THE EMERGENCE OF CLASS CONCEPT FORMATION IN PRESCHOOL CHILDREN

BY

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B.A., University of British Columbia, 1970

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in the Department

of

Psychology

We accept this thesis as conforming to the

required standard

THE UNIVERSITY OF BRITISH COLUMBIA

September, 1974

Department of Psychology

The University of British Columbia
Vancouver 8, Canada

Date September 6, 1974

Abstract

The ability to classify complex visual forms was studied in three, four, and five year old children. Each subject performed two tasks based on two classes of computer-generated stimuli. The oddity task required the identification of the odd form in a set of three eight-sided polygons. The sequential task required the assignment of each sequentially presented single polygon to one of two classes. No feedback was given. The results revealed a marked developmental change in classification ability occurring between about 4 1/2 and 5 1/2 years of age. The oddity task appeared to be a more sensitive test of class concept formation.

Signature of Supervisor

TABLE OF CONTENTS

List of Tables

List of Figures

Acknowledgement

I would like to express my appreciation and gratitude to Tannis M. Williams for the assistance, support, and encouragement given to me at every point from the preparation to the completion of this thesis.

The ability to classify complex visual patterns was studied developmentally by Aiken and Williams (1973). Using a task in which subjects were required to identify one odd pattern in sets of three, they found that children in Grade 5 and adults, who did not differ, were both more accurate than children in Grades 1 and 3, who also did not differ. However, while the two younger age groups were statistically significantly less accurate than the two older age groups, the absolute differences were small and, the youngest group, Grade 1, still performed significantly above chance levels. These results indicated to Aiken and Williams (1973) that development of the ability to perform their oddity classification task occurs sometime prior to age six.

In order to assess developmental change of strategy in approach to their classification task, Aiken and Williams (1973) conducted several psychophysical analyses. They found that subjects at all age levels tended to make the same errors and used the same physical features for judging pattern class membership. The data indicated that the two younger age groups were merely slightly less proficient at using the same strategies used by the older groups.

The stimuli used by Aiken and Williams (1973) were eight sided polygons generated from each of two prototypes. Psychophysical analyses of their data revealed that subjects at all age levels used both the general similarity between patterns and their prototypes and two particular physical pattern features to judge pattern class membership. In other words, neither prototypes nor distinctive features were sufficient to account for performance. This finding contradicts the view of

E. J. Gibson (1969) who has argued that the learning of distinctive features is the most important process in perceptual learning and development. To support her argument, she cites work done by Pick (1965) on visual and tactual form discrimination. Pick found that the discovery of distinctive features facilitated transfer of learning more than did the formation of prototypes. She trained kindergarten children to discriminate between standard forms and specified transformations of them and then made three tests for transfer of learning. The experimental group which was given new standards and transformations which had the same dimensions of difference as those in the training session made fewest errors in the transfer task, indicating that learning depended on discovering the dimensions by which transformations and their standards differed. The group which had the same standards (i.e., prototypes) but new transformations made fewer errors than the group which had both new standards and new transformations. Thus, Gibson (1969) argued that while prototype learning may play a role when retention over time is required, distinctive feature learning is the more important process in perceptual learning and development.

In discussing the roles played by distinctive features and prototypes in perceptual development, it is important to note the type of perceptual task under consideration. When the task requires the detection of what is different among stimuli, as in discrimination, it is reasonable to assume that distinctive features will be more useful. On the other hand, when the task requires the detection of what is common among stimuli, as in classification, it seems reasonable to assume that prototypes will be more useful. Pick (1965) used a discrimination matching task; Aiken and Williams (1973) used a classification task. It is therefore not surprising that the results of the former study indicated that subjects used distinctive features more than they used prototypes. While the subjects in the Aiken and Williams (1973) study did use distinctive features, they selected pattern-features which were unrelated to class memberships. Indeed, reliance on these features misled subjects at all age levels on certain problems. Thus, classification accuracy was primarily due to the use of prototype information rather than to the use of distinctive pattern features.

The present study was designed to answer some of the questions left unanswered by Aiken and Williams (1973). Of primary interest was the question of when in development (prior to age six) the ability to classify complex visual patterns first occurs. Accordingly, the oddity task employed by Aiken and Williams (1973) was given to children 3, 4, and 5 years of age. In addition, the forms used in the oddity task were presented sequentially to the same subjects. While the oddity task is based on the assumption that accurate performance requires the assignment of each form to one class or the other, it is possible that subjects need only discriminate the odd form in any group of three. The sequential task was included in the present study because it provides a more stringent test of the prototype use in the classification of complex visual forms. Direct comparison of the stimuli is impossible and therefore accurate performance must reflect pattern class learning. A sequential classification task using the same pattern classes employed in the oddity task was used successfully with adults by Aiken and Brown (1971).

Method

Subjects

Subjects for the study were three, four and five year old children attending eight day care centres in metropolitan Vancouver, British Columbia. Half of the twelve children in each age group were female and half were male. Subjects were selected so that at least four months had passed since their last birthday in order to make the age groups more homogeneous and therefore avoid obscuring developmental age-related changes. The mean chronological ages of the three age groups were 3 years, 8 months (S.D. 2.22 months), 4 years, 8 months (S.D. 2.27 months), and 5 years, 7 months (S.D. 3.11 months), respectively. All subjects were tested during June and July, with all but 8 of the 72 testing sessions occurring during the morning. Twenty potential subjects were eliminated for a variety of reasons. Five subjects were absent for their second testing session (one 3 year old, two 4 year olds, and two 5 year olds). One 4 year old had to be eliminated because of projector malfunction. Fourteen subjects were eliminated for inattention or inappropriate responses to the sequential task. Of these, five were three year olds, four were 4 year olds and five were 5 year olds. Because the number of subjects at each age level eliminated from the study due to their inability to perform the task was comparable across age levels, age-related results were not likely to be due to subject selection.

Stimuli

The stimuli were eight-sided polygons computer generated from two prototypes to form two classes of patterns. Within each class, patterns were generated at three levels of similarity to their prototypes and thus three levels of classification difficulty: low, moderate and high. Patterns most similar to their own prototypes are easiest to distinguish from patterns of the other class. The procedure for generating the patterns has been described in detail by Aiken and Brown (1971). The overall principle is one of producing random changes in each of the prototype vertices.

Oddity task problems consisted of three patterns placed horizontally on a 4" x 6" card. Examples of problems are shown in Figure 1. On each problem, two patterns were from one prototype class and one was from the other class, but all were of the same degree of similarity to their prototype and thus were all of low, moderate, or high difficulty. There were 36 problems in total, selected from the 63 problems used by Aiken and Williams (1973) so as to include 12 at each difficulty level. The correct pattern occurred equally often in each position and equally often from each prototype class. No more than two problems of the same difficulty level occurred in sequence. The correct pattern occurred in the same position and was from the same class no more than three times in a sequence. The problems were arranged in three blocks of 12 trials each with four problems of each difficulty level in each block. The blocks were presented in the

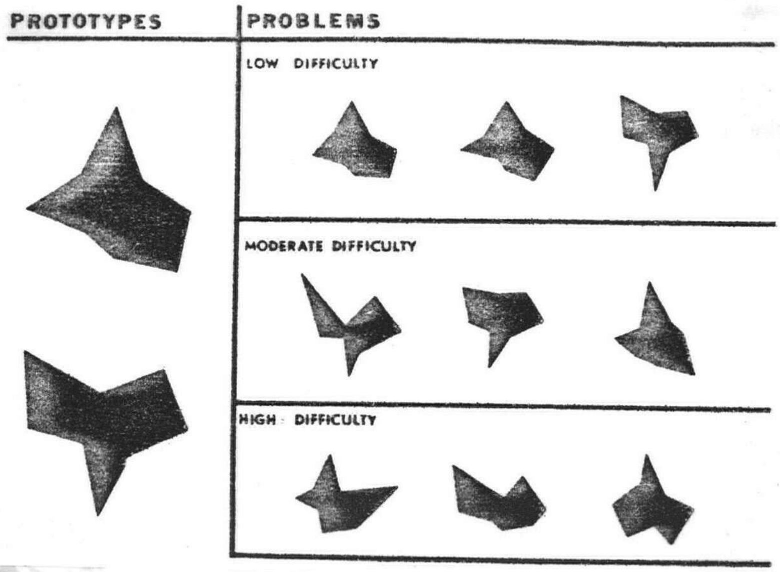

Figure 1. Prototypes and sample problems at three difficulty levels. [On each problem the subject's task is to choose the pattern that is odd or different (e.g., Patterns 3, 3, and 2, respectively). Subjects were never shown the prototypes.]

three orders of a balanced Latin Square. In each age group, two males and two females were assigned to each block order. In each case, the first block was presented again at the end of the task as a measure of improvement over time. Aiken and Williams (1973) had found that 15 (approximately 25%) of their 63 problems were especially difficult; less than a chance proportion of subjects at one or more age levels got each of these 15 problems correct. In order to maintain a comparable proportion of difficult problems, 9 of the 15 problems found by Aiken and Williams (1973) to be especially difficult were included in the present study, with three occurring in each block of 12 patterns.

Patterns for the sequential tasks were eight sided polygons from the stimulus samples used in the oddity task. In the sequential task, each problem consisted of a single pattern on a transparent slide. As in the oddity task, there were 36 problems arranged in 3 blocks of 12 problems each. Each block contained four problems from each difficulty level and no more than two problems of the same difficulty level occurred in sequence. Within any block, variations on each prototype occurred equally but no more than three times in a row. As in the oddity task, the blocks were presented in the three orders of a balanced Latin Square and the first block was repeated after the third, making a total of 48 trials.

Each child received the same block order for both the sequential and the oddity task. Task presentation order was counterbalanced, with half the females and half the males at each age level receiving each task first. The tasks were presented in separate sessions for each child. Time between sessions ranged from three to eight days, with a mean of 6.10 days.

Procedure

All children were tested by the same woman in a quiet room away from the rest of the day care centre.

Oddity Task. The child was seated opposite the experimenter and given the following instructions.

I am going to show you some cards. There are three shapes on each of these cards. Two of these shapes belong to one family and one of the shapes belongs to another, different family. When I show you a card, I want you to look very carefully at the shapes. You will see that two of the shapes go together and one does not go with the others. I want you to point to the one shape that does not go with the others, the one that does not belong.

Now, let's look at some cards for practice; (the experimenter showed the child the card -- two squares and a circle). Point to the one that does not belong with the others. That's right. These two are the same, they belong together. (Experimenter points to two squares) and this one (points to circle) is different. This is the one that does not belong.

The second, third, and fourth training problems consisted of two similar but not identical shapes, such as a square and a rectangle, and one different shape, such as a circle. The fifth training problem consisted of three polygons similar to the experimental stimuli. After the child had responded to each of the training problems, the experimenter verbalized the solution while pointing to the appropriate shapes.

<u>Sequential Task</u>. The sequential task stimuli were back-projected onto a screen, placed on the table about two feet in front of the child. About 6" directly in front of the child was a 6" x 4" x 1/2" black wooden panel. Two plastic circles 1 1/4" diameter were nailed flat on the black panel. The circle on the left was red; the one on the right was blue. The experimenter, who operated the projector with a remote control, gave the following instructions:

I am going to show you some shapes. There are two different kinds of shapes. If you see one that looks like this, (experimenter shows first slide, low variability example of one class) I want you to point to this circle here, the red one. Now you point to it. This is what one kind of shape looks like. This (experimenter shows second slide, low variability example of other class) is what the other shapes look like. If you see one that looks like this, you point to this circle, the blue one. Now you point to it. All the shapes you will see look either like this one (second slide) or like this one (first slide). O.K. Let's look at some new ones. (Then, two examples of first family, also low variability, are shown; then two examples of second family, also low variability, are shown.) When each slide is on experimenter says, "Which circle do you think you should point to now?" Mistakes made by children on training trials were corrected. The experimenter says, "No, for this one you should point to the red circle, because this shape looks like the other one where you pointed to the red circle."

Each experimental session lasted from 10-20 minutes depending on the speed with which the child made choices.

Results

Two sets of analyses of variance were performed, one on the data from only the first three blocks (Times 1-3) and one on the data from all four blocks (Times 1-4, including the repeated first block). In each case three analyses were conducted: one on the data for both tasks, one for only the oddity data and one for only the sequential data. Only the results of the analyses of the data from all four blocks (Times 1-4) will be discussed because the differences between the two sets of analyses were not substantial. The strengthening of significant effects that occurred in the Time 1-4 analyses can be attributed to the increased numbers of task items. The results of the analyses of the data from only the first three blocks (Times 1-3) are given in the Appendix.

The results of the three types of analyses are presented in order, with the data from the combined analyses being discussed first.

Combined Analyses

The probability of being correct by chance on any one trial was .33 for the oddity task and .5 for the sequential task. In order to make the data from the two tasks comparable, the number of correct responses per block per subject was divided by the chance number correct per block for that task. The resulting values were analyzed in an analysis of variance of Order (oddity first, sequential second, or vice-versa) by Sex by Age (3, 4, 5, years) by Task (oddity, sequential) by Variability Level (low, moderate, high) by Time (trials 1-12, 13-24, 25-36, 37-48). Conservative degrees of freedom were used for all tests of significance involving repeated measures. The results of the analysis are summarized in Table 1.

The Age main effect was significant ($F_{2, 24} = 6.61$, $p < .01$), with a Newman Keuls analysis revealing that 5-year-olds were significantly more accurate than both 4 and 3 year olds ($p < .01$ in both cases), who did not differ.

The significant Task main effect ($F_{1, 24} = 25.60$, $p < .01$) reflected greater overall accuracy on the oddity than on the sequential task.

Both the Age and Task main effects must be interpreted in conjunction with the significant Age by Task interaction ($F_{1, 12} = 5.54$, $p < .05$). A simple effects analysis revealed that there were significant age differences in performance on the oddity task ($F_{2, 24} = 11.24$, $p < .01$) but not on the sequential task ($F < 1$). A Newman Keuls analysis further revealed that on the oddity task, 5 year olds were significantly more accurate than both 4 year olds and 3 year olds ($p < .01$ in both cases), who did not differ. When task differences were examined at the various age levels, simple effects analyses revealed task differences only for the 5 year olds ($F_{1, 24} = 31.71$, $p < .01$), who were more accurate on the oddity than on the sequential task.

The variability main effect was significant ($F_{1, 12} = 69.28$, $p < .01$) with all difficulty levels being differentiated in the expected direction ($p < .01$ for all comparisons in a Newman Keuls analysis).

The Age by Variability interaction was also significant ($F_{2, 24} =$

Table I. Summary of analysis of variance of number of correct responses on both oddity and sequential tasks.

Source	df	ms	F
Between subjects			
A (order)	1	.17	< 1
B (sex)	1	5.94	3.28
C (age)	2	11.95	6.61**
AB	1	.02	< 1
AC	2	2.13	1.18
BC	2	1.96	1.08
ABC	2	1.81	1.00
Ss with grps.	24	1.81	
Within subjects			
D (Task)	1	11.48	25.60**
AD	1	.26	< 1
BD	1	.40	< 1
CD	2	2.48	5.54*
ABD	1	.32	< 1
ACD	2	2.05	4.57
BCD	2	.18	< 1
ABCD	2	.88	1.96
D x Ss	24	.45	
F (variability)	2	20.55	69.28**
AF	2	.15	< 1
BF	2	.45	1.52
CF	4	1.26	4.25*
ABF	2	.74	2.50
ACF	4	.34	1.16
BCF	4	.91	3.08
ABCF	4	.03	< 1
F x Ss	48	.30	
G (time)	3	.07	< 1
AG	3	.01	< 1
BG	3	.25	< 1
CG	6	.38	1.01
ABG	3	.90	2.43
ACG	6	.42	1.13
BCG	6	.40	1.07
ABCG	6	.29	< 1
G x Ss	72	.37	

Table I (Cont'd)

	df	ms	F
DF	2	7.20	23.53**
ADF	2	.46	1.51
BDF	2	.17	< 1
CDF	4	.74	2.45
ABDF	2	.55	1.79
ACDF	4	.14	< 1
BCDF	4	.41	1.34
ABCDF	4	.27	< 1
DF x Ss	48	.31	
DG	3	.61	1.83
ADG	3	.58	1.76
BDG	3	.19	< 1
CDG	6	.16	< 1
ABDG	3	.45	1.35
ACDG	6	.28	< 1
BCDG	6	.06	< 1
ABCDG	6	.05	< 1
DG x Ss	72	.33	
FG	6	.21	< 1
AFG	6	.13	< 1
BFG	6	.37	1.01
CFG	12	.36	< 1
ABFG	6	.12	< 1
ACFG	12	.23	< 1
BCFG	12	.30	< 1
ABCFG	12	.30	< 1
FG x Ss	144	.37	
DFG	6	.14	< 1
ADFG	6	.34	1.25
BDFG	6	.13	< 1
CDFG	12	.28	1.01
ABDFG	6	.30	1.10
ACDFG	12	.31	1.14
BCDFG	12	.25	.90
ABCDFG	12	.14	.51
DFG x Ss	144	.27	

Note: Conservative degrees of freedom were used for tests of all effects involving repeated measures. * indicates $p < .05$; ** indicates $p < .01$.

4.25, $p < .05$). A simple effects analysis revealed that there were age differences in accuracy on low ($F_{2,\ 24} = 11.24$, $p < .01$) and moderate ($F_{2,\ 24} = 6.05$, $p < .01$) but not on high difficulty problems. Newman Keuls analyses indicated that on both low and moderate variability problems, 5 year olds were significantly more accurate than both 4 and 3 year olds ($p < .01$ in both cases), who did not differ. Simple effects analyses also revealed that there were significant differences in accuracy due to pattern variability at all age levels (for 5 year olds, $F_{2,\ 48} = 50.90$, $p < .01$; for 4 year olds, $F_{2,\ 48} = 16.30$, $p < .01$; for 3 year olds, $F_{2,\ 48} = 10.66$, $p < .01$). At all age levels, accuracy on low variability items was significantly greater than on both high ($p < .01$ for all age groups) and moderate variability items ($p < .01$ for 5 and 4 year olds and $p < .05$ for 3 year olds). Furthermore, at all age levels performance on moderate items was significantly more accurate than on high variability items ($p < .01$ for 5 and 4 year olds and $p < .05$ for 3 year olds). Thus, at all age levels, all variability levels were significantly differentiated.

The Task by Variability interaction was significant ($F_{1,\ 24} = 23.53$, $p < .01$), with a simple effects analysis revealing that performance across pattern variability levels differed significantly on both tasks (for the oddity task, $F_{2,\ 48} = 85.80$, $p < .01$; for the sequential task, $F_{2,\ 48} = 6.46$, $p < .01$). Newman Keuls analyses indicated that on the oddity task, performance on all variability levels was significantly differentiated in the expected directions ($p < .01$ for all comparisons). On the sequential task, accuracy was greater on low than on higher variability problems ($p < .01$) and also greater on moderate than on high difficulty problems ($p < .05$). When performance on the two tasks was examined at each variability level, greater accuracy on the oddity than on the sequential task was found for low ($F_{1, 24} = 66.66$, $p < .01$) and moderate variability problems ($F_{1, 24} = 6.02$, $p < .05$), with no task differences on the high variability problems.

None of the effects involving Order, Sex, or Time were significant.

Oddity Task Analyses

The mean number of oddity problems (per block) correctly solved by age and by difficulty level is shown in Table 2. The performance of 5 year olds was significantly above chance on low ($p < .01$) and on moderate ($p < .05$) variability problems but not on high variability problems. Four year olds performed above chance levels on only low variability problems ($p < .05$) and the performance of 3 year olds did not exceed chance at any variability level.

The proportion of subjects in each age group correctly answering each of the nine problems found to be especially difficult in the Aiken and Williams (1973) study, and the most popular pattern choice, are given in Table 3 along with the data for the older age groups in the Aiken and Williams (1973) study. Problems that were especially difficult for older subjects were apparently also difficult for pre-school children, who tended to make the same wrong choices.

Number of correct oddity task responses was examined in an analysis of variance of Order by Sex by Age by Variability by Time. Conservative degrees of freedom were used for all tests of significance involving

Table II. Mean number of oddity problems correctly solved (per block) by age and by difficulty level.

Age	Variability Level			
	Low	Moderate	High	Overall
3 years	2.08	1.72	1.25	1.69
4 years	2.31*	1.78	1.44	1.84
5 years	3.31**	2.22*	1.69	2.41
$\bar{X}$	2.57	1.91	1.46	

Note: In relation to the chance probability of 1.33 correct per block, * = $p < .05$; ** = $p < .01$.

Table III. Proportion of correct choices and most frequently chosen pattern for nine especially difficult problems. (Data for grades 1, 3, 5, and adult groups are from Aiken and Williams, 1973.)

Problem Number	Proportion Correct: Age 3 yrs	4 yrs	5 yrs	Gr 1	Gr 3	Gr 5	Adult	Most Popular Choice: Age 3 yrs	4 yrs	5 yrs	Gr 1	Gr 3	Gr 5	Adult
Low Difficulty														
1	.25	.50	.58	.44	.48	.31	.19*	3	1	1	1	1	3	3
Moderate Difficulty														
2	.25	.25	.50	.22*	.25	.31	.36	3	3	1,3[a]	3	3	3	3
3	.17*	.25	.25	.15*	.02*	.11*	.38	2	3	3	3	3	3	1
4	.25	.25	.42	.39	.17*	.22*	.24	2	1	3	2	2	2	2
High Difficulty														
5	.42	.17*	.17*	.10*	.08*	.18*	.17*	2	2	2	2	2	2	2
6	.17*	.25	.17*	.15*	.10*	.31	.21*	2	1	1	1	1	1	1
7	.25	.17*	.33	.15*	.04*	.07*	.05*	3	1	1	3	3	3	3
8	.17*	.08*	.17*	.05*	.06*	.13*	.24	2	2	2	2	2	2	3
9	.17*	.33	.50	.39	.23	.20*	.26	2	2	1,2[a]	2	2	2	2

Note: * indicates choice made by significantly fewer than chance number of subjects ($p < .05$).
[a] two patterns chosen by equal number of subjects.

repeated measures. The results of the analysis are summarized in Table 4, and serve to confirm the results reported above for the combined analysis.

The Age main effect was significant ($F_{2, 24} = 10.5$, $p < .01$), with a Newman Keuls analysis indicating that 5 year olds were significantly more accurate than both 4 year olds ($p < .01$) and 3 year olds ($p < .01$), who did not differ.

The Variability main effect was also significant ($F_{1, 24} = 69.55$, $p < .01$) with all difficulty levels significantly differentiated from one another in the expected direction ($p < .01$ in all comparisons).

The only significant interaction was Age by Variability ($F_{2, 24} = 3.78$, $p < .05$). A simple effects analysis revealed that the age groups differed on low ($F_{2, 24} = 17.72$, $p < .01$) and moderate ($F_{2, 24} = 4.12$, $p < .05$) but not on high difficulty problems. Newman Keuls analyses revealed that in both low and moderate difficulty problems, 5 year olds were significantly more accurate than both 4 and 3 year olds ($p < .01$ in all cases), who did not differ. When the effects of variability were examined at each age level, simple effects analyses revealed that variability affected performance at all age levels (for 5 year olds, $F_{2, 48} = 47.83$, $p < .01$; for 4 year olds, $F_{2, 48} = 18.31$, $p < .01$; and for 3 year olds, $F_{2, 48} = 10.98$, $p < .01$). Newman Keuls analyses indicated that the accuracy of both the 5 and 4 year age groups was significantly greater on low than on both moderate and high variability problems ($p < .01$ for all comparisons). The 3 year age group was more accurate on both low and moderate than on high difficulty problems

Table IV. Summary of analysis of variance of number of correct responses on the oddity task.

Source	df	ms	F
Between subjects			
A (order)	1	.01	< 1
B (task)	1	8.33	3.93
C (age)	2	22.40	10.57**
AB	1	.15	< 1
AC	2	3.72	1.76
BC	2	.92	< 1
ABC	2	1.09	< 1
_Ss_ within groups	24	2.12	
Within subjects			
F (variability)	2	45.65	69.56**
AF	2	.56	< 1
BF	2	.13	< 1
CF	4	2.48	3.78*
ABF	2	2.24	3.41
ACF	4	.77	1.18
BCF	4	1.58	2.40
ABCF	4	.30	< 1
F x _Ss_	48	.66	
G (time)	3	.84	1.05
AG	3	.52	< 1
BG	3	.38	< 1
CG	6	.50	< 1
ABG	3	1.50	1.86
ACG	6	1.06	1.32
BCG	6	.62	< 1
ABCG	6	.24	< 1
G x _Ss_	72	.81	
FG	6	.49	< 1
AFG	6	.56	< 1
BFG	6	.80	< 1
CFG	12	.82	1.02
ABFG	6	.40	< 1
ACFG	12	.67	< 1
BCFG	12	.72	< 1
ABCFG	12	.44	< 1
FG x _Ss_	144	.80	

Note: Conservative degrees of freedom were used for tests of all effects involving repeated measures. * indicates $p < .05$; ** indicates $p < .01$.

($p < .01$ in both cases).

Sequential Task Analyses

The mean number of sequential problems solved by age and by difficulty level is shown in Table 5. The performance of the 5 year olds was significantly above chance on low ($p < .05$) and on moderate ($p < .05$) but not on high variability items. The performance of the 4 and 3 year age groups did not exceed chance at any variability level.

The number of correct sequential task classifications was examined in an analysis of variance of Order by Sex by Age by Variability by Time. The results of the analysis are summarized in Table 6. As with the oddity task analysis, the results serve to confirm the findings described above for the combined analysis.

Only the Variability main effect was significant ($F_{1, 24} = 8.40$, $p < .01$). A Newman Keuls analysis revealed that performance on both low and moderate variability problems was significantly better than performance on high variability problems ($p < .01$ for both comparisons).

Discussion

The results of the present study provide convincing evidence that the ability to classify complex visual patterns does indeed develop prior to six years of age. A marked developmental change in accuracy takes place between the ages of about 4 1/2 and 5 1/2 years. Evidence for this developmental shift can be found in the significant age main effects, the age-related interactions and the data concerned with performance relative to chance levels. The performance of the 3 year age

Table V. Mean number of sequential problems (per block) correctly solved by age and by difficulty level (maximum possible = four).

	Variability Level			
Age	Low	Moderate	High	Overall
3	2.52	2.21	2.23	2.32
4	2.52	2.44	2.23	2.40
5	2.96*	3.04*	2.21	2.74
$\bar{X}$	2.67	2.56	2.22	

Note: In relation to the chance probability of 2.0 correct per block, ** indicates $p < .01$; * indicates $p < .05$.

Table VI. Summary of analysis of variance of number of correct responses on the sequential task.

Source	df	ms	F
Between subjects			
A (order)	1	1.69	< 1
B (sex)	1	6.50	1.53
C (age)	2	7.09	1.67
AB	1	1.02	< 1
AC	2	8.31	1.96
BC	2	6.47	1.53
ABC	2	8.31	1.96
Ss within groups	24	4.24	
Within subjects			
F (variability)	2	7.78	8.40**
AF	2	1.17	1.27
BF	2	2.20	2.37
CF	4	2.44	2.64
ABF	2	.09	< 1
ACF	4	.17	< 1
BCF	4	1.73	1.87
ABCF	4	.51	< 1
F x Ss	48	.93	
G (time)	3	.82	< 1
AG	3	1.19	1.21
BG	3	.90	< 1
CG	6	1.02	1.03
ABG	3	2.01	2.03
ACG	6	.42	< 1
BCG	6	.42	< 1
ABCG	6	.81	< 1
G x Ss	72	.99	
FG	6	.26	< 1
AFG	6	.61	< 1
BFG	6	.29	< 1
CFG	12	.69	< 1
ABFG	6	.80	1.03
ACFG	12	.67	< 1
BCFG	12	.55	< 1
ABCFG	12	.74	< 1
FG x Ss	144	.77	

Note: Conservative degrees of freedom were used for tests of all effects involving repeated measures. * indicates $p < .05$; ** indicates $p < .01$.

group was not above chance on either task, the 4 year age group performed above chance on only low variability items in the oddity task, and the five year age group performed significantly above chance levels on both low and moderate variability items on both tasks. This developmental change in classification ability can also be clearly seen in Table 7, which gives the proportion of correct responses on the oddity task at each variability level achieved by 3, 4, and 5 year olds in the present study along with the proportion of correct responses achieved by adults and 6, 8, and 10 year olds in the Aiken and Williams (1973) study.

The sequential task was included in the present study because it provides a more stringent test of classification skills and the use of prototypes in classification than does the oddity task. The subject sees the prototypes themselves in neither task, but accurate performance in the oddity task might be possible merely through discrimination of the odd pattern in each set of three, rather than through prototype learning. In the sequential task, the subject must classify each pattern merely on the basis of his past experience with instances of each class. That performance relative to chance levels was comparable on the two tasks in terms of the skills being tapped lies in the absence of significant effects involving order of task presentation. If prototype learning occurred differentially in the two tasks, then performance would be likely to vary with order of task presentation, since the prototypes on which the classes were based were the same in both cases. It is not surprising that the sequential task was in general more difficult than the oddity task. Indeed, it is more surprising that 5 year olds were

Table VII. Proportion of correct responses on the oddity task by variability level and by age.

	Variability		
Age	Low	Moderate	High
3 yr	.5104	.4323	.3177
4 yr	.5729	.4427	.3229
5 yr	.8177	.5729	.4167
6 yr	.8240	.5643	.4476
8 yr	.8264	.5644	.4541
10 yr	.8960	.6041	.4930
adult	.9035	.6398	.5038

Note: Data for ages 6, 8, 10 yrs and adults are from Aiken and Williams, 1973. These proportions are based on sixty-three problems.
Proportions from the present study are based on forty-eight problems.

able to perform at above chance levels on the sequential task, which requires pattern comparisons from memory. In summary, the results provide strong evidence that the oddity and sequential tasks assess the same underlying perceptual and/or cognitive processes.

While the absence of significant effects involving order and sex was expected, the absence of significant effects involving time is more thought-provoking. While it is possible that with a larger sample of problems (e.g., as used by Aiken and Williams, 1973) performance might improve significantly over time, the results suggest that learning the nature of the classes, including whatever prototype learning took place, occurred relatively early in both tasks. It is also likely, however, that the very young subjects tired as the trials progressed, and that improvement in classification ability and fatigue effects tended to cancel one another.

Although the present study did not include psychophysical analyses relating prototype and distinctive feature measures to classification accuracy, the finding that 5 year olds in the present study were so similar in accuracy to the 6 and 8 year olds in the Aiken and Williams (1973) study suggests that they did indeed use the same bases of judgment. Further evidence that subjects in the present study used strategies similar to those used by older subjects exists in their comparably poor performance in the nine particularly difficult problems, and the fact that they tended to make the same wrong choices (see Table 7).

These results clearly indicate that mastery of the ability to classify complex visual patterns occurs between 4 1/2 and 5 1/2 years of age. The question to be answered now is why 3 and 4 year olds are unable to perform the task successfully. It is tempting to hypothesize that this change in classification ability is related to advancement from the preoperatory to the concrete operatory stage of development, but confirmation would have to come in a study demonstrating that subjects who are more accurate on the classification task are more advanced in terms of Piaget's developmental stages.

References

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APPENDIX I: Raw Data

Subject Number	Task Order (1=odd. 1st) 2=seq. 1st)	Sex	Age (in years)	Oddity Task Low Time 1234	Oddity Task Mod Time 1234	Oddity Task High Time 1234	Sequential Task Low Time 1234	Sequential Task Mod Time 1234	Sequential Task High Time 1234
				Number of Correct choices (out of a possible 4)					
01	1	M	3	2122	2111	1113	1233	2231	2222
02	1	M	3	3344	3322	2232	4444	4442	2423
03	1	M	3	2130	1222	2122	2204	1132	2222
04	1	F	3	3213	2212	2212	3122	1012	3200
05	1	F	3	3243	2113	1210	3221	3112	2322
06	1	F	3	2130	2112	1010	2312	0112	2121
07	2	M	3	1423	2311	3101	2323	0203	2332
08	2	M	3	3200	2211	1010	4241	3442	3211
09	2	M	3	3323	1221	1302	2112	3433	1234
10	2	F	3	2222	1223	2112	2344	0242	3242
11	2	F	3	2010	1121	1012	2123	3111	2322
12	2	F	3	2203	2322	2100	4444	4444	4324
13	1	M	4	4410	2113	2222	4444	4434	2432
14	1	M	4	2213	2222	0220	0331	2242	3212
15	1	M	4	1123	2212	0111	3333	2131	1122
16	1	F	4	2222	0231	2101	1222	0420	3221
17	1	F	4	2211	2011	2320	2222	2132	1233
18	1	F	4	1322	2122	0211	3202	4122	3112
19	2	M	4	4444	3234	1130	4344	4234	3332
20	2	M	4	3104	2201	0220	3114	2222	3142
21	2	M	4	4444	3331	2212	4344	3244	3224
22	2	F	4	1432	2221	2131	2231	1332	1131
23	2	F	4	2121	2021	1222	3212	3242	1232
24	2	F	4	1331	2112	0110	2231	2123	4341
25	1	M	5	3434	3243	3232	4434	4444	2243
26	1	M	5	2443	2233	1222	2323	4242	0213
27	1	M	5	4233	2213	2211	2223	3313	2232
28	1	F	5	2443	2222	1231	4433	3432	1222
29	1	F	5	4442	2231	1201	4444	3333	4123
30	1	F	5	3434	3213	3113	4444	4424	3333
31	2	M	5	3414	4321	2221	1234	2334	2222
32	2	M	5	4334	2232	1321	4444	3444	2332
33	2	M	5	4422	2224	2112	1112	4214	1122
34	2	F	5	4433	2213	1122	2332	4231	2222
35	2	F	5	4243	1122	3121	1232	2333	1312
36	2	F	5	3333	4323	1202	3244	3224	2234

APPENDIX 2: Summary of analysis of variance of number of correct choices, both tasks included, for time 1-3 (problems 1-12; 13-24; 25-36) only.

Source	df	ms	F
Between subjects			
A (order)	1	.11	< 1
B (sex)	1	3.24	2.17
C (age)	2	7.46	4.98*
AB	1	.00	< 1
AC	2	1.88	1.26
BC	2	1.08	< 1
ABC	2	.83	< 1
Ss within groups	24	1.50	
Within subjects			
D (task)	1	10.75	27.88**
AD	1	.07	< 1
BD	1	.55	1.42
CD	2	2.16	5.60*
ABD	1	.80	2.08
ACD	2	1.65	4.27
BCD	2	.22	< 1
ABCD	2	.60	1.57
D x Ss	24	.39	
F (variability)	2	14.00	40.84**
AF	2	.14	< 1
BF	2	.57	1.66
CF	4	1.16	3.39
ABF	2	.35	1.01
ACF	4	.37	1.07
BCF	4	.73	2.13
ABCF	4	.11	< 1
F x Ss	48	.34	
G (time)	2	.11	< 1
AG	2	.01	< 1
BG	2	.18	< 1
CG	4	.27	< 1
ABG	2	1.32	3.49
ACG	4	.60	1.58
BCG	4	.35	< 1
ABCG	4	.19	< 1
G x Ss	48	.38	

APPENDIX 2 (Cont'd)

Source	df	ms	F
DF	2	5.92	17.79**
ADF	2	.40	1.21
BDF	2	.07	< 1
CDF	4	.66	1.98
ABDF	2	.19	< 1
ACDF	4	.12	< 1
BCDF	4	.29	< 1
ABCDF	4	.11	< 1
DF x Ss	48	.33	
DG	2	.67	2.00
ADG	2	.81	2.41
BDG	2	.21	< 1
CDG	4	.21	< 1
ABDG	2	.34	1.01
ACDG	4	.42	1.24
BCDG	4	.04	< 1
ABCDG	4	.05	< 1
DF x Ss	48	.34	
FG	4	.20	< 1
AFG	4	.16	< 1
BFG	4	.31	< 1
CFG	8	.46	1.33
ABFG	4	.07	< 1
ACFG	8	.27	< 1
BCFG	8	.16	< 1
ABCFG	8	.13	< 1
FG x Ss	96	.34	
DFG	4	.06	< 1
ADFG	4	.29	1.24
BDFG	4	.14	< 1
CDFG	8	.32	1.37
ABDFG	4	.24	1.03
ACDFG	8	.43	1.84
BCDFG	8	.33	1.41
ABCDFG	8	.13	< 1
DFG x Ss	96	.23	

Note: Conservative degrees of freedom were used for all tests involving repeated measures. * indicates $p < .05$; ** indicates $p < .01$.

APPENDIX 3: Summary of analysis of variance of number of correct choices on the oddity task only, for time 1-3 only.

Source	df	ms	F
Between subjects			
A (order)	1	.00	< 1
B (sex)	1	5.71	3.31
C (age)	2	15.58	9.04**
AB	1	.69	< 1
AC	2	3.11	1.81
BC	2	.30	< 1
ABC	2	.45	< 1
Ss within groups	24	1.72	
Within subjects			
F (variability)	2	33.19	47.47**
AF	2	.60	< 1
BF	2	.23	< 1
CF	4	2.09	2.98
ABF	2	.73	1.05
ACF	4	.65	< 1
BCF	4	.96	1.37
ABCF	4	.27	< 1
F x Ss	48	.70	
G (time)	2	1.00	1.18
AG	2	.74	< 1
BG	2	.54	< 1
CG	4	.51	< 1
ABG	2	1.75	2.05
ACG	4	1.55	1.82
BCG	4	.49	< 1
ABCG	4	.26	< 1
G x Ss	48	.85	
FG	4	.40	< 1
AFG	4	.56	< 1
BFG	4	.73	1.10
CFG	8	.99	1.49
ABFG	4	.20	< 1
ACFG	8	.95	1.44
BCFG	8	.67	1.02
ABCFG	8	.39	< 1
FG x Ss	96	.66	

Note: Conservative degrees of freedom were used for all tests involving repeated measures. * indicates $p < .05$; ** indicates $p < .01$.

APPENDIX 4: Summary of analysis of variance of number of correct choices on the sequential task only, for time 1-3 only.

Source	df	ms	F
Between subjects			
A (order)	1	.69	< 1
B (sex)	1	2.25	< 1
C (age)	2	3.26	< 1
AB	1	1.63	< 1
AC	2	7.06	1.94
BC	2	4.51	1.24
ABC	2	4.71	1.29
Ss within groups	24	3.64	
Within subjects			
F (variability)	2	4.63	4.13
AF	2	.84	< 1
BF	2	2.06	1.84
CF	4	2.57	2.29
ABF	2	.48	< 1
ACF	4	.49	< 1
BCF	4	1.91	1.70
ABCF	4	.28	< 1
F x Ss	48	1.12	
G (time)	2	.85	< 1
AG	2	1.62	1.72
BG	2	.34	< 1
CG	4	.76	< 1
ABG	2	2.69	2.86
ACG	4	.57	< 1
BCG	4	.46	< 1
ABCG	4	.37	< 1
G x Ss	48	.94	
FG	4	.12	< 1
AFG	4	.53	< 1
BFG	4	.14	< 1
CFG	8	.89	1.09
ABFG	4	.80	< 1
ACFG	8	.64	< 1
BCFG	8	.43	< 1
ABCFG	8	.17	< 1
FG x Ss	96	.82	

Note: Conservative degrees of freedom were used for all tests involving repeated measures. * indicates $p < .05$; ** indicates $p < .01$