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ABSTRACT

A schema is best understood as a statistically defined concept. Schematic concept formation consists of abstracting the common elements or properties of a defined class in a schema. Thereafter, both discrimination and retention are facilitated, since only deviations from the schema need be processed for any particular class exemplar. In the present study, 240 children ranging from 6 to 12 years of age were trained in an oddity task, either with or without knowledge of results to distinguish 67 percent redundant patterns representing different schemata. Schematic concept formation was found to occur prior to age 6 and increase in efficiency to ages 11 or 12. This ability did not depend on knowledge of results and was not related to traditional measures of intelligence. The schematic concept formation task appears to be a promising nonverbal and perhaps culture-independent measure of learning potential or ability. (Author)

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Developmental Aspects of Schematic Concept Formation

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Introduction

Consider an Occidental businessman, who believes himself particularly adept at associating names with faces, on his initial visit to the Orient. After meeting a number of people he feels quite perplexed since he can remember names but can no longer readily assign them to the appropriate faces. Soon, however, our businessman no longer experiences this difficulty. Moreover, he is now puzzled that at one time all Orientals seemed to "look alike" since these people now appear to be as different as his Occidental acquaintances.

Such an experience as this represents a type of perceptual learning which may be called schematic concept formation (SCF). Briefly, a schema is best understood as a statistically defined concept. Schematic concept formation consists of abstracting the common elements or properties of a defined class into a schema. Thereafter, both discrimination and retention are facilitated since only deviations from the schema need be processed for any class exemplar. Thus our hypothetical businessman could not initially differentiate among Oriental faces because all these faces deviated from his previously acquired American "face" schema or prototype in an almost identical manner. The differentiation became much easier once he acquired the Oriental "face" schema since a particular Oriental face could then be remembered simply as a deviation from this schema.

Lippsitt and Serunian (1963) have shown that normal children improve from kindergarden to third grade in solving certain oddity problems. Moreover, evidence exists (e.g., Honkavaara, 1958; Jones, 1971; Spitz, 1964) that in a variety of perceptual tasks both backward and mentally retarded children can abstract a concept from a set of varying instances representing that concept. In the natural environment, however, instances representing many concepts or schemata are mixed together. If schematic encoding is to be used, humans must be able to distinguish between members of different schema families and associate each instance with its appropriate schema family.

Although a considerable amount of evidence exists (e.g., Attneave, 1954, 1957, 1959; Edmonds & Mueller, 1967a, 1967b, 1967c, 1970) that human adults can readily perform this task, a most relevant question concerns how this ability, which is basic for cognition, develops with age and experience. In an attempt to answer this question, children ranging from 6 to 12 years of age were trained either with or without knowledge of results (KR) in an oddity discrimination task to distinguish patterns representing a schema family from patterns belonging to different schema families. In previous research using adults (Edmonds, Evans & Mueller, 1966), the effect of KR was to indicate the relevant dimensions (schema) along which oddity was to be sought rather than to assist SCF per se. This same result was expected at these earlier age levels if SCF is a basic, spontaneous process which can be done with only the information in the stimuli themselves.

House (1966) and Jones (1971) have obtained evidence that the ability to abstract rules or regularities is related to I.Q. Using mentally retarded

...ldren Jones (1971) found significant correlations between abstraction ability ... verbal scores measured by the WISC and Stanford-Binet. Although these correlations are to be interpreted with caution due to several biasing factors, the data does indicate that SCF ability might offer the possibility of a non-... devise to measure the intellectual and developmental stages. To evaluate these suppositions the relationship between I.Q. and SCF performance was investigated at each of the six age levels.

Method

The subjects were 240 students enrolled in grades 1 through 6 at the Episcopal Day School, which is located in Augusta, Georgia. The 40 students enrolled at each of these six age levels were randomly assigned to two groups which are referred to as Group KR (knowledge of result-condition) and Group NKR (no knowledge of result condition). Mental age variations were comparable at each of the chronological age levels.

Patterns. A computer program, VARGUS 7 (Edmonds & Evans, 1966; Evans, 1967; Edmonds & Mueller, 1970), has been developed which allows quantification of pattern populations in information terms and permits independent manipulation of several population parameters. The patterns from VARGUS 7 are similar in appearance to the "histoform" patterns introduced by Fitts, Weinstein, Rappaport, Anderson, & Leonard (1956). The VARGUS 7 patterns, however, are produced from a seven element Markov process by mapping the elements into column heights. A schema can be introduced into the patterns by selecting transitional probabilities to favor a most probable sequence (MPS) of column heights; different MPS's constitute different schemata. A population of schemata may also be sampled by forming random permutations of column height sequences. Redundancy is determined by the magnitude of the probabilities associated with each step of the MPS, and stimulus channel capacity in bits per stimulus is manipulated by changing the number of columns in a pattern. All three of these variables can be manipulated independently. Manipulations of schema and redundancy do not affect certain other potentially relevant variables such as the average pattern area.

In the present study the VARGUS 7 computer program used four different most probable column height sequences (MPS's), designated pattern sets PS1, PS2, PS3, and PS4, to produce 67% redundant patterns containing 12 columns. These patterns had been used in previous research and the MPS's (schemata) did not differ in difficulty.

Task and Procedure. The subjects received five training trials, each of which consisted of two similar forms and one different form (e.g., square, rectangle, triangle). On each trial the subjects were instructed to select the form that was not like the others. All subjects correctly performed this task. Each subject was then given a 20 page booklet with three nonidentical VARGUS 7 patterns printed on each page and appropriately instructed to select the pattern on each page that was "most different from" the other two patterns. Each page of the booklet contained two different PS1 patterns and a third pattern chosen at random from PS2, PS3, or PS4. Thus two of the patterns represented one schema and the third pattern represented a different schema. The position of the third pattern in each three pattern set was randomly varied. Both groups were allowed 45 seconds to choose a pattern on each page. Group KR was then told which pattern was correct. Group NKR received no feedback. The intertrial interval was 25 seconds.

Results and Discussion

A 2 by 6 (2 levels of KR by 6 age levels) analysis of variance based on the number of patterns identified correctly on the last three oddity trials indicated that the age main effect was significant ($F = 8.67$, $df = 5/228$, $p < .01$). The KR main effect and the interaction were not significant.

Comparisons among grade levels indicated that, except for the grade 5 and grade 6 comparison, all performance differences were significant ($p < .01$ for all comparisons). In other words, the performance of the first graders was significantly above chance and performance significantly increased from grade level 1 through grade level 5 both with and without KR. The results thus indicate that SCF ability develops prior to age 6 but increases in efficiency until age 11 or 12. These findings are supported in an experiment by Aiken & Williams (1973) which indicated no significant SCF performance differences between fifth graders and adults. Moreover, Aiken & Williams (1973) concluded that any performance variations among age levels reflected accuracy rather than stategy differences.

In the present study all performance comparisons between Groups KR and NKR were nonsignificant. This result is consistent with previous research (e.g. Edmonds, Evans & Mueller, 1966; Edmonds & Mueller, 1967a; Edmonds & Mueller, 1967b) and lends further support to the notion that schematic concept formation is a spontaneous process which occurs without need for supplementary information.

Correlations of performance by Groups KR and NKR with both I.Q. (Otis-Lennon Mental Ability Test) and mental age were not significant, ranging from .08 to .22. Shields, Gordon & Evans (1969) obtained only moderate relationships between SCF performance and traditional measures of intelligence. These data suggest that performance on the SCF task may be a measure of learning ability that is independent of academic achievement. The results of an experiment by Price & Evans (1972) support this supposition. They found that SCF performance provided a better prediction of learning potential in disadvantaged students than did intellectual capacity. Price & Evans (1972) believe that these and other related findings indicate that the SCF task may prove useful as a non-verbal and perhaps culture-independent measure of certain cognitive abilities.

Conclusions

The results indicate that the ability to learn concepts defined by objects in the environment without any source of feedback or knowledge of results develops prior to age 6 and increases in efficiency to around age 11 or 12. This ability does not appear to be related to standard measures of intelligence which sample what has already been learned rather than measuring learning ability itself. Preliminary investigations indicate that the schematic concept formation task may be a process oriented measure of learning ability since it shows promise as a predictor of academic potential in disadvantaged students. Research is currently being performed to more adequately evaluate these findings.

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