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ABSTRACT

Evidence for suggested basic differences in the abstract reasoning capacity of Negro and Caucasian children includes consistent findings of significantly poorer performance by Negroes on Raven's Progressive Matrices (PM). This study investigated the PM performance of Negro children taught algebra via a discovery method of instruction. It was administered to 16 5th-6th grade experimental students and 19 5th and 6th grade control students. Mean score for the experimental students was 36.2. A t-test of the difference in mean scores for the 2 groups was significant, suggesting that, given encouragement and training in complex problem solving, Negro children can develop the same abstract reasoning skills measured by the PM as Caucasian children. (Author)

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Abstract

Evidence for suggested basic differences in the abstract reasoning capacity of Negro and Caucasian children includes consistent findings of significantly poorer performance by Negroes on Raven's Progressive Matrices (PM). This study investigated the PM performance of Negro children taught algebra via a discovery method of instruction. It was administered to 16 5th-6th grade experimental Ss and 19 5th and 6th grade control Ss. Mean score for the experimental Ss was 36.2. A t-test of the difference in mean scores for the 2 groups was significant ($p < .001$), suggesting that, given encouragement and training in complex problem solving, Negro children can develop the same abstract reasoning skills measured by the PM as Caucasian children.

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This study was designed to examine the question of a qualitative difference between the intellectual abilities of Negro and Caucasian children, a question of general psychological and social significance, with more specific and immediate implications for education. If their integration in our schools is to result in successful education for both, instruction must be geared to the abilities known to exist in individual children. Whether as groups Negroes and whites can profit from the same sorts of learning experiences must be determined by assessing their respective learning styles and specific cognitive abilities.

Two levels of learning ability have been postulated, associative learning and conceptual learning (Jensen, 1969). Level I (associative learning) is best exemplified by rote and trial-and-error learning tasks; level II (conceptual learning), by concept learning and abstract (logical) problem solving (Jensen, 1969, p.111). Jensen hypothesizes that these levels describe basic racial differences in mental ability that underlie discrepancies in performance of Negroes and whites on intelligence,

achievement, and "culture-free" tests, as well as their differential abilities to profit from related instructional programs.

Because of the many variables affecting both test results and classroom learning, an eventual resolution of the question of qualitative differences in learning abilities requires investigations that go beyond assessing the development of specific cognitive skills resulting from traditional educational experiences or short-term intervention programs. Obtained qualitative differences may partially reflect differential responses to the generally rigid and unimaginative instructional techniques which have been basic to the educational system, rather than genetic differences in mental ability. Measurement of the effects of other instructional techniques should precede inferences about genetic differences in basic cognitive abilities.

Algebra is one subject which requires abilities defined by Jensen's level II, conceptual reasoning. An innovative algebra program is presently underway with socioeconomically disadvantaged elementary-school children (Johntz, "Special Elementary Education for the Disadvantaged" (SEED)), evaluations of which indicate that (1) these lower class elementary school children are learning high-school and college-level algebra (unpublished study by mathematics specialists, Calif. Institute of Technology), and (2) given a dynamic learning environment, Negro children learn conceptual material as eagerly and as well as any other children (Johntz, 1966). Significant variables in this algebra program are (1) instructors with college degrees in mathematics who have demonstrated competence in transmitting their own excitement

about mathematics to children, and (2) a discovery method of instruction, which emphasizes student participation through constant and careful questioning, prodding children to discover the basic principles of algebra through their own mental efforts. Being a mathematics specialist, the teacher generally understands and can respond to the relevance of even "wrong" answers, so that participation is positively reinforced; hence a high level of attention and motivation is sustained.

The rationale for the following study developed from an initially intuitive assumption that 10-12 year old children, taught algebra by a discovery method of instruction, might develop the kinds of problem solving abilities necessary to insure average performance on Raven's Progressive Matrices (PM). This test was developed expressly as a measure of Spearman's "g", (the intelligence "factor common to all tests of complex problem solving" (Jensen, 1969, p.9)); that is, of the kind of logical reasoning measured by most IQ tests (Raven, 1938). Furthermore it has been considered a measure with low cultural loading relative to other IQ tests, and thus has frequently been used to assess Negro versus white performance on a reportedly "culture-free" non-verbal test of mental ability. Jensen cites studies of Negro performance on the PM as evidence of a qualitative difference in intellectual skills between Negroes and whites, because lower SES populations generally, and Negro populations specifically, perform at least as poorly on this as on supposedly more culturally biased tests. Noting that gains in test scores following special educational treatment obtain only for tests

with high cultural loadings, he suggests that these gains reflect only the "acquisition of simple learning" rather than "actual improvement in cognitive skills" as measured by such tests as the PM (Jensen, 1969, p.101). There seems to have been no assessment to date of 10-12 year old Negro childrens' performance on the PM following long-term instruction in a subject area as specifically dependent upon the development of abstract reasoning skills as is the algebra curriculum. Thus it seemed that an assessment of the PM performance of such children might help to clarify the question of possible qualitative differences in Negro and Caucasian reasoning abilities. Because Jensen's dichotomy of mental abilities suggests direct parallels to Piaget's description of the developmentally different cognitive stages of concrete and formal operations, perhaps the place to look for possible development of level II reasoning would be among children ages 10-12, who are at a transitional period between the two stages.

Shuey (1966) reported a 7-15 point difference between the means of black and white subjects, from the same neighborhood, on nonverbal group tests. Higgins and Sivers (1958) found a 10-point difference between black and white subjects on the PM, which they interpret as measuring a specific skill, rather than "g" as Raven suggests. While there is a question of the construct validity of the PM (Buros, 1965), the difference between blacks and whtes remains consistently significant, so that whether it is measuring logical reasoning as is generally assumed (Raven, 1938; Anastasi, 1961), or only "perceptual accuracy"

as Bortner (Buros, 1965) suggests, it is measuring a cognitive process in which Negroes have consistently manifested inferior performance. Sperazzo and Wilkins (1958) reported that the differences found in nonverbal group tests depend on variations of nonrace factors, a position which Jensen (1959) challenged by critizing their interpretations of the statistical interactions. Jensen (1969) summarily finds very small changes in IQ as a result of compensatory (government-sponsored preschool) programs. He summarizes and interprets the research as indicating that (1) Negroes have a differential propensity for the simpler associative forms of learning and (2) more diffuse types of enrichment programs have failed. Thus, he suggests, the solution to the problem of educating the disadvantaged might be a qualitatively different approach, based on such mental abilities as associative learning. It seems that such a suggestion is short-sighted, that more exclusive emphasis on associative learning would tend to perpetuate what my already be a sort of arrested mental development due to instruction which simply is not effective in developing abstract reasoning in disadvantaged children. Jensen fails to consider the many ways standard instructional methods may inhibit development of a possibly latent potential of lower SES children for abstract reasoning.

The object of this research was (1) to ascertain the effects of the SEED algebra program on 10-12 year old Negro children's performance on the PM, and concomitantly, (2) to consider the possible usefulness of the PM as a measure of growth of more generalized reasoning skills associated with the learning of algebra via discovery instructional techniques. It was hypothesized

that Negro children instructed in a special algebra program (SEED) for six months would obtain higher scores on Raven's PM than a comparable group who had not had such instruction. It was relatedly expected that the experimental group mean score might approximate the norms published for white populations.

Method

The subjects were from lower class neighborhoods of the North Sacramento school district of Del Paso Heights, whose population is approximately 48% Negro, 48% Mexican-American and 4% Caucasian. The experimental group was an intact 5th-6th grade class from Del Paso Heights Elementary School; the control group, an intact 6th grade class from Fairbanks Elementary School, plus eight Negro 5th graders chosen randomly from an intact 5th grade class of Del Paso Heights School in order to equate the mean age (11.6) of the experimental and control groups.[1] All members of the intact classes were tested, but only the Negro children's scores were used in the analysis. After testing the 24 6th grade control Ss it was learned that 13 of them had been in a class which was in the algebra program the previous school year (1968-69). These scores were also eliminated so that the final control group of 19 Ss was composed

1. I am very grateful to Dr. William Johntz, director of the SEED Project, and Warren Leffler, a program demonstrator, whose help and cooperation made this study possible. I would also like to thank Mrs. Griffith, Mr. Hood and Mr. Durest for allowing me to test their students, and Dr. Nadine Lambert, Dr. Paul Ammon and Mrs. Margaret Wilcox for their suggestions throughout the study.

of 12 6th and 8 5th graders. Only 16 of the 23 Ss administered the PM in the algebra class were black. Thus, the final groups consisted of 16 experimental Ss and 19 control Ss.

The two criteria by which classes are selected for the algebra program are (1) that they be composed primarily of lower class, "disadvantaged" children, and (2) that the homeroom teachers are sympathetic to the program, which involves their sitting on the sidelines for the hour per day when the (uncredentialed) algebra instructor is teaching. The algebra class selected for this study was chosen by Dr. Johntz, director of the program. Two selection factors prohibit considering the experimental class or its students as entirely representative of all algebra classes in the program: (1) being a demonstration class for the algebra program, the algebra teacher is possibly more experienced and dynamic than the average and the children may get somewhat more attention as a group; (2) because it happens to be the only combination (5th-6th grade) class in the school, classroom organizers made an attempt to select students relatively more capable of working independently of teacher direction. In terms of academic achievement and group aptitude scores, however, the class is no differnet from any other in the school.

Form A, B, C, D, E of the PM was individually administered to each S by the experimenter, with a conscious attempt to keep introductory greetings, directions and any words of encouragement standardized for both experimental and control Ss. Upon completion of the test, each S was asked to explain how he arrived at the answer to two of the most difficult matrices on which he had

succeeded, in the hope of establishing the kind of reasoning used: "You chose this answer, which was correct. Try to tell me what you thought about as you looked at this design, that made you choose this answer".

The mean score of the experimental group was 36.19 (s.d.=8.1), which compares favorably with the mean score of 35 reported by Raven for the individually administered Scottish normative population of the same age, and the mean score of 36 reported by Tuddenham, for the group-administered Richmond sample of Ss (age 11.4). The mean score of the control group was 24.7 (s.d.=9.7), which falls in the range of scores reported in the literature for Negro populations (7-15 points below the white norms). A two-tailed t-test of the difference between the two groups' means yielded a value of 3.74 for 33 df, $p.<.001$.

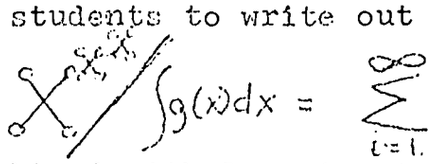
Responses to the question designed to elicit descriptions of reasoning processes used were categorized as "Correct process, accurately described", "Correct process, poorly described", and "Incorrect process or guess". These data are not very revealing, primarily because of the wide range of items for which descriptions were elicited (29 out of 60 items). The students who gave the best descriptions were also the ones who received high scores. However, the questioning process did serve to demonstrate significant personality differences between good and poor performers, and hence between the two groups generally. While most of the children obviously enjoyed both trying to describe their complex thought processes aloud and the examiner's interest in them, the poorer performers were more

reticent to make the attempt. Most of the algebra students were more self confident and willing to try, attitudes which must certainly be related to the capabilities which contributed to their success on the PM.

Discussion

It was apparent that those students who performed well were capable of sustained thought about a problem whereas the poor performers were not. The age of these students may represent a crucial time for encouraging children, through a curriculum such as has been described, to perform operations with statements and other representational symbols. Lacking such direction, the majority of the students in the control group gave evidence of a crippling dependence on concrete givens (e.g. selecting for an answer a design which matched the nearest design in the pattern). The difference between the performance of the two groups suggests that this dependence on perceptual givens reflects arrested development of cognitive structures rather than a determined difference in the cognitive inheritance of Negroes.

The following description of some specific aspects of curriculum content and instructional techniques may help more fully define the independent variables: (a) the teacher walked up and down the aisles every five to ten minutes, checking each student's attempt to solve, on scratch paper, an orally presented problem; (b) he used an immediate and public reward system as he checked their answers, announcing, e.g. "Give six stars to Wanda!"; (c) at the beginning of each period a basic problem, usually of a review nature, was presented and was continuously

elaborated until, by the end of the hour, a train of complex thought had been developed in the minds of virtually all of the students; (d) imaginative abstract notation was used, often with symbols created by the students (e.g.  , called "kigglywig", was used in a problem requiring students to write out as an infinite series the equation  .

The use of such expressions, combined with learning to understand algebraic relationships among them, suggests distinct similarities to both the conformation of the matrix patterns and to the reasoning processes required to see the significant relationships within them; (e) learning always involves verbal intereaction with the instructor and the other studemts; there are neither textbooks nor pencil and paper assignments, other than the on-the-spot type described above. Of possible significance is the program's emphsis on and constant encouragement of verbal communication, which may develop verbal mediators necessary for logical reasoning. Correlations between success on more difficult items of the PM and performance on the Peabody Picture Vocabulary Test have suggested the possible necessity of verbal mediators in order to solve these items (Frederickson, C., & Ross, H., unpublished study).

The children from the algebra class associated the examiner with their algebra teacher, whom they greatly admire and hence for whom they have become accustomed to make great mental efforts. Thus they came into the testing situation mentally alert and motivated to do well. Contrariwise, the control Ss, who were also interested in being tested, did not seem as mentally alert

and only a few exceptionally bright children seemed ready to make the effort to think through each problem. There was also a difference in level of understanding of the test's demands. Asked what they had heard about the test from their classmates, those in the algebra class invariably said, "They said it was hard!" while most of the control group students said, "They said it was easy".

In describing the PM as a measure of what Cattell calls "fluid" (versus "chrystallized") intelligence, Jensen (1969) speaks of the "capacity for new conceptual learning and problem solving, a general brightness and adaptability, relatively independent of education and experience, which can be invested in the particular opportunities for learning encountered by the individual in accordance with his motivations and interests" p,13). This study indicates that, for lower class children, conceptual learning and problem solving abilities as measured by the PM are dependent on and can develop in response to education.

The results of this study suggest that lower class Negro children can develop abstract reasoning abilities to a significant degree, and that they are developed more effectively, as Jensen suggests (1969) when instructional intervention is direct and highly concentrated (rather than diffuse, as in most cultural enrichment programs). The study additionally suggests the possible usefulness of the PM as a measure of cognitive growth associated with learning algebra by discovery methods of instruction. The reliability of these findings would be enhanced by similar assessments of a more representative sample of classes involved in the SEED Project.

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