between the two groups of subjects was in the number of trials taken to reach criterion of 24 correct trials on the FR4 schedule during training in Experiment I. The autistic subjects took a greater number of trials than the controls to reach criterion during training, although the difference was not extremely large. Also, this difference was not replicated in the second part of Experiment I in which subjects were trained to discriminate between a vertical line and lines tilted progressively closer to the vertical. In Experiment III the autistic subjects took a greater number of trials to reach the criterion of 8 consecutive correct trials on a multidimensional discrimination task. Again the difference was not that clear.

It is interesting to note that the autistic subjects in the present study discriminated very small differences in line orientations, and that they did not differ very significantly from the control subjects in terms of discriminating differences in line orientations. All the autistic subjects discriminated between a vertical and a 2^{o} line tilt to a criterion of 8 consecutive correct trials (see Experiment I, part two). The degree to which autistic subjects discriminated line orientations argues against Hermelin and O'Connor's proposition that there is impaired visual discrimination in autistic children. The subjects in Hermelin and O'Connor's (1965) study were unable to discriminate between a horizontal and a vertical line. The disparity between the findings of the present study and that of Hermelin and O'Connor's could be a function of the procedure employed. Herelin and O'Connor did not employ a matching-to-sample procedure. In order to do well in a task in which the standard stimulus is not provided the child not only has to be able to discriminate between stimuli, but he also has to recall the consequences of his previous response. Over and Over (1967) have demonstrated the importance of distinguishing between the two processes. The experimental results obtained by Hermelin and O'Connor (1965) and the findings of the present study suggest that the problems with autistic children is related to memory factors. When autistic children were presented with a standard stimulus with which to compare the choice stimuli, as was done in the present study, their performance did not differ from normal children. An interesting follow-up study would be to conduct a study in which the standard stimulus was gradually faded out once response had reached the desired criterion. If response strength showed a marked decline when the standard stimulus was removed, then one could conclude that the unresponsivity in autistic children is directly related to their failure to recall previous experiences.

For the purpose of the present study, the definition of stimulus selectivity was extended to include steep dimensional control gradients and the ability to discriminate small differences between stimuli that lie along a specific dimension. The failure to obtain steeper line tilt gradient and any marked differences in discrimination acquisition in the present study suggests that at least with unidimensional stimuli, stimulus selectivity is not greater in autistic than in normal children. In listing the obvious qualifications that had to be imposed on the data he obtained, Lovaas et al (1971) pointed out that the stimuli elements in his study were distributed across modalities. He surmised that if all the stimulus elements had fallen within one modality, the results obtained may have been different. In the present study the stimuli were of the visual modality only.

In Experiment III, the autistic subjects took a greater number of trials to reach the criterion of 8 consecutive correct trials than did the controls. This result may seem to suggest that the responses of autistic children tend to be brought under the control of only one aspect of the stimulus. However, if this was the case, none of the autistic subjects would have reached criterion as it was necessary to attend to both the shape of the stimuli and the presence or absence of the star within it, in order to respond correctly to all 8 cards. Alternatively, the greater number of errors made by the autistic subjects compared to the control subjects could be attributed to the greater number of comparisons made available to the subjects. Subjects had to choose from four comparison stimuli instead of from two, as in Experiments I and II. There is some evidence which suggests that the autistic child is unable to attend to stimuli for an extended period of time. Hermelin and O'Connor (1967) found that autistic children spend more time in non-directed gazing and less time inspecting the visual display, than either normal and subnormal children. Perhaps given the nature of the visual inspecting behavior of the autistic children, increasing the amount of stimuli presented would mean that autistic children would require a longer time to gain equal amount of information from the same stimulus display than would normal children.

Unlike the subjects in the present study, the subjects in Lovaas _et al_'s study did not have to discriminate between several multidimensional stimuli. They were trained only to press the bar in the presence of the complex stimulus, and not to press the bar during the intervals between stimulus complex presentations. The results showed that autistic subjects needed a far greater number of training sessions than the normals and the retardates to learn this discrimination. In both Lovaas _et al_'s study and the present study, the stimuli were multidimensional. This suggests that autistic children may have difficulty in dealing with multidimensional discrimination tasks in which they would be required to match the standard stimulus with one of several comparison stimuli. For example, Experiments I and II may be replicated with the exception that the comparison stimuli would consist of six or more lines of different orientations, instead of just two. If the problem with autistic children is a failure to learn multidimensional discrimination there should be no difference between autistic and control subjects in dimensional control. On the other hand, if their problem is related to failure to attend to increasing numbers of stimuli, then the autistic subjects should take a greater number of trials to acquire the discrimination, and possibly though not necessarily, dimensional control should be greater in the control than in the autistic subjects.

It should be noted that the autistic subjects in the present study did not possess extremely severe behavior disorders as compared, for example, with the autistic subjects in Lovaas et al's studies. Note also that the subjects in the Hermelin and O'Connor studies (1965, 1967) were residents of mental institutions. They were often from different hospitals and in many cases speech development was absent.

At this juncture, it might be appropriate to call attention to the differences between speaking and nonspeaking autistic children. While it may be argued that language disorder does not lie at the root of the problem in autistic children, it is clear that differences exist between speaking and nonspeaking autistic children (Hermelin and O'Conner, 1965). It is plausible that the absence of speech development could have led to other complications not directly related to the basic disorder. The results of a visual discrimination study by Hermelin and O'Connor (1965), in which subjects were tested on four dimensions, indicated that speaking autistic children did better than nonspeaking autistic children. Similarly, Frith and Hermelin (1969) found that speaking and nonspeaking autistics differed in the type of strategy they adopted on solving three tasks. In any case, both of the above cited studies failed to find any significant difference between speaking autistic children and the controls, but there were marked and significant differences between the nonspeaking autistics and the controls. The theoretical implications of this data is unclear, although in practice it is recommended that the two groups be treated differently both in empirical work and in therapy. All the autistic subjects in the present study could speak intelligibly and could follow simple instructions. It would be interesting to see what the results would be when nonspeaking children are used as subjects.

It is often the case that the ages of the autistic children used as subjects vary considerably, especially in comparison with the age ranges of control groups. For example, in the study by Frith and Hermelin (1969), the ages of the subjects ranged from 6 to 15 years for the autistic group, 14 years to 17 years 7 months for the subnormal group and 3 years 9 months to 6 years 6 months for the normal group. In another study (Hermelin and O'Connor, 1967) the autistics ranged from 7 years to 18 years 11 months, the subnormals from 10 years to 17 years and the normals from 4 years 3 months to 6 years 1 month. Although in these cases the controls are found to perform better than the autistic subjects it is difficult to give an unequivocal interpretation of the data. The matching of subjects on the basis of scores obtained on a pre-test, does not alter the fact that autistic children have had 10 more years of life, all of which were possibly spent in an institution. In the present study an attempt was made to narrow the age range as much as possible; all of the subjects were between the ages of 5 years 11 months and 9 years. With the age range of the subjects narrowed, there was little difference obtained between the autistic and control subjects in the number of trials taken to reach criterion during training. Although the autistic subjects took more trials to reach criterion during training, the criterion was reached in the first training session and maintained at the 100 per cent level during subsequent training sessions.

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APPENDIX

Wing (1969) conducted a study in which autistic children were compared with normal children and children with Down's Syndrome, receptive aphasia, executive aphasia and partially blind, partially deaf children. The autistic children were divided into a speaking and a non-speaking group. All had been diagnosed autistic by two psychiatrists. Their verbal behavior was sufficient to indicate basic needs in short phrases such as naming of some common objects and following simple instructions. They had no clinically detectable evidence of brain damage.

Although no information was available on the chromosomal structure of the children with Down's Syndrome, all of the children were associated with mental retardation (I.Q. range: 30-50) and had the typical characteristics of mongolism such as short stature, oblique, narrow eyes, a gutteral voice and poor articulation. Congenital receptive aphasia is an abnormality associated with speech comprehension. All the children in the group were said to have peripheral deafness, although their problem of speech comprehension was more severe than could be accounted for by their degree of deafness. Congenital executive aphasia is a disorder associated with speech production, not associated with peripheral sensory deficit. The fifteen children in the blind/deaf group were all handicapped with congential cataracts and deafness, due to maternal rubella. Only three had useful verbal behavior.

Comparisons between the groups were made by retrospective surveys by means of a questionnaire that was mailed to parents of suitable children who had lived with them since birth until at least five years of age. The occupational level of the parents selected, tended to be above average. The questionnaire that was sent out to the parents consisted of a schedule designed to elicit a history of abnormalities in development, covering the various categories of behavior which are characteristic of early infantile autism.

The results indicated that autistic children manifested more abnormal responses to auditory and visual stimuli than the children in the other group, and their sensory response patterns closely resembled that of the partially blind/partially deaf group. Like the blind/deaf children, the autistic children had great difficulty in understanding gestures, showed abnormal body movements and a preference for exploring their surroundings with their hands. Some differences between the speaking and non-speaking autistic children were also evident, although the difference was not significant. All of the twenty speaking autistic children were scored as performing well on non-verbal skills and interests, while only four of the seven non-speaking children achieved the same high score. Wing suggested that the anomalies in the autistic childrens' responses to sensory stimuli are directly linked to their inability to communicate as a result of their language problems, and that difficulties in social behavior evident in these children are to be regarded as secondary to the more basic handicaps.

There is one problem with Wing's study and that is the bias inherent in retrospective questionnaires. It is very probable that parents of older children would rate fewer abnormalities for the pre-school years, than parents of younger children. An examination of the age distribution of subjects in Wing's study indicates that the autistic group and the mongoloid group had the greatest number of subjects within the 12 - 16 year age bracket, while as many as 67% of the deaf/blind children were between 4 and 5 years old. In view of this, the results should be interpreted with caution.

Rutter (1968) proposed that the primary defects in early childhood autism are a language disorder and impairment of sounds. Rutter claims that there is adequate evidence in support of this hypothesis in view of the similarities between autistic children and those suffering from severe developmental language disorders, and of the importance of language as a prognostic factor. Specifically, Rutter cites the studies by Kranner Eisenberg (1956) and Creak (1961) in which it was found that bad prognosis was associated with a prolonged failure in speech development.

To test his hypothesis, Rutter conducted a massive five to fifteen year follow-up study of 63 psychotic children and 61 control children (1967 a, 1967 b). The behavioral description of the psychotic children closely conformed to the diagnostic criteria of early childhood autism, and an unequivocal diagnosis of the syndrome had been agreed by all the consultant psychiatrists at the Maudsley Hospital. The psychotic and normal children were closely matched for I.Q., age and sex.

The mean age at which the children were first observed was six years and the mean age when examined at follow-up was 16 years. At the beginning of the study, each child was given a neurological and psychiatric examination. The children were also observed in an unstructured situation with other children and with adults at home, school or hospital. A detailed description of the child's past and present behavioral and social states, together with an account of illness and other medical information of the health of the rest of the family, were obtained from the parent or parent-substitute using a standard interview schedule. Specified behaviors were rated on a five-point scale. Similar tests and interviews were conducted when the subjects were re-examined at the end of the follow-up period. At the time of follow-up, information concerning the subjects' administrative placement, the amount of schooling they had received and progress at school, psychiatric and medical treatment and developmental course of individual behavioral characteristics were obtained.

The results indicated that the child who was not speaking by age five or who manifested a profound lack of response to sounds in early childhood, was less likely to achieve a normal or near normal level of social adjustment at a later stage, than would a child who, at the age of five, could speak and respond to sounds normally. Rutter found that the social outcome of the psychotic children at follow-up was significantly worse than that of the control children. He attributed this difference in outcome between the two groups, to the language disorders of the psychotic children. Unfortunately, the majority of the control children had some degree of mental subnormality and in many cases the retardation was accompanied by impairments in speech. Rutter gives no explanation for the better social outcome of the control group in spite of their speech disorders. This diminishes the strength of Rutter's argument that language disorder is the primary abnormality in early childhood autism and that prognosis is primarily associated with speech development at an early stage.

The argument that the basic defect in early childhood autism is language disorder seems more tenuous when one reviews the vast body of literature on deaf children. Furth (1966, 1973), for example, has sufficiently demonstrated that deaf children can perform as well as normal children in most non-verbal tasks. Furthermore, the language hypothesis has difficulty explaining why social withdrawal does not accompany deafness, although it is possible that the aloofness is less obvious in deaf children because their handicap was detected at an early age and a remedial program introduced immediately after.