A DEVELOPMENTAL ANALYSIS OF THE COMPARATIVE DIFFICULTY LEVEL OF ODDITY AND TWO-CHOICE DISCRIMINATION LEARNING IN CHILDREN

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A Developmental Analysis of the Comparative Difficulty Level of Oddity and Two-choice Discrimination Learning in Children

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ABSTRACT

This investigation was designed to compare the relative difficulty of the oddity, one irrelevant dimension discrimination, and two irrelevant dimension discrimination tasks, with colour or form as the relevant dimension. Subjects were seventy-two children in three age levels: preschool, kindergarten, and grade 2. All subjects were given planometric colour, form, and size pretraining followed by stereometric oddity, one irrelevant dimension discrimination, and two irrelevant dimension discrimination training in a counterbalanced order. The Raven's Coloured Progressive Matrices was administered individually following the last experimental task.

The data were analysed by nonparametric statistics and the results showed significant main effects for age, task, and dimension. The findings of this study show considerable agreement with and extend the results of other studies in this area.

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INTRODUCTION

Statement of the problem:

The topic of oddity discrimination has been widely discussed in recent psychological literature (Lipsitt & Serunian, 1963; Hill, 1965; Porter, 1965; Gollin & Shirk, 1966; Strong, 1966; Penn, Sindberg & Wohlhueter, 1969), especially with regard to achieving a greater understanding of concept formation in young children. Oddity is a relatively simple task, and its analysis may prove helpful in clarifying the underlying processes of complex human behaviour.

Oddity is a type of problem which is classed under the broad heading of discrimination learning. It is a specific form of nonspatial discrimination called multiple-sign learning (Harlow, 1951). Nonspatial or object discrimination involves a task in which the reward of the positional and object cues is ambiguous on any particular trial. This ambiguity means that two or more cues are being rewarded simultaneously, thus making it difficult for the organism to know for what it is being rewarded on any given trial. The multiple-sign problems are more complex than the nonspatial problems because they involve the ambiguous reward of more than two cues on any given trial, and the solution of such problems requires the consistent response to only a single cue over a series of trials, and the ability to ignore the remaining irrelevant cues. Hence, the two types of problems: oddity and two-choice discrimination are fairly similar in that they differ only on the number of cues which are ambiguously rewarded.

From this apparent similarity, it would seem feasible to relate these two types of problems on a scale. By subdividing the general two-choice discrimination problem into subtasks according to the number of relevant and irrelevant variables used, a more comprehensive scale could be constructed, and presumably oddity would take its place comparable to its level of difficulty in relation to the discrimination tasks.

Harlow (1969) has stated that "no one has even attempted to scale the various learning problems or classes of problems in steps of equal difficulty (p. 269)", but this was in reference to learning ability amongst animals, rather than humans. However, there has been one study reported in the literature that has attempted this type of comparison with humans. Hill's (1965) study compared simple discrimination learning, oddity learning, and conditional oddity learning over an age range consisting of 1, 4, 6 and 12 year old children. This single piece of evidence does not provide a complete description of the relative difficulty of oddity and discrimination learning, and consequently, the objective of this study is to broaden the range of this comparison by introducing more and different problems.

<u>Literature review</u>:

In oddity learning, two different pairs, each consisting of identical stimuli are used, but only three stimuli are presented on each trial, e.g. ○□○. The odd stimulus, the one that is singly represented, is always rewarded and the sequences of trials are arranged so that one member from each pair of identical stimuli is odd on 50% of all test trials (Harlow, 1951).

On any single trial, the sources of error are ambiguous, for on each trial there is the reward of the object itself, of the position of the object, and of the oddity of the object. Over a series of trials, however, only the oddity is rewarded 100% of the time. Hence, the subjects must learn to ignore the irrelevant stimulus and situational variables, which are the position of the reward and the particular object rewarded, in order to solve the problems (Harlow, 1951).

An analysis of oddity learning by Moon and Harlow (1955) has emphasized another difficulty, in that they attribute oddity learning not only to an increase in the strength of the oddity response as a result of consistent reinforcement but also to the elimination of perseverative tendencies to previously-rewarded objects, and the avoidance of previously-unrewarded objects as a result of their nonreinforcement. These latter two habits are developed in and required for the solution of simple object discrimination problems, but must be ignored for successful oddity solution.

This type of learning does not seem to be based on simple S-R associations because the stimulus attributes change from trial to trial making oddity a simple example of the abstraction 'same' or 'different'. Thus, one can say as a general rule for successful oddity performance that although the stimulus attributes provide the cue, only knowledge of the conceptual rule, i.e. the relationship among the simultaneously-presented stimuli, will produce significantly correct choices on the first trial of each new problem. Spence (1952) arrived at a similar conclusion but by different means, as he directly opposed the concept of rule learning. He classified oddity problem learning as a type of transverse patterning because consistently correct performance could be achieved only by responding to a specific cue in the presence of certain other cues. Therefore, although there is a direct contrast in terms, both approaches convey the same underlying idea.

Oddity learning in animals:

The first study that demonstrated oddity learning was by Robinson (1933). He devised a situation in which the animal would have to respond solely to a relationship, as no "constant physically definable stimulus cue (p. 232)" was correct in itself. The correct stimulus was defined only by its relationship to the other elements in the stimulus array. More specifically, the procedure introduced was that of requiring the subjects to respond to the odd one of the three stimuli in a discrimination.

Although oddity learning is now classified as a distinct type of discrimination learning, Robinson originally considered it in terms of the process of abstraction, the main idea being to single out the relevant part or aspect of the whole situation, i.e. the relationship between stimuli, and respond to it. He trained a Philippine macaque (*Macaca irus*) to respond to a criterion of 90% correct responses to oddity in approximately 400 trials, using two pairs of identical stimuli, one pair consisting of plain grey boxes, the other pair, grey boxes with black discs. In half of the trials, one grey box and two with black discs were presented, and in the other half of the trials, the two grey boxes and one with a black disc were presented.

Robinson's study is an example of the classical three-position oddity procedure, for which Levinson (1958) has defined three standard conditions, which are: "first, the odd stimulus may be located at any of the three positions of the test tray; second, both stimuli are correct (odd) an equal number of trials; third, the animal is permitted only a single choice on each trial (p. 4)." A second procedure was developed by Moon and Harlow (1955) for use in the study of oddity learning. This was a two-position display in which the centre stimulus was immobile, so that only the left or right end position could hide the reward. Hence, the animals were only given two choices and the response to the middle position extinguished quite rapidly as it was never reinforced. Robinson's three-position oddity procedure was chosen to be used in this experiment because the Moon and Harlow procedure allows only a choice between the two end stimuli. This task is considered to be too similar to the discrimination problems themselves to give an accurate and valid comparison between oddity and discrimination learning.

Many attempts have been made with animals to train the oddity task, but they have met with very limited success because the animals, especially below the primate level, are not able to learn the task, presumably because of its cognitive complexity. Harlow (1969) feels that the oddity task is also beyond the intellectual capacity of young children. However, continuing research on the topic has provided much evidence to the contrary.

Oddity learning in children:

One of the first studies with children was a two-position colour oddity task by Romba (1956a) using an age range of 5-8 years. It was found that only 40% of the subjects tested learned the concept, but a developmental trend was noted among them. Also, learning "appeared to be somewhat of an insightful process (p. 228)" and not incremental as was thought, as the responding remained at chance level for the non-learners as it did for the learners until they hit upon the correct principle for solution. Sex differences were found, but were thought to be due to the small sample tested. A second study by Romba (1956b) utilized the identical procedure but limited the age range of the subjects to 5 and 6 year olds only. Approximately half of the subjects tested learned the task, and learning again appeared to be 'insightful' in nature because in all cases a) the solution was sudden, b) the solution persisted as a permanent aquisition, and c) there was novelty of solution, that is the stimuli had to be viewed in a unique way in order to attain solution. The results showed that both mental age (MA) and chronological age (CA) were positively correlated with problem solving ability, as were the non-language and logical reasoning scores of the California Mental Maturity Test.

Lipsitt and Serunian (1963) utilized the three-position oddity procedure using colour cues and found that 100% of grade 3 (9 years) children, 53.6% of kindergarten (5-6 years) children, and 16.7% of preschool (less than 5 years) children attained the criterion of six consecutively correct responses in a maximum of 54 trials. The aim of this study was to establish age norms for oddity learning, as it was believed to be a developmental attribute. Evidence for this statement was found because the rapidity of oddity problem solution and the ability to solve the problems improved directly with increasing CA, and presumably also with MA. Additional supportive data was given by Gollin and Shirk (1966) when they replicated the procedure used by Lipsitt and Serunian, and extended the age range to younger groups of children. The results showed that 42% of preschool (4-4 1/2 years) children and 58% of kindergarten (5-6 years) children are capable of solving the problem, hence giving contrary evidence to Harlow's assumption that oddity is too complex for young children. Both the above-mentioned studies found that with increasing CA, the number of correct responses on the oddity task increased, while the number of trials to criterion and the percentage of failures decreased. This confirmed the hypothesis that facility in oddity learning may be characterized as a developmental attribute, and hence supports a developmental view of the oddity concept.

A parallel study to Lipsitt and Serunian's was Porter's (1965) study in which he used the three-position oddity procedure, but with form cues instead of colours, with an age range of 3 1/2 to 7 1/2 years. His predictions were similar to those of Lipsitt and Serunian, and Gollin and Shirk, but he also thought that a certain level of maturation was necessary to master the oddity problem. His results showed that CA was directly related to the number of correct responses achieved on the oddity problem and inversely related to the number of trials to criterion. The level of maturation required for the solution of the problem, i.e. a criterion of nine consecutively correct responses in a maximum of 54 trials, occurred largely between 5 1/2 and 6 1/2 years of age. He also found that the number of subjects solving the task increases with CA in approximately a linear fashion, emphasizing that the level of development is a key factor in oddity learning when form is the discriminandum. The consistency of these results with the data from the previous two studies can be regarded as further evidence for the developmental nature of oddity.

The above studies have dealt almost exclusively with the relationship between CA and oddity performance, with only slight and inferred reference to MA. Ellis and Sloan (1959) using form cues conducted probably the first study of oddity learning in mental defectives, comparing retarded and normal children with MAs of 4, 6, and 7 years. Only 15% of the 4 year group attained solution, but the other two groups were able to achieve significant levels of oddity performance. Fifty-five per cent of the normal 6 year olds and 58% of the defectives of corresponding MA, and 85% of the normal 7 year olds and 78% of the defectives of the corresponding MA reached criterion. However, differences were found in the rate of growth of the curves, with the normal subjects tending toward rectilinearity while the mentally defective subjects showed typically negativelyaccelerated performance curves which increased in elevation and degree of bow with increasing MA. Thus, the data show that performance on the oddity problem is at least partially dependent on intellectual development as measured by MA scores. This development trend was reaffirmed by Ellis, Hawkins, Pryer and Jones (1963), with mentally defective children of MAs 6, 7, and 8 years, and also by Penn, Sindberg and Wohlhueter (1969). Penn et al. used a three-position colour task similar to that used by Gollin and Shirk and found that children with MAs of 3 and 4 years responded only at or below chance level (33.3%), while children with MAs of 5 years and above reached approximately 80% correct responses as averaged over nine blocks of six trials. These and similar results (House, 1964; Martin & Blum, 1961) also support the developmental picture of MA-related performance on oddity tasks.

Further normative data for the developmental nature of the oddity concept have been found in studies dealing mainly with CA. Hill (1962) found that 80% of the 6 1/2 year olds tested were successful in learning the oddity problem, but solution did occur in some children between age 3-6 years. Similarly in her 1965 study, Hill's data showed that 6 year olds are generally capable of solving oddity problems. However, Strong (1966) has extended this age range downwards to 4 1/2 year olds, with 64% of 6 year olds learning the task, and did have one child aged 3 years and 4 months successfully complete the task. This is the youngest recorded age for the successful solution of the oddity problem.

Evidence has been presented which links successful performance on the oddity task with increasing CA, and also with MA, which is an index of intellectual development. This indicates that intelligence is an integral part of the developing child, and because of the developmental nature of oddity, intelligence would thus be of correlative interest.

<u>Discrimination</u> <u>learning</u>:

A brief explanation of discrimination learning will now be given to complete the introduction to the two types of problems to be dealt with in this comparison.

Discrimination is "the process by means of which an organism responds to differences between stimuli (p. 1)" (Fellows, 1968). The method of achieving the discrimination is simply to reinforce the responses that are made to the positive stimulus and extinguish all responses to the negative stimulus. In non-spatial discrimination, problems arise because not only does one have positional cues from which to select the positive and negative stimuli, but also other dimensional cues such as colour, form, size, etc. Thus on any particular trial, the correct choice results in the ambiguous reinforcement of more than one cue. However, learning is dependent on the differential frequency of reward over a series of trials. This ambiguous reinforcement of cues introduces the discrimination problems which contain information which is irrelevant to correct solution. Basically, a problem can have one irrelevant dimension, e.g. $\underset{+}{\square}$ $\bullet$, form with colour irrelevant, or colour with form irrelevant; or two irrelevant dimensions, e.g. $\underset{+}{\square}\,\bullet$, meaning either form with colour and size irrelevant, or colour with size and form irrelevant, or size with colour and form irrelevant, on any one trial. The above examples illustrate what is meant by ambiguity of reinforcement on a particular trial, for two or more cues can be rewarded simultaneously, without the subject knowing which cue is actually correct, for both squareness and whiteness are being rewarded in the example: $\underset{+}{\square}\,\bullet$. The number of irrelevant dimensions in a discrimination problem can be either greater or less than two. The types of problems which will be used in this study are the one irrelevant dimension problems: form with colour irrelevant, and colour with form irrelevant; and the two irrelevant dimension problems: form with colour and size irrelevant, and colour with form and size irrelevant.

<u>Dimensional dominance</u>:

A topic which is arousing much interest recently in child studies is that of dimensional dominance. Dominance means that the child has a marked preference for one type of cue: form, colour, etc., and so will consistently respond to this cue to the exclusion of all other cues, regardless of whether or not that cue is relevant or irrelevant to the task at hand. Heal, Bransky and Mankinen (1966) have found that dimensional dominance is a confounding factor in concept attainment tasks.

Early data (Descoudres, 1914; Tobie, 1926) have shown that colour was dominant with preschool children, but only with geometric figures and not with meaningful ones. Brian and

Goodenough's (1929) study pointed out that children below age three prefer form, that 3-6 year olds prefer colour and that 6-14 year olds revert back to form preferences. Smiley and Weir (1966) showed contrary findings as 82% of their kindergarten subjects demonstrated preference for form cues and only 18% showed preference for colour. Kagan and Lemkin (1961) added an additional cue of size and found for children ranging in age from 3.8 to 8.5 years, that their preference was greatest for form, next for colour, and last for size.

Further attempts to explore the form-colour issue were made by Corah (1964, 1966). He required his subjects to match stimuli to comparison figures to see whether they matched by colour or form, thus finding their dimensional preferences. He found no significant sex differences, but his results did show that younger children ($\overline{X}$ age of 4.6 years) chose colour and older children ($\overline{X}$ age of 8.8 years) chose form predominantly, showing that a significantly greater number of colour responses were obtained from preschool children than older subjects. Another interesting result was that the average preference for colour over form decreased with increasing age.

Piaget's concept of centration (Piaget, 1950) states that the young child attends to the dominant colour characteristic of a configuration. Hence, colour is chosen consistently at the expense of form. However, as the child's perception becomes decentered, he would attend more readily to form and from this position it would be predicted that given a task in which a matching on the basis of either colour or form can be made, the young child will more readily use colour as a function of the degree to which the form stimulus differs from the colour stimulus (Corah & Gross, 1967). It was also noted that the differences in contrast of the stimuli are very influential in colour matching because reducing the distinctness of the colour dimension increases the proportion of form choices made by kindergarten-age children. Similarly, Huang (1945) suggested that very young children match stimuli on the basis of the dimension along which the differences between the stimuli are most discriminable.

Suchman and Trabasso's (1966a) data also revealed that young children preferred mostly colour, and older children preferred form, but disagreed with the Brian and Goodenough data in that they found the colour-form preference transition age to be 4 years 2 months on the average. Also, they discovered that some children have a mixed preference, and this does not alter or increase in frequency with age. Of interest is some evidence which suggests a preference hierarchy, for when the preferred stimulus was removed, the colour-preferring children showed an increase in their preference for form over size with age, but the converse for form-preferring children was not true.

A suggestion that concept attainment may be influenced by the subject's preference for the relevant dimension of the problem led to a subsequent study by Suchman and Trabasso (1966b). Using 4 year olds, they investigated the relationship between the cue function of colour and form dimensions and stimulus preference by young children and established that if the preferred dimension was relevant, then concept learning was facilitated, but if the preferred dimension was irrelevant, then concept learning was retarded. This relationship was found to hold regardless of either the specific preferred dimension or the relevant dimension.

Pretraining:

Recently, Tighe and Tighe (1968a) have demonstrated that first grade children who are perceptually pretrained are significantly facilitated in learning a subsequent discrimination problem. The authors assume that such pretraining facilitates the differentiation of the task stimuli, and that the positive transfer to the discrimination problem following such treatment is due to an increase in the subject's sensitivity to the distinguishing dimensions of the task. The authors (Tighe & Tighe, 1968b) also predicted a relationship "between perceptual pretraining and the speed of original learning as the stimulus-reward demands of the task are increased (p. 757)." Hence, as the task becomes more difficult, pretraining should have a noticeable effect on original learning, and it is hoped that prior exposure to the stimulus dimensions will eliminate any dimensional dominance that is present in the subjects.

Supporting evidence for this idea has come from two sources. First, Mitler and Harris (1969) related children's preferences for stimulus dimensions to their performance on concept identification tasks involving preferred and nonpreferred dimensions, and found that all form-preferring subjects trained on the Wisconsin Card Sorting Test (WCST) eventually reached criterion for each of the dimension tasks of form, colour, and number. Hence these results indicate the considerable importance of immediate prior experience in the assessment of the ability to solve multidimensional concept identification problems. Secondly, Johnson, Warner and Silleroy (1971) investigated whether a rejection strategy could be trained which would permit young children to rapidly solve concept identification problems in which the nonpreferred dimension is relevant, because they found that although older children have little difficulty when the preferred dimension is irrelevant, in younger children this quite often leads to the nonsolution of the task problems. Johnson et al. used a type of pretraining similar to the WCST and found that this also resulted in substantial facilitation, indicating that the ability to inhibit responding to dominant cues is an important factor in problem solving in young children.

Thus pretraining appears to be necessary to bring the subjects to a demonstrable attentional level such that each child is able to utilize the three dimensions of form, colour, and size. The WCST uses the dimensions of form, colour, and number, and also trains in how to solve the concept identification problems. Training on this test unfortunately involves countertraining against a dominant dimension in at least some of the subjects, and such countertraining may lead to a large number of unsuccessful trials with a good possibility that the subjects will never learn to reject their dominant dimension. However, even if they do learn, this would involve the subjects in a long history of failure in the testing situation, which would be detrimental to their subsequent performance (Ford, 1963; Hill, 1965; Endsley, 1966). In addition, this would most probably introduce a bias or order effect which is an extra variable which would negate the scaling effects that this study is attempting to elicit; and failure would be a direct cause of increasing the difficulty level over and above the inherent difficulty of the task itself.

Specific aims:

The purpose of this study is the comparison of the level of complexity of oddity learning and two-choice discrimination learning with one and two irrelevant dimensions. An investigation of this kind is important in this area because it will link together three tasks which are all classed under the broad heading of discrimination learning. Data of this type are negligible. In fact, only one such comparison has been reported in the literature.

This study was designed to collect data on the comparison of oddity learning and two types of discrimination learning: problems with one and two irrelevant dimensions. A specific age range (4-8 years) was chosen to illustrate that the successful solution of oddity and two-choice discrimination problems is developmental in nature. This particular age range was selected because it demonstrates the period during which the ability to solve oddity problems is acquired.

The idea for this study originated in the similar statements by Moon and Harlow (1953) that "the oddity problem has been recognized as being more difficult than discrimination learning (p. 193)", and House (1964) that "solution of the oddity problem...is more complex than simple discrimination learning (p. 635)". Consequently, it is the aim of this study to compare oddity, one irrelevant dimension discrimination, and two irrelevant dimension discrimination; over a specified age range; using colour, form, and size as cues.

The specific aims of this experiment are as follows:

1) To compare the relative difficulty levels of oddity learning, with one and two irrelevant dimension discrimination learning.
2) To see if this relationship changes over age range, i.e. do the difficulties remain constant or change in some way with increasing age level.
3) To see if successful oddity solution correlates with CA and intelligence as measured by the Coloured Progressive Matrices test for children.

METHOD

Subjects:

The subjects were seventy-two children from an elementary school and three preschools in the St. John's and Mount Pearl area.[1] Twenty-four children were selected from each of the following grade levels: preschool, kindergarten, and grade 2. The mean age of the preschool subjects was 4.1 years, ranging from 3.5 to 4.9; the mean age of the kindergarten subjects was 6.25 years, ranging from 5.9 to 6.5; and the mean age of the grade 2 subjects was 8.2 years, ranging from 8.0 to 8.6. An equal number of males and females was assigned to each of the groups.

Two preschool children did not co-operate with the experimenter and were replaced; however, no subjects had to be replaced due to absence. The experimenter had received written parental permission for all subjects to take part in the study.

Apparatus:

It was decided to use a single dimension discrimination pretraining on the dimensions of colour, form, and size, and train each subject to a criterion of ten consecutive correct choices on each dimension. The WCST, as used by Mitler and Harris (1969), was judged unsuitable for this experiment because the dimensions used were number, form, and colour; because it trains in how to solve the problems, and in this study original

[1] The author would like to thank the staff of St. Andrew's Elementary School, Busy Bee Daycare Centre, Pee Wee Daycare Centre, and Gerann Daycare Centre for making the children available for this study.

learning is being measured; and also because it involved counter-training some subjects against their dominant dimension. Three sets of cards were developed to match the experimental parameters, one set for each of the three categories of form, colour, and size. The form cards depicted a black diamond and a black cross, the colour cards depicted a red and a green 6-point star, and the size cards depicted a large (side length 1.4 in.) and a small (side length .7 in.) pink equilateral triangle. The figures were placed .6 in. from each end of 3" x 5" white file cards, and were separated by approximately 2 in.

The apparatus for both the oddity and discrimination problems consisted of circular Rubbermaid turntables, no. JFO 2715 2, which were 15.5 in. in diameter. A 1 in. high circular piece of white styrofoam was placed on each turntable and covered with transparent MacTac to give a smooth surface. A 12 in. high sheet of white cardboard was then placed around approximately half (28 in.) of the circumference of each turntable as a surrounding screen which blocked the experimenter's manipulations from the subject. For the oddity problem, three holes (1.2 in. in diameter) were made in the test tray. The centre hole was placed 3.8 in. from each of the side holes, and these were 2.1 in. from each edge of the turntable. For the discrimination problems, two holes (1.2 in. in diameter) were made in the test tray. The distance between them was 5.3 in., and they were situated 3.9 in. from their respective edges. All the holes were 1 in. deep, and lined on the bottom with a layer of sponge rubber in order to eliminate any auditory cues as to the position of the reward. The reward consisted of a glass marble, and was hidden under the correct stimulus for each particular trial.

The stimuli for the oddity and the one irrelevant dimension discrimination (1 irrel.) problem were three-dimensional wooden objects which differed on two levels of each of two dimensions: colour (blue and yellow), and form (sphere and cube). The stimuli for the two irrelevant dimension discrimination (2 irrel.) problem included size (large and small), in addition to the colour and form dimensions. The diameter of the large spheres was 2.9 in. and the side length of the large cubes was 2.5 in., hence giving approximately the same visual area. The diameter of the small spheres was 2 in. and the side length of the small cubes was 1.75 in.

The test that was chosen to give a comparative measure of intelligence is the Raven's Coloured Progressive Matrices, Sets A, A_B, B, (Revised Order 1956).[2] It was impossible to use a test of general intelligence such as the Stanford-Binet, as it would have doubled the testing time.

[2]The Raven's Coloured Progressive Matrices was chosen because the problems of the test are similar to the experimental tasks, and it is considered to be a good measure of complex cognitive learning, of which concept learning and problem solving are examples (Jensen, 1969). Also, it has been found that Coloured Progressive Matrices IQs correspond quite closely with Stanford-Binet IQs and Weschler Intelligence Scale for Children (WISC) IQs. Correlations of .91 and .75 have been found between the Raven's Progressive Matrices and the WISC by Martin & Wiechers (1954) and Barratt (1956), respectively; and correlations of .86 and .67 have been found between the Raven's Progressive Matrices and the Stanford-Binet (1937 Edition) by Raven (1948) and Estes, Curtin, DeBurger & Denny (1961), respectively.

<u>Procedure:</u>

In order to task-orient the children and attempt to eliminate dimensional preferences, each subject participated in a pretraining session immediately preceding the first experimental problem. The subjects were run to a criterion of ten consecutive correct trials, or a maximum of 25 trials, on a single dimension discrimination task on each of the three dimensions of form, colour, and size. The order of the pretraining tasks was randomized separately within the two main experimental dimensions of form and colour. No nonpretraining group was included because it would have made the study too large for the available population.

There are 12 possible position-counterbalanced combinations for each of the two dimensions of form and colour for the oddity problem, 4 possible position-counterbalanced combinations of the dimensions for the 1 irrel. problem, and 8 possible position-counterbalanced combinations of the dimensions for the 2 irrel. problem. These position-counterbalanced combinations are shown in Table 1. The combinations of trials for each of the problems were constructed randomly with constraints, such that the same form (sphere or cube), colour (blue or yellow), or position (left, centre, or right for oddity, and left or right for discrimination) was not rewarded on more than three consecutive trials. Also, there was an equal number of left, centre, and right positions correct for the oddity trials, and likewise, an equal number of left and right positions correct for the discrimination trials. When form was the relevant variable, an equal number of blue and yellow stimuli were presented, and when

TABLE 1

Position-counterbalanced Combinations for the Oddity Problem, the One Irrelevant Dimension Discrimination Problem, and the Two Irrelevant Dimension Discrimination Problem

	Oddity	
	Colour	Form
1	DDC	DDB
2	DCD	DBD
3	CDD	BDD
4	CCD	BBD
5	CDC	BDB
6	DCC	DBB
7	BBA	CCA
8	BAB	CAC
9	ABB	ACC
10	AAB	AAC
11	ABA	ACA
12	BAA	CAA

	1 Irrelevant
	Colour & Form
1	CB
2	DA
3	BC
4	AD

	2 Irrelevant
	Colour, Form & Size
1	GB
2	HA
3	CF
4	DE
5	BG
6	AH
7	FC
8	ED

Note.– A = ●, B = ○, C = ■, D = □,

E = ●, F = ○, G = ■, H = □.

colour was the relevant variable an equal number of spheres and cubes were presented. Tables 2a, 2b, and 2c show the sequences used in the investigation. These sequences were derived from the chance stimulus sequences by Fellows (1967). There was a maximum of 72 trials for each of the three problems. Each subject was tested on the oddity problem and both discrimination problems. These were counterbalanced to control for order effects. The subjects were then randomly assigned to the six orders, with the restriction that each age-sex subgroup was represented in each order. The order of the trial sequences was constant within each problem for all subjects. The three problems were presented on three consecutive school days.

On all oddity trials, the singly-represented stimulus was reinforced, while on the discrimination trials, the relevant variable was reinforced, both regardless of their position in the stimulus array. The odd object appeared in either of the three positions on the test tray, and the relevant variable appeared in either of the two positions in the discrimination array.

The testing of the elementary school children took place during the morning and afternoon sessions of school days in a small, relatively quiet office in the school. The preschoolers were tested throughout the day under similar environmental conditions. All subjects were tested individually.

On the first testing day, when the subject was seated comfortably across the table from the experimenter, the following instructions were given for the pretraining:

TABLE 2a

Trial Sequences for the Oddity Problem

Colour				Form			
1	ABA	19	ABA	1	ACA	19	ACA
2	BBA	20	DDC	2	CCA	20	DDB
3	DCC	21	BAA	3	DBB	21	CAA
4	DDC	22	CDC	4	DDB	22	BDB
5	BAA	23	DCC	5	CAA	23	DBB
6	AAB	24	DCD	6	AAC	24	DBD
7	BAB	25	BAA	7	CAC	25	CAA
8	CCD	26	BBA	8	BBD	26	CCA
9	ABB	27	CDC	9	ACC	27	BDB
10	DCD	28	DDC	10	DBD	28	DDB
11	CDD	29	ABA	11	BDD	29	ACA
12	CDC	30	AAB	12	BDB	30	AAC
13	BAB	31	ABB	13	CAC	31	ACC
14	AAB	32	CCD	14	AAC	32	BBD
15	CDD	33	BAB	15	BDD	33	CAC
16	CCD	34	CDD	16	BBD	34	BDD
17	ABB	35	DCD	17	ACC	35	DBD
18	BBA	36	DCC	18	CCA	36	DBB
			repeat				repeat

Note.– A = ●, B = ○, C = ■, D = □.

TABLE 2b

Trial Sequences for the One Irrelevant Dimension Discrimination Problem

Colour						Form					
1	BC	25	CB	49	BC	1	BC	25	CB	49	BC
2	AD	26	DA	50	CB	2	DA	26	AD	50	CB
3	DA	27	AD	51	CB	3	AD	27	DA	51	DA
4	BC	28	CB	52	DA	4	AD	28	CB	52	AD
5	CB	29	BC	53	DA	5	CB	29	BC	53	BC
6	CB	30	DA	54	DA	6	DA	30	AD	54	AD
7	AD	31	DA	55	CB	7	DA	31	BC	55	DA
8	BC	32	CB	56	CB	8	BC	32	CB	56	DA
9	DA	33	AD	57	AD	9	AD	33	DA	57	CB
10	BC	34	AD	58	DA	10	BC	34	CB	58	AD
11	AD	35	BC	59	BC	11	CB	35	BC	59	BC
12	AD	36	BC	60	AD	12	CB	36	BC	60	CB
13	DA	37	AD	61	AD	13	AD	37	DA	61	CB
14	BC	38	CB	62	DA	14	AD	38	CB	62	AD
15	CB	39	BC	63	BC	15	CB	39	AD	63	BC
16	AD	40	DA	64	CB	16	DA	40	AD	64	DA
17	AD	41	BC	65	AD	17	CB	41	BC	65	CB
18	DA	42	AD	66	CB	18	AD	42	DA	66	DA
19	BC	43	AD	67	BC	19	BC	43	DA	67	AD
20	BC	44	CB	68	DA	20	BC	44	CB	68	AD
21	CB	45	DA	69	DA	21	DA	45	AD	69	BC
22	AD	46	BC	70	AD	22	CB	46	BC	70	CB
23	DA	47	BC	71	CB	23	BC	47	DA	71	DA
24	CB	48	AD	72	BC	24	DA	48	AD	72	BC

Note.– A = ●, B = ○, C = ■, D = □.

TABLE 2c

Trial Sequences for the Two Irrelevant Dimension Discrimination Problem

Colour						Form					
1	GB	25	HA	49	CF	1	GB	25	ED	49	DE
2	DE	26	ED	50	HA	2	ED	26	HA	50	FC
3	CF	27	BG	51	BG	3	CF	27	AH	51	BG
4	AH	28	BG	52	ED	4	HA	28	BG	52	HA
5	BG	29	CF	53	GB	5	BG	29	DE	53	GB
6	HA	30	AH	54	AH	6	AH	30	CF	54	DE
7	HA	31	GB	55	DE	7	AH	31	GB	55	ED
8	ED	32	DE	56	FC	8	DE	32	AH	56	BG
9	CF	33	HA	57	HA	9	CF	33	ED	57	AH
10	GB	34	FC	58	CF	10	GB	34	AH	58	GB
11	DE	35	AH	59	GB	11	FC	35	CF	59	CF
12	FC	36	CF	60	DE	12	FC	36	CF	60	BG
13	ED	37	BG	61	FC	13	DE	37	BG	61	ED
14	AH	38	FC	62	AH	14	HA	38	ED	62	HA
15	BG	39	ED	63	ED	15	BG	39	HA	63	GB
16	DE	40	GB	64	BG	16	AH	40	GB	64	ED
17	FC	41	AH	65	FC	17	ED	41	HA	65	FC
18	CF	42	FC	66	HA	18	DE	42	FC	66	FC
19	AH	43	DE	67	ED	19	GB	43	FC	67	HA
20	ED	44	HA	68	GB	20	HA	44	BG	68	DE
21	BG	45	GB	69	CF	21	FC	45	DE	69	CF
22	FC	46	ED	70	BG	22	ED	46	GB	70	AH
23	GB	47	DE	71	DE	23	CF	47	FC	71	AH
24	HA	48	CF	72	AH	24	BG	48	DE	72	CF

Note.– A = ●, B = ○, C = ■, D = □,
E = ●, F = ○, G = ■, H = □.

> We're going to play a game with some cards. Now, there are two pictures on each of these cards, and I am going to think very hard about one of them. I want you to try and guess which picture is right - okay? You point to the one that you think is right.

After each trial, the experimenter said, "Yes, that's right", or "No, that's wrong", according to whether the response was correct or not. The pretraining instructions were repeated before each of the three pretraining tasks. When the pretraining was complete, the instructions for the first experimental problem were given. The same instructions were used for all three experimental problems. They were repeated on each testing day. The instructions were as follows:

> In this game I am going to hide a marble and you have to try and find it. I can hide the marble in this hole (pointing to left) or this hole (pointing to centre) or in this hole (pointing to right). (Only the two holes, right and left, were indicated for the discrimination problems). Then I am going to cover the holes with some of these (pointing to the stimuli). Next, I am going to turn the table around like this (with screen blocking subject's view of holes) so that you can't see where I am hiding the marble. When I have hidden it, I will let you look for it. Remember, you can only choose one object each time. Okay? Now, find the marble.

In case of hesitation, the experimenter asked, "Which one do you think it is? You point to it."

When the subject had been shown the apparatus and told that a marble could be found under one of the stimuli covering the holes, the turntable was turned to face the experimenter and she placed a marble under the correct stimulus for that particular trial. The turntable was then turned back so that the stimulus array faced the subject, and thus permitted him to make his choice. When the response had been made, the turntable was turned back again to face the experimenter and the response was recorded. Each subject was tested until he had attained a criterion of nine consecutive correct choices on each of the three problems, or reached the maximum number of trials for each problem. A non-correction technique was used.

The Coloured Progressive Matrices was given to all subjects on the last day of testing, immediately following the third experimental problem.

Experimental design:

A 3 (problem) x 3 (age) x 2 (dimension) x 2 (sex) factorial design was used (see Table 3). The n per cell was six.

TABLE 3

Factorial Design of the Experiment

		Colour						Form					
		Preschool		Kindergarten		Grade 2		Preschool		Kindergarten		Grade 2	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	1	n=6	n=6	n=6	n=6	n=6	n=6	n=6	n=6	n=6	n=6	n=6	n=6
Task	2	"	"	"	"	"	"	"	"	"	"	"	"
	3	"	"	"	"	"	"	"	"	"	"	"	"

RESULTS

It was decided not to use parametric statistics for the following reasons. A test for homogeneity of variance was performed on all variables for both dependent measures. Statistical significance was found only on dimension for errors (F_{max} = 2.06, df = 2/107, p<.01). The means and variances of the data for errors and trials to criterion were then correlated and found to be highly significant (r_{errors} = 0.96, p<.0005; r_{trials} = 0.98, p<.0005). Log, square root, natural exponential, and square transformations were then performed. None of these transformations sufficiently reduced the correlation coefficients between the means and variances to allow the use of parametric statistics. The lowest correlation coefficient obtained was 0.63 (p<.02), using the natural exponential transformation. Hence, because the assumptions underlying the analysis of variance were violated, nonparametric statistics were used to analyse the data.

Pretraining:

Inspection of the pretraining data showed that the initial problem generally required more trials to criterion and had a greater number of errors than the subsequent problems, regardless of which dimension, colour, form or size, was presented first. Friedman two-way analyses of variance showed no significant differences between the three dimensions for either of the dependent measures: errors (λ_r^2 = 0.77, df = 2) and trials to criterion (λ_r^2 = 1.44, df = 2).

Table 4 summarizes the Spearman correlations computed between pretraining and the three experimental tasks on both the dependent measures of errors and trials to criterion. These results indicate that there was very little, if any relationship between the pretraining problems and the experimental tasks.

Errors

The means and standard deviations of errors for each of the three age levels on the three experimental tasks are presented in Table 5. The means and standard deviations for error scores on dimension, age, sex, and task are presented in Tables 6, 7, 8, and 9, respectively. Kruskal-Wallis analyses of variance indicated significant main effects for dimension ($H = 15.81$, $df = 1$, $p<.001$), and age ($H = 9.19$, $df = 2$, $p<.02$), but not for sex. No interactions between these three variables were significant. A summary of these analyses is presented in Table 10. The significant dimension effect revealed that there was a significantly greater number of errors for colour than there were for form. Individual comparisons within the main effect for age showed a significant age difference between preschool and kindergarten ($H = 4.47$, $df = 1$, $p<.05$), and between preschool and grade 2 ($H = 8.16$, $df = 1$, $p<.01$), but not between kindergarten and grade 2. This demonstrates that the most errors occurred in the preschool group, with fewer errors occurring for both the kindergarten and grade 2 groups.

A Friedman analysis of variance showed a significant difference for task ($\lambda_r{}^2 = 37.59$, $df = 2$, $p<.001$). Individual

TABLE 4

Summary of Spearman Correlation Coefficients and Probability Levels Computed for Pretraining and all Dependent Measures

	rho	p
Errors		
Pretraining/Oddity	-.113	n.s.
Pretraining/1 Irrel.	-.007	n.s.
Pretraining/2 Irrel.	-.069	n.s.
Pretraining/Total	-.099	n.s.
Trials to criterion		
Pretraining/Oddity	.001	n.s.
Pretraining/1 Irrel.	-.014	n.s.
Pretraining/2 Irrel.	-.016	n.s.
Pretraining/Total	-.053	n.s.

Note.– Approximate probability values were computed for N = 72 from Appendix Table 10, p. 390, in Practical Nonparametric Statistics, by W.J. Conover.

TABLE 5

Means and Standard Deviations of Number of Errors for both Dimensions for all Ages on Oddity, One Irrelevant Dimension Discrimination, and Two Irrelevant Dimension Discrimination Problems

Age		Preschool		Kindergarten		Grade 2	
Dimension		Colour	Form	Colour	Form	Colour	Form
Task							
Oddity	$\bar{X}$ =	42.75	40.34	32.25	28.92	26.67	18.25
	SD =	13.73	12.90	13.21	17.92	20.70	15.88
1 Irrel.	$\bar{X}$ =	34.42	14.75	28.58	9.08	26.50	6.83
	SD =	8.27	14.20	13.65	12.72	14.55	8.75
2 Irrel.	$\bar{X}$ =	32.83	19.17	28.00	14.67	28.08	10.58
	SD =	4.82	15.60	12.42	16.58	13.14	13.75
Total	$\bar{X}$ =	110.00	74.25	88.83	52.67	81.25	35.67
	SD =	17.32	35.41	32.61	40.86	40.99	28.25

TABLE 6

Means and Standard Deviations of Number of Errors and Trials to Criterion for Dimension

Response Measure		Errors		Trials to Criterion	
Dimension		Colour	Form	Colour	Form
Task					
Oddity	$\bar{X}$ =	33.89	29.17	58.00	54.72
	SD =	17.16	17.78	22.58	23.71
1 Irrel.	$\bar{X}$ =	29.83	10.22	62.17	30.64
	SD =	12.58	12.24	21.28	23.04
2 Irrel.	$\bar{X}$ =	29.64	14.81	65.17	36.80
	SD =	10.74	15.33	18.64	26.67
Total	$\bar{X}$ =	93.36	54.19	185.06	122.17
	SD =	33.30	37.76	52.65	57.95

TABLE 7

Means and Standard Deviations of Number of Errors and Trials to Criterion for Age

Response Measure		Errors			Trials to Criterion		
Age		P	K	2	P	K	2
Task							
Oddity	$\bar{X}$ =	41.54	30.58	22.46	67.50	56.29	45.29
	SD =	13.09	15.49	18.55	15.09	21.24	26.53
1 Irrel.	$\bar{X}$ =	24.58	18.83	16.67	54.00	44.33	40.88
	SD =	15.17	16.80	15.45	24.09	28.43	28.11
2 Irrel.	$\bar{X}$ =	26.00	21.33	19.33	58.08	48.54	46.33
	SD =	13.28	15.86	15.90	23.08	27.40	29.59
Total	$\bar{X}$ =	92.12	70.75	58.46	179.58	149.75	132.50
	SD =	32.81	40.60	41.56	46.56	65.61	68.98

Note.– P = Preschool K = Kindergarten 2 = Grade 2

TABLE 8

Means and Standard Deviations of Number of Errors and Trials to Criterion for Both Sexes

Response Measure		Errors		Trials to Criterion	
Sex		Female	Male	Female	Male
Task					
Oddity	$\bar{X}$ =	33.03	30.03	59.53	53.19
	SD =	16.07	18.96	20.63	25.12
1 Irrel.	$\bar{X}$ =	19.22	20.83	46.33	46.47
	SD =	15.22	16.52	26.69	27.98
2 Irrel.	$\bar{X}$ =	22.06	21.39	51.94	50.03
	SD =	15.36	15.03	27.69	26.53
Total	$\bar{X}$ =	75.31	72.25	157.53	149.69
	SD =	35.78	45.15	54.88	71.56

TABLE 9

Means and Standard Deviations of Number of Errors and Trials to Criterion for Task

Response Measure		Errors	Trials to Criterion
Task			
Oddity	$\bar{X}$ =	31.53	56.33
	SD =	17.39	22.92
1 Irrel.	$\bar{X}$ =	20.03	46.40
	SD =	15.68	26.96
2 Irrel.	$\bar{X}$ =	22.22	50.99
	SD =	15.01	26.75
Total	$\bar{X}$ =	73.78	153.61
	SD =	40.20	63.00

TABLE 10

Summary of Kruskal-Wallis Analysis of Variance of Dimension, Age, and Sex for Errors and Trials to Criterion

Kruskal-Wallis one-way analysis of variance

		H	df	p
Dimension	errors	15.81	1	<.001
	trials	19.64	1	<.001
Age	errors	9.19	2	<.02
	trials	5.36	2	n.s.
Sex	errors	0.03	1	n.s.
	trials	0.27	1	n.s.
Age x Dimension	errors	1.04	2	n.s.
	trials	0.36	2	n.s.
Sex x Dimension	errors	0.78	1	n.s.
	trials	0.87	1	n.s.
Age x Sex	errors	0.36	2	n.s.
	trials	0.79	2	n.s.

comparisons revealed significant differences between 1 irrel. and oddity problems ($\lambda_r^2 = 30.68$, df = 1, $p<.001$) and between 2 irrel. and oddity problems ($\lambda_r^2 = 19.01$, df = 1, $p<.001$), but not between 1 irrel. and 2 irrel. The greatest number of errors were found in the oddity task, with fewer occurring for both the 1 irrel. and 2 irrel. tasks. The task x dimension interaction was significant ($\lambda_r^2 = 10.76$, df = 2, $p<.01$), although none of the other task interactions were. The analyses for task and its interactions are summarized in Table 11.

Individual comparisons within the task x dimension interaction revealed that there was a significant difference between colour and form for 1 irrel. ($H = 22.21$, df = 1, $p<.001$), and 2 irrel. ($H = 11.11$, df = 1, $p<.001$), but not for oddity. Within the dimension colour, there was a significant difference between 1 irrel. and oddity problems ($\lambda_r^2 = 11.11$, df = 1, $p<.001$) and between 2 irrel. and oddity problems ($\lambda_r^2 = 4.00$, df = 1, $p<.05$), but not between 1 irrel. and 2 irrel. problems. The same applied for form: there was a significant difference between 1 irrel. and oddity problems ($\lambda_r^2 = 20.25$, df = 1, $p<.001$) and between 2 irrel. and oddity problems ($\lambda_r^2 = 17.36$, df = 1, $p<.001$), but not between 1 irrel. and 2 irrel. problems.

Table 12 summarizes the Spearman correlations computed between error scores on the oddity task and chronological age (in years), between error scores on the oddity, 1 irrel., and 2 irrel. tasks and scores on the Raven's Coloured Progressive Matrices, and between age and scores on the Raven's Coloured Progressive Matrices. These correlations revealed a significant

TABLE 11

Summary of Friedman Analysis of Variance of Task for Errors and Trials to Criterion

Friedman two-way analysis of variance

		χ_r^2	df	p
Task	errors	37.59	2	<.001
	trials	8.05	2	<.02
Task x Age	errors	4.34	4	n.s.
	trials	0.38	4	n.s.
Task x Dimension	errors	10.76	2	<.01
	trials	16.43	2	<.001
Task x Sex	errors	5.01	2	n.s.
	trials	2.54	2	n.s.

TABLE 12

Summary of Spearman Correlation Coefficients and Probability Levels

	rho	p
Errors		
Oddity/Age	-.397	<.001
Oddity/Progressive Matrices	-.503	<.001
1 Irrel./Progressive Matrices	-.221	<.05
2 Irrel./Progressive Matrices	-.233	<.05
Trials to criterion		
Oddity/Age	-.364	<.01
Oddity/Progressive Matrices	-.482	<.001
1 Irrel./Progressive Matrices	-.187	n.s.
2 Irrel./Progressive Matrices	-.304	<.01
Age/Progressive Matrices	.795	<.001

Note.— Approximate probability values were computed for N = 72 from Appendix Table 10, p. 390, in Practical Nonparametric Statistics, by W.J. Conover.

relationship between oddity and age (rho = $-.397$, $p<.001$), between oddity and the Matrices' scores (rho = $-.503$, $p<.001$), between 1 irrel. and the Matrices' scores (rho = $-.221$, $p<.05$), and between 2 irrel. and the Matrices' scores (rho = $-.233$, $p<.05$). The correlation between age and the Matrices' scores was also significant (rho = $.795$, $p<.001$).

Trials to criterion:

The means and standard deviations of trials to criterion for each of the three age levels on the three experimental tasks are presented in Table 13. The means and standard deviations for trials to criterion on the variables of dimension, age, sex, and task are presented in Tables 6, 7, 8, and 9, respectively. The Kruskal-Wallis analysis of variance for dimension was significant ($H = 19.64$, $df = 1$, $p<.001$), indicating that a greater number of trials to criterion are required for colour than for form. Although there was a decreasing number of trials with increasing age, the main effect for age did not quite meet the required level of significance ($H = 5.36$, $df = 1$, $p<.07$). Individual comparisons showed that there was a significant difference only between the number of trials to criterion for preschool and grade 2 ($H = 5.05$, $df = 1$, $p<.05$), and not for preschool and kindergarten, or kindergarten and grade 2. Neither sex, nor the interactions between dimension, age, and sex were significant. The analyses for the main effects and the interactions are summarized in Table 10.

A Friedman analysis of variance for task revealed a significant difference ($\lambda_r^2 = 8.05$, $df = 2$, $p<.02$), and individual

TABLE 13

Means and Standard Deviations of Number of Trials to Criterion for both Dimensions for all Ages on Oddity, One Irrelevant Dimension Discrimination, and Two Irrelevant Dimension Discrimination Problems

Age		Preschool		Kindergarten		Grade 2	
Dimension		Colour	Form	Colour	Form	Colour	Form
Task							
Oddity	$\bar{X}$ =	67.00	68.00	59.00	53.58	48.00	42.58
	SD =	17.32	13.24	20.03	22.93	26.88	27.07
1 Irrel.	$\bar{X}$ =	67.75	40.25	61.75	26.92	57.00	24.75
	SD =	11.69	25.77	23.95	21.32	25.84	20.43
2 Irrel.	$\bar{X}$ =	72.00	44.17	62.00	35.08	61.50	31.17
	SD =	0.00	26.29	21.71	26.52	23.62	27.76
Total	$\bar{X}$ =	206.75	152.42	181.92	115.58	166.50	98.50
	SD =	19.76	50.31	55.14	59.67	67.01	54.19

comparisons showed significant differences between 1 irrel. and 2 irrel. ($\lambda_r^2 = 4.01$, df = 1, $p<.05$) and between 1 irrel. and oddity problems ($\lambda_r^2 = 5.56$, df = 1, $p<.02$), but not between 2 irrel. and oddity problems. The task x dimension interaction was the only significant task interaction ($\lambda_r^2 = 16.43$, df = 2, $p<.001$). The Friedman analyses of variance are summarized in Table 11. Individual comparisons within the task x dimension interaction indicated that there was a significant difference between colour and form for 1 irrel. (H = 23.59, df = 1, $p<.001$) and 2 irrel. (H = 22.24, df = 1, $p<.001$), but not for oddity. No significant differences were found between the tasks for colour, but there were significant differences between 1 irrel. and oddity problems ($\lambda_r^2 = 14.49$, df = 1, $p<.01$) and 2 irrel. and oddity problems ($\lambda_r^2 = 8.03$, df = 1, $p<.01$) for form.

Table 12 summarizes the Spearman correlations computed between trials to criterion on the oddity task and chronological age (in years), between trials to criterion scores on the oddity, 1 irrel., and 2 irrel. tasks and scores on the Raven's Coloured Progressive Matrices, and between age and scores on the Raven's Coloured Progressive Matrices. These correlations revealed a significant relationship between oddity and age (rho = -.364, $p<.01$), between oddity and the Matrices' scores (rho = -.482, $p<.001$), and between 2 irrel. and the Matrices scores (rho = -.304, $p<.01$), but not between 1 irrel. and the Matrices' scores (rho = -.187). The correlation between age and the Matrices' scores was very significant (rho = .795, p .001).

Percent success:

The data have been tabulated under percent success as well as under the number of errors and the number of trials to criterion, as this measure is more meaningful in the context of problem solving.

For the preschool subjects, on the oddity task, 8.33% reached criterion on the dimension of colour and 16.67% on the dimension of form. On the 1 irrel. task, 16.67% of the subjects reached criterion on colour and 75.00% on form, and on the 2 irrel. task, 0.00% of the subjects reached criterion on colour and 58.33% on form.

For the kindergarten subjects, on the oddity task, 41.66% reached criterion on the dimension of colour and 50.00% on the dimension of form. On the 1 irrel. task, 16.67% of the subjects reached criterion on colour and 91.67% on form, and on the 2 irrel. task, 25.00% of the subjects reached criterion on colour and 75.00% on form.

For the grade 2 subjects, on the oddity task, 50.00% reached criterion on the dimension of colour and 66.67% on the dimension of form. On the 1 irrel. task, 33.33% of the subjects reached criterion on colour and 91.67% on form, and on the 2 irrel. task, 25.00% of the subjects reached criterion on colour and 91.67% on form.

Since the fundamental analyses and significance tests of the above data are the same as the analyses on which the scaling is based, they will be presented as the scaling results. The number and percentage of subjects reaching criterion is presented in Table 14.

TABLE 14

Number and Percentage of Subjects Reaching Criterion (n = 12)

Age	Preschool				Kindergarten				Grade 2			
Dimension	Colour		Form		Colour		Form		Colour		Form	
	#	%	#	%	#	%	#	%	#	%	#	%
Task												
Oddity	1	8.33	2	16.67	5	41.66	6	50.00	6	50.00	8	66.67
1 Irrel.	2	16.67	9	75.00	2	16.67	11	91.67	4	33.33	11	91.67
2 Irrel.	0	0.00	7	58.33	3	25.00	9	75.00	3	25.00	11	91.67

Note.— Chance level for oddity = 33.3%

Chance level for 1 irrel. and 2 irrel. = 50%

Scaling:

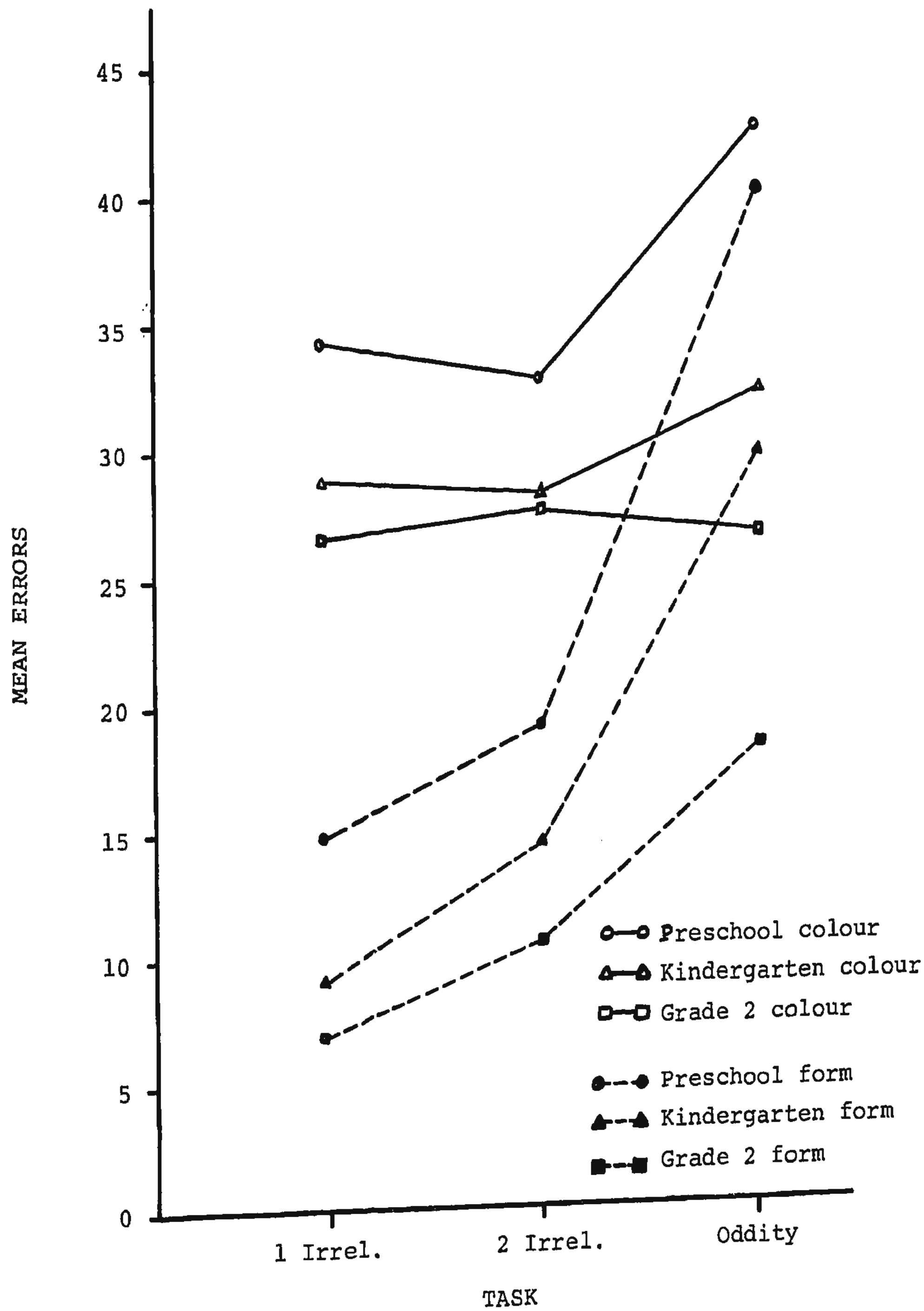
Errors: The greatest number of errors for the preschool and kindergarten subjects was found on the oddity problem. There were significant differences between colour and form for the 1 irrel. problem for preschool ($\lambda_r^2 = 3.94$, df = 1, $p<.05$), for kindergarten ($\lambda_r^2 = 5.05$, df = 1, $p<.05$), and for grade 2 ($\lambda_r^2 = 5.81$, df = 1, $p<.02$). There were no significant differences between colour and form on any of the three age levels for the 2 irrel. or oddity problems.

No significant differences were found between the 1 irrel. and 2 irrel. problems, or between the 2 irrel. and oddity problems for any of the three age levels on the dimension form, but there were significant differences between the 1 irrel. and oddity problems on form for preschool ($\lambda_r^2 = 5.95$, df = 1, $p<.02$), and kindergarten ($\lambda_r^2 = 5.18$, df = 1, $p<.05$), but not for grade 2. There were no significant differences between the 1 irrel., 2 irrel., and oddity problems on any age level for colour. The scale for the error scores is shown in Figure 1.

Trials to criterion: For the 1 irrel. problem, significant differences between colour and form were found for kindergarten ($\lambda_r^2 = 6.84$, df = 1, $p<.01$), and grade 2 ($\lambda_r^2 = 6.36$, df = 1, $p<.02$). For the 2 irrel. problem, only grade 2 had a significant difference between colour and form ($\lambda_r^2 = 4.97$, df = 1, $p<.05$), and there were no differences between colour and form on any of the three age levels for oddity.

There were no significant differences between the 1 irrel. and 2 irrel. problems, or the 2 irrel. and oddity problems on

FIGURE 1. Scale of Mean Errors



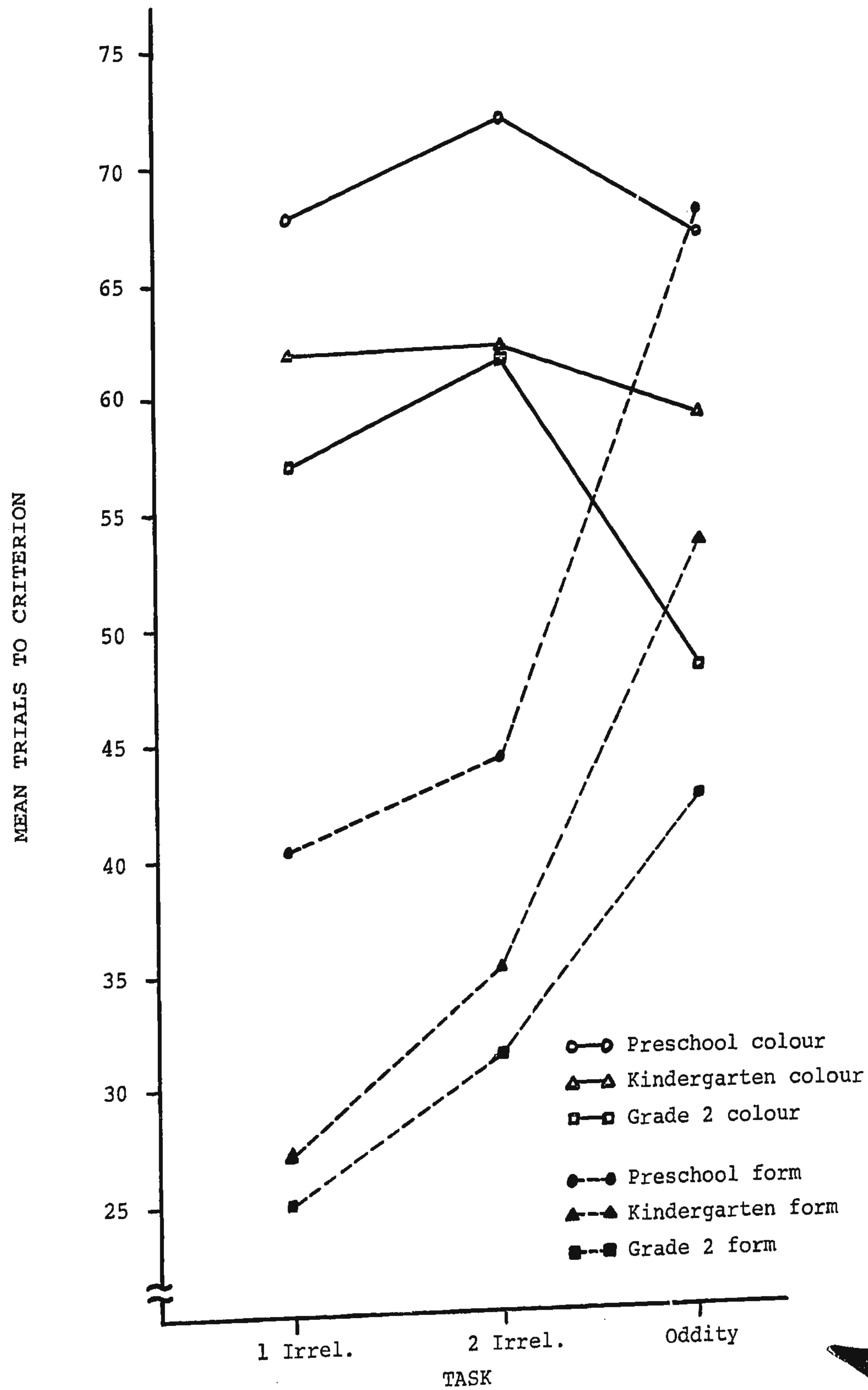
form for either the preschool, kindergarten or grade 2 subjects. However, there was a significant difference between the 1 irrel. and oddity problems for the kindergarten subjects on form (λ_r^2 = 4.42, df = 1, $p<.05$), but not for the preschool or grade 2 subjects. On the dimension of colour, no significant differences were found for any of the tasks on any of the three age levels. The scale for trials to criterion is shown in Figure 2.

Percent success: Significant differences were found between colour and form for the 1 irrel. problem for preschool (λ_r^2 = 18.55, df = 1, $p<.001$), kindergarten (λ_r^2 = 25.96, df = 1, $p<.001$), and grade 2 (λ_r^2 = 13.61, df = 1, $p<.001$); and for the 2 irrel. problem for preschool (λ_r^2 = 29.17, df = 1, $p<.001$), kindergarten (λ_r^2 = 25.00, df = 1, $p<.001$), and grade 2 (λ_r^2 = 19.04, df = 1, $p<.001$). There were no significant differences between colour and form for oddity on any of the three age levels.

For preschool subjects on the dimension of form, significant differences were found between the 1 irrel. and oddity problems (λ_r^2 = 18.55, df = 1, $p<.001$), and the 2 irrel. and oddity problems (λ_r^2 = 11.57, df = 1, $p<.001$), but not between the 1 irrel. and 2 irrel. problems. A significant difference on form was also found between the 1 irrel. and oddity problems for the kindergarten subjects (λ_r^2 = 6.12, df = 1, $p<.02$), but not between the 1 irrel. and 2 irrel. problems, or the 2 irrel. and oddity problems. No significant differences were found between tasks for grade 2 on form.

For the dimension colour, significant differences were found between the 1 irrel. and 2 irrel. problems for preschool

FIGURE 2. Scale of Mean Trials to Criterion



($\lambda_r^2 = 8.33$, df = 1, $p<.01$); between the 1 irrel. and oddity problems for kindergarten ($\lambda_r^2 = 5.36$, df = 1, $p<.05$); and between the 2 irrel. and oddity problems for grade 2 ($\lambda_r^2 = 4.17$, df = 1, $p<.05$). No significant differences were found for colour between the 1 irrel. and oddity problems or the 2 irrel. and oddity problems for the preschool subjects; between the 1 irrel. and 2 irrel. problems or the 2 irrel. and oddity problems for the kindergarten subjects; or between the 1 irrel. and 2 irrel. problems of the 1 irrel. and oddity problems for the grade 2 subjects.

The scale for percent successes is shown in Figure 3.

<u>Raven's Coloured Progressive Matrices</u>:

The Raven's scores from this study were compared with the norms of the Raven's Coloured Progressive Matrices. For the grade 2 subjects (8 years), the median scores were 22 and 18 for the present study, and the Raven's Coloured Progressive Matrices, respectively. For the kindergarten subjects (6 years), the median scores were 19 and 15, respectively. No norms were available for the preschool subjects (4 years). The comparison data are given in Table 15.

<u>Spearman correlations between errors and trials to criterion</u>:

A significant correlation was found between total errors and total trials to criterion (rho = .960, $p<.001$). Significant correlations were also found across tasks, ages, and dimensions. These data are summarized in Table 16. Therefore, trials to criterion will not be included in the discussion.

FIGURE 3. Scale of Percent Successes

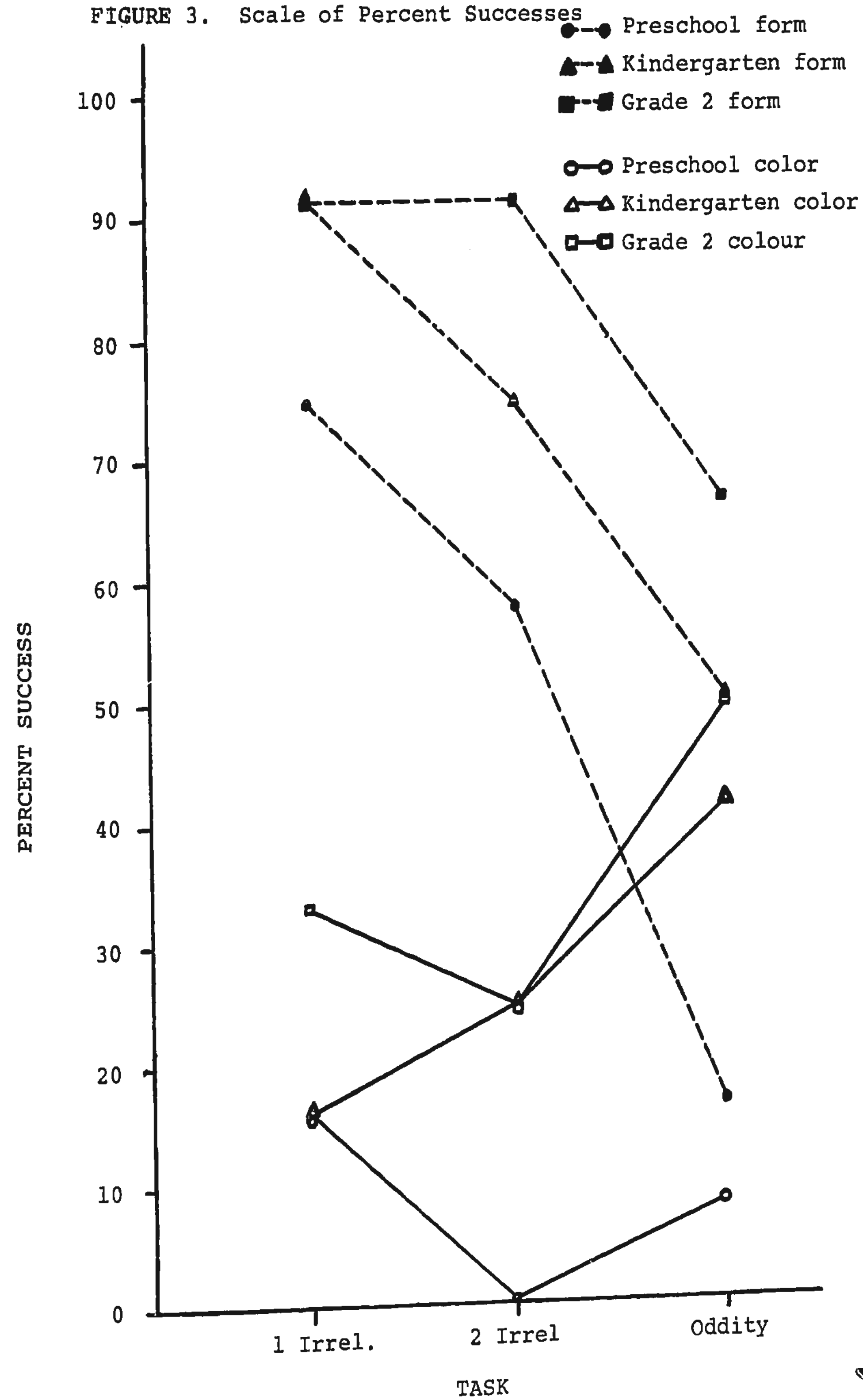


TABLE 15

Comparison of Present Study Data with Norms for the Raven's Coloured Progressive Matrices (RCPM)

Age	4	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	10 1/2	11	Percentile	IQ Score
Present study	8	15				18							10%	77
RCPM		12	12	13	14	14	15	16	18	20	20	21		
Present Study	10	16				20							25%	88
RCPM		13	14	14	15	16	17	19	21	22	22	24		
Present study	12	19				22							50%	100
RCPM		15	15	16	17	18	20	22	24	24	26	28		
Present study	13	21				28							75%	112
RCPM		17	18	19	20	21	23	26	28	28	29	31		
Present study	14	23				31							90%	123
RCPM		20	21	22	23	24	26	28	31	31	31	34		

Note.— Norms for the RCPM were reprinted from the <u>Guide to Using the Coloured Progressive Matrices, Sets A, A_B, B</u>, (Revised Order 1956), by J.C. Raven.

TABLE 16

Summary of Spearman Correlation Coefficients Between Errors and Trials to Criterion (all $p<.001$)

	rho
Total Errors/Trials to Criterion	.960
Task	
Oddity Errors/Trials to Criterion	.867
1 Irrel. Errors/Trials to Criterion	.944
2 Irrel. Errors/Trials to Criterion	.881
Age	
Preschool Errors/Trials to Criterion	.939
Kindergarten Errors/Trials to Criterion	.953
Grade 2 Errors/Trials to Criterion	.982
Dimension	
Colour Errors/Trials to Criterion	.968
Form Errors/Trials to Criterion	.885

DISCUSSION

Although it has been suggested that oddity learning is more difficult than discrimination learning, and it has been inferred that its solution is more complex, the empirical data of this experiment only partly support this suggestion because it was found that the relationship between oddity and discrimination learning is not a simple one. Overall, it was found that oddity was significantly different from both one irrelevant dimension discrimination and two irrelevant dimension discrimination learning, although one irrelevant dimension discrimination and two irrelevant dimension discrimination were not significantly different from one another. However, when the data are divided according to age and dimension a more complex pattern emerges.

In Figure 1, it can be seen that the most errors occurred for the preschool subjects on oddity for both the dimensions of colour and form, hence making this the most difficult task across age and dimension. With the exception of form oddity for the kindergarten subjects, all the tasks next highest in difficulty include the dimension of colour, regardless of age level or task, and there were no significant differences between tasks across all three age levels for colour. The remaining lower portion of the scale contains different age levels and tasks, but all are on the same dimension of form. From this it can be seen that dimension plays an important part in the scaling of the oddity, one irrelevant dimension discrimination and two irrelevant dimension discrimination tasks across the preschool, kindergarten, and grade 2 age levels.

A scale was also made for percent success. The percent success scale is perhaps the most meaningful of the three; errors, trials to criterion and percent success. The reason for this is that the very nature of problem solving indicates that it should be judged on whether or not the individual can achieve solution, rather than group scores, which do not necessarily reflect final solution behaviour on the part of any subject or subjects within the group. Thus, although traditional analyses of learning have been done on error scores and the number of trials to criterion, in problem solving it is more meaningful to deal with individuals and their ability to solve the problems. This argument also applies to developmental capacity, as this involves ascertaining whether or not individual subjects of a given age can achieve solution. Consequently, as the data had to be scaled, the best measure was percent success.

The scale for percent success (see Figure 3) was comparable to the scale for mean errors, but gave a more meaningful representation of the data. It was found that the fewest successes were on the two irrelevant dimension discrimination colour task for the preschool subjects. However, this was followed very closely by the oddity problem for the preschool subjects on both dimensions, colour and form. The dimensional difference also emerges, as significant differences were found between colour and form for all three age levels on the one irrelevant dimension discrimination and two irrelevant dimension discrimination tasks. However, there were no significant differences between colour and form on the oddity problem.

As in the scale for mean errors, the most difficult tasks for all ages appear to be those which contain the colour dimension, whereas the least difficult ones contain the dimension of form. Thus it can also be seen here that the relationship between age and task is confounded by dimension. For the form tasks, the one irrelevant dimension discrimination task is the easiest, followed by the two irrelevant dimension discrimination task, with oddity as the most difficult, as judged by the percent of successes. For colour, the one irrelevant dimension discrimination task is easier than the two irrelevant dimension discrimination task for preschool and grade 2, but the easiest task is oddity.

This last result posed a problem, and the raw data were studied in an endeavour to ascertain the reason why colour oddity was easier than the one irrelevant dimension discrimination and two irrelevant dimension discrimination colour tasks, and form oddity more difficult than the one irrelevant dimension discrimination and two irrelevant dimension discrimination form tasks. All age levels were studied for position preferences, and it was found that the preschool form group contained three subjects who consistently preferred a single position, and only one subject in the preschool colour group who had a consistent position preference. The colour oddity data were then studied, and it was found that the subjects could not exhibit a consistent form preference because both cubes and spheres were never presented on the same trial. Consequently, the subjects could not always choose the sphere because it was present on only 50% of the trials, or the cube because it was present on only 50% of the trials. It is thought that because of this, part of the difficulty of the problem is removed, and hence colour oddity would be easier.

The form oddity data were also examined and it was found that 3/12 of the grade 2 subjects, 3/12 of the kindergarten subjects, and 5/12 of the preschool subjects exhibited consistent form preferences. Responding in this manner eliminates the possibility of success on the oddity problem. Consequently, such form preferences reduce the percent of success on the form oddity problem.

If dimension had not been a confounding factor, the data would have shown oddity to be more difficult than the two irrelevant dimension discrimination and the one irrelevant dimension discrimination tasks. Two explanations for this are possible. The first is that the one irrelevant dimension discrimination and the two irrelevant dimension discrimination problems are concrete in nature, i.e. they involve only the differentiation between definite observable aspects of the stimuli, while oddity is a relational concept requiring the subject to respond to a relationship between the stimuli such that correct performance will occur only when the subject responds to a specific cue in the presence of certain other cues. The second explanation is based on the difference in the number of ambiguous cues that must be handled. For one irrelevant dimension discrimination and two irrelevant dimension discrimination problems there are positional and object cues, while for oddity there is the additional cue of relation.

Because dimension was a significant variable, a more complex explanation is needed. For the form oddity data, the first explanation of the two different types of concepts fits remarkably well, but it cannot explain the colour oddity data. This may be accounted for by the second explanation concerning the number of cues. Previously, it was shown that the difficulty of the colour oddity task was diminished because the form cue was removed, such that each succeeding trial did not contain the same shaped objects. This means that part of the object cue is removed, and since position is not an integral part of oddity, it is more likely that the subjects will attend to the relational cue more strongly, at the expense of the object and positional cues. Therefore, the colour oddity problem would be easier than the colour discrimination problems.

The explanation based on cues can also be used to account for the difficulty of the form oddity problem in relation to the form discrimination problems. In oddity, the subject must attend to positional, object, and relational cues, whereas in the discrimination problems, the subject only has to attend to the object and positional cues. Hence, the additional cue that has to be attended to will increase the difficulty of the form oddity problem.

There was a significant dimension effect because colour was more difficult than form on all age levels for the one irrelevant dimension discrimination task and the two irrelevant dimension discrimination task, but not for the oddity task (see Table 14). The finding that the colour dimension was not more difficult than form on the oddity task is consistent with Porter's (1965) comparison of his form oddity data and Lipsitt and Serunian's (1963) colour oddity data. The performance on the two dimensions were remarkably comparable.

Because the analysis of the data showed a significant main effect for dimension, it was evident that the pretraining had not accomplished its aim, which was to enable the subjects to utilize both dimensions equally well. Tighe and Tighe (1966) suggested "giving the subject some form of training or exposure to stimuli which are to be used in a subsequent discrimination task (p. 363)." This implies that the same stimuli should be used for the pretraining and the experimental tasks. Hence, the failure of the pretraining may have been due to the difference between the type of stimuli used in the pretraining and the experimental tasks. The pretraining stimuli consisted of two-dimensional pictures of objects, while the experimental task stimuli were three-dimensional wooden objects.

Wolff (1967) assumed that the facilitation of learning in pretrained subjects should apply to the original learning in discrimination as it does to the reversal shift phase. Tighe and Tighe (1968b), however, stated that "the differentiation analysis of this two-dimensional task indicates that only during shift, and not during original learning, is there a clear basis upon which to predict differences in ease of learning between perceptually pretrained and control subjects (p. 756)." Hence, they suggest that pretraining does not necessarily facilitate the learning of the one irrelevant dimension discrimination, two irrelevant dimension discrimination, and oddity tasks. In fact, in this study no positive transfer appeared to have occurred at all. Furthermore, there seemed to be no relation whatsoever between the pretraining and the experimental tasks.

Another reason why pretraining and the experimental tasks were unrelated could be the inherent differences in the tasks themselves. This, nevertheless, was necessary as the aim of the study was to observe original learning, and if the pre-training tasks had been the same as the experimental tasks, this aim would have been defeated. In pretraining, there were no irrelevant dimensions and the response was made on the basis of the given cues. In the two discrimination tasks, there were irrelevant dimensions and the subject had to select out and then discard the irrelevant cues before he could respond to the relevant one. Lastly, in oddity, the subject had to discard the irrelevant cues as in the two discrimination tasks, but he also had to have knowledge of the conceptual rule in order to compare the cues and select the correct one - oddity. The differences in the tasks are representative of the whole field of learning, which is itself composed of a multitude of different kinds of tasks, and this highlights the difficulty of making broad theoretical generalizations across tasks.

The correlation between successful oddity performance and chronological age showed that performance improvement over age is indicative of the developmental nature of the capacity to solve oddity problems. Oddity also correlated significantly with scores on the Raven's Coloured Progressive Matrices, while the one irrelevant dimension discrimination and two irrelevant dimension discrimination tasks correlated very poorly. This suggested that oddity and the problems of the Raven's Coloured Progressive Matrices were similar in nature, whereas the one irrelevant dimension discrimination and two irrelevant dimension discrimination problems were of a different type altogether.

An interesting consistency with the developmental nature of this study is the extremely high correlation between the means and variances. Usually, this is taken as an indication of faulty statistical procedure, but in developmental learning studies, it is to be expected because with an increase in age, an increase in the number of correct responses and conversely a decrease in the number of errors is anticipated.

Porter (1965) proposed that a certain level of maturation was required for the solution of oddity problems. He suggested that this level occurred between the ages 5 1/2 and 6 1/2 years. The data in this experiment are comparable because the kindergarten children (6 years) respond above chance level 33.3% and the preschool children (4 years) respond below chance level (see Table 14).

Only one other study (Hill, 1965) has been reported in which discrimination and oddity learning have been compared. Hill used stereometric stimulus objects, but the dimensions were not varied from trial to trial, therefore the problem was a simple discrimination problem with zero irrelevant dimensions. Because of this, the subjects could use either colour, form or size as their relevant dimension, depending on their preference. The present study specified the relevant dimension and hence utilized the one irrelevant dimension discrimination and two irrelevant dimension discrimination problems. Both studies, however, used the oddity problem and the results did not differ markedly from one another when the data from this study was collapsed over dimension (see Table 17 and Figure 4).

Hill used the two-position oddity method, thus facilitating the subject's choice by removing one-third of the ambivalence of the choice situation. Hence, any differences between the two studies may be accounted for by the different methods of presentation, cell sizes, types of stimuli, and maximum number of trials (Hill ran all subjects to a maximum of 200 trials).

The oddity data from the present study were also compared with much of the relevant data in the field of oddity learning (see Table 18). All the data appear to be very consistent, and are evidence that the ability to solve oddity problems increases developmentally.

In conclusion, this study has shown the complex relationship between the oddity problem, the one irrelevant dimension discrimination problem, and the two irrelevant dimension discrimination problem. Also it has emphasized the role that dimension plays, in that it is so evident within the age and task subgroups. The results, therefore, expand the only previous comparison study (Hill, 1965) and are consistent with the antecedent findings of children's performance on oddity problems.

TABLE 17

Comparison of Performance Data of Present Study and Hill's (1965) Study

Task		0 Irrel.				1 Irrel.				2 Irrel.				Oddity			
Dimension		Colour		Form		Colour		Form		Colour		Form		Colour		Form	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Age 4 years	Present study					2	16.67%	9	75.00%	0	0.00%	7	58.33%	1	8.33%	2	16.67%
	Hill (1965)			28	93.33%											3	10.00%
6 years	Present study					2	16.67%	11	91.67%	3	25.00%	9	75.00%	5	41.66%	6	50.00%
	Hill (1965)			29	96.67%											17	56.67%

Note.— Mean percentage of colour and form oddity for the present study for 4 years = 12.50%, and for 6 years = 45.83%.

FIGURE 4. Comparison of Percent Success Data of Present Study and Hill (1965) Study

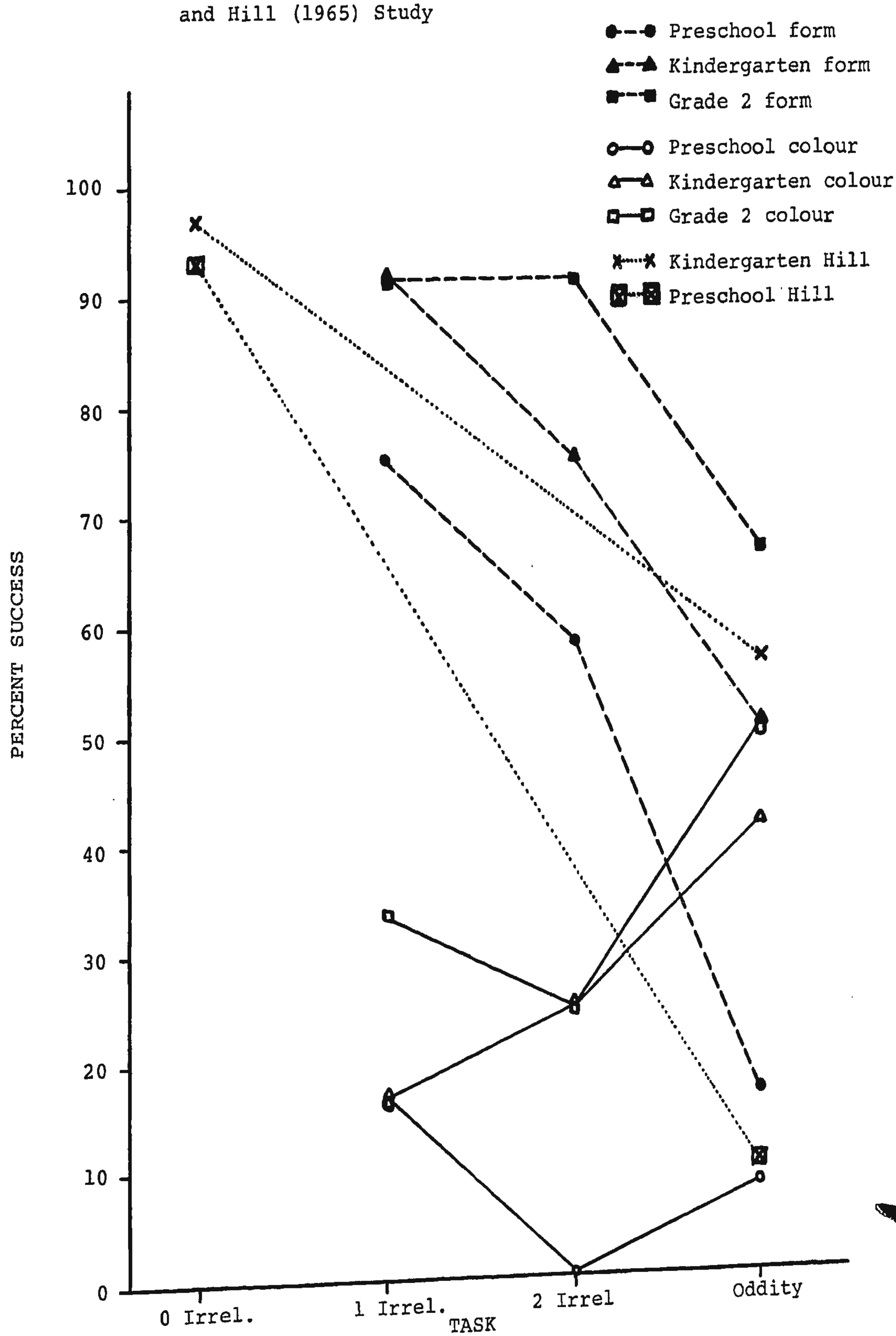


TABLE 18

Comparison of Successful Oddity Performance and Age Level

Author	% Success	Age	Dimension
Present study	8.33%	4 years	colour
Hill (1965)	10.00%	4 years	colour, form or size
Porter (1965)	10.00%	4.3 "	form
Present study	16.67%	4 "	form
Lipsitt & Serunian (1963)	16.70%	5 "	colour
Romba (1956a)	40.00%	6 "	colour
Present study	41.66%	6 "	colour
Gollin & Shirk (1966)	42.00%	4-4 1/2 "	colour
Romba (1956a)	50.00%	8 "	colour
Present study	50.00%	8 "	colour
Present study	50.00%	6 "	form
Lipsitt & Serunian (1963)	53.60%	5-6 "	colour
Hill (1965)	56.67%	6 "	colour, form or size
Gollin & Shirk (1966)	58.00%	5-6 "	form
Porter (1965)	65.00%	6 "	form
Present study	66.67%	8 "	form
Porter (1965)	100.00%	7.3 "	form
Lipsitt & Serunian (1963)	100.00%	9 "	colour

Further research on this topic should investigate why dimension has such a significant effect on this type of problem. Also, the scale constructed in this investigation could be further developed and standardized so that it might be used to evaluate children's developmental levels. Such a cognitive developmental scale would be a much more rigorous measure than any of the current developmental scales which measure only environmentally determined and school acquired accomplishments.

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APPENDIX

TABLE 1

Summary of Raw Data for Errors

	Colour						Form					
	Preschool		Kindergarten		Grade 2		Preschool		Kindergarten		Grade 2	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1 Irrel.	39	34	33	37	31	30	3	30	1	1	1	1
	36	41	34	34	38	0	4	7	1	27	0	1
	39	39	36	0	40	26	31	7	4	7	12	2
	29	37	43	29	11	36	37	0	12	2	11	9
	36	36	34	34	0	33	8	34	41	1	2	1
	37	10	1	28	35	38	0	16	0	12	30	12
2 Irrel.	30	38	30	35	27	35	11	33	8	5	0	23
	25	35	33	27	33	1	3	2	7	38	3	27
	30	36	35	2	32	34	8	32	3	4	1	1
	30	32	27	38	31	36	38	0	28	38	4	1
	43	34	35	37	1	42	19	35	42	2	1	3
	33	28	3	34	34	31	41	8	1	0	40	23

APPENDIX - TABLE 1 (cont'd.)

	Colour						Form					
	Preschool		Kindergarten		Grade 2		Preschool		Kindergarten		Grade 2	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
	49	2	28	42	55	43	35	49	17	35	36	0
	52	43	35	18	49	13	10	27	18	46	4	16
Oddity	42	52	47	36	12	18	56	54	1	11	0	37
	48	51	47	43	3	0	48	32	41	52	4	27
	40	48	35	36	1	38	40	48	44	35	4	18
	49	37	13	7	42	46	43	42	3	44	30	43

APPENDIX

TABLE 2

Summary of Raw Data for Trials to Criterion

	Colour						Form					
	Preschool		Kindergarten		Grade 2		Preschool		Kindergarten		Grade 2	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1 Irrel.	72	72	72	72	72	72	31	68	10	10	10	10
	72	72	72	72	72	9	14	25	10	58	9	10
	72	72	72	9	72	63	72	35	16	39	44	11
	61	72	72	72	27	72	72	9	38	17	35	32
	72	72	72	72	9	72	22	72	72	10	11	10
	72	32	12	72	72	72	9	54	9	34	72	43
2 Irrel.	72	72	72	72	72	72	32	72	20	21	9	64
	72	72	72	72	72	10	21	11	22	72	17	67
	72	72	72	11	68	72	31	72	23	24	10	10
	72	72	72	72	72	72	72	9	65	72	14	10
	72	72	72	72	12	72	45	72	72	11	13	17
	72	72	21	64	72	72	72	21	10	9	72	71

APPENDIX - TABLE 2 (cont'd.)

	Colour						Form					
	Preschool		Kindergarten		Grade 2		Preschool		Kindergarten		Grade 2	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Oddity	72	12	48	72	72	72	72	72	41	72	72	9
	72	72	72	37	72	30	26	72	45	72	14	49
	72	72	72	72	25	48	72	72	11	40	9	72
	72	72	72	72	22	9	72	70	72	72	23	61
	72	72	71	72	10	72	72	72	72	59	15	43
	72	72	28	20	72	72	72	72	15	72	72	72

APPENDIX

TABLE 3

Summary of Pretraining Raw Data for Errors and Trials to Criterion

Preschool						Kindergarten						Grade 2					
Colour		Form		Size		Colour		Form		Size		Colour		Form		Size	
e	t	e	t	e	t	e	t	e	t	e	t	e	t	e	t	e	t
2	12	1	11	1	11	4	19	9	25	3	20	0	10	1	11	4	17
1	11	0	10	0	10	0	10	2	12	2	11	1	11	10	25	0	10
1	13	2	12	2	15	1	11	1	11	0	10	1	11	1	11	2	14
0	10	0	10	1	11	0	10	1	11	1	12	0	10	3	15	1	11
1	11	1	11	1	11	1	11	1	11	2	13	3	19	0	10	0	10
0	10	1	11	1	11	0	10	1	12	0	10	4	21	0	10	0	10
1	11	1	11	1	12	3	18	1	11	1	11	1	11	1	11	1	11
1	12	0	10	1	11	1	11	0	10	1	11	0	10	0	10	2	14
1	12	1	11	1	11	3	18	0	10	0	10	3	15	1	11	1	11
1	11	1	11	1	11	1	11	2	13	0	10	3	14	2	14	1	11
2	18	1	11	2	14	1	11	0	10	0	10	2	12	0	10	0	10
1	11	1	11	1	11	12	25	13	25	12	25	0	10	2	12	1	11
1	12	1	11	1	11	1	11	1	11	2	13	2	15	0	10	1	12
2	12	0	10	2	13	1	15	14	25	8	25	1	11	1	11	0	10
1	13	1	11	1	11	3	20	1	11	1	11	0	10	0	10	1	11
0	10	1	11	1	11	0	10	1	11	1	12	1	11	1	11	1	11
0	10	0	10	1	11	5	19	1	11	1	18	0	10	1	12	1	11
5	23	2	19	1	11	0	10	2	13	1	11	3	16	0	10	1	11
5	19	1	15	3	21	1	11	0	10	2	13	4	19	1	16	1	11
11	25	5	25	10	25	0	10	2	12	2	12	1	11	1	12	0	10
2	15	4	21	1	12	3	14	2	12	1	11	1	11	1	11	2	12
1	11	1	11	3	13	1	12	0	10	1	11	0	10	1	12	0	10
3	14	0	10	1	11	4	19	0	10	0	10	0	10	0	10	1	11
0	10	2	16	0	10	1	11	2	12	1	11	1	11	0	10	1	11

Note.– e = errors, t = trials to criterion

APPENDIX

TABLE 4

Summary of Raven's Coloured Progressive Matrices' Data

Preschool	Kindergarten	Grade 2
12	18	21
16	16	27
10	19	28
13	22	24
14	16	18
13	21	22
9	15	21
12	25	20
12	19	33
11	15	18
10	20	25
15	21	20
12	17	20
8	21	26
11	17	24
14	13	19
11	19	18
14	16	22
9	20	21
14	22	31
11	26	32
12	23	30
10	18	28
8	15	19