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ABSTRACT

In an attempt to specify the nature of the variables associated with socioeconomic status, Jensen has proposed a two-level model of mental abilities. The first level represents associative learning. The second level involves higher-order conceptualization, and problem solving. The purpose of the present study was to develop a matrix completion training task that could be mastered by either Level 1 or Level 2 processing. The different modes of processing should be reflected in three kinds of performance differences: Initial ability to solve matrices, learning proficiency, and ability to transfer acquired skills. A matrix completion training task consisting of four sets of items, each of which could be solved by using a specific rule, was administered to low-SES and middle-SES first and third grade boys. Differences between grades were found for the more difficult sets. In these cases, the third grade middle-SES subjects outperformed all of the other groups. For those subjects who reached a learning criterion, all groups performed significantly better on the transfer items. These findings suggest that although there are social-class differences in rate of acquisition, once criterion has been reached there is considerably less evidence that what has been learned is different for different social class groups. (Author/JM)

April, 1974

A Comparison of the Matrices Learning Ability of Low-SES and Middle-SES Boys

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Abstract

The purpose of the study was to determine three kinds of performance differences (initial ability to solve matrices, learning proficiency, and ability to transfer acquired skills) on a task that could be solved using either Level I or Level II (Jensen). A matrix completion training task consisting of four sets of items, each of which could be solved by using a specific rule, was administered to low-SES and middle-SES first and third grade boys. Differences between grades were found for the more difficult sets. In these cases, the third grade middle-SES Ss outperformed all of the other groups. For those subjects who reached a learning criterion, all groups performed significantly better on the transfer items.

A Comparison of the Matrices Learning Ability of Low-SES and Middle-SES Boys

Although it is now a well recognized fact that low-SES children do not perform as well as middle-SES children on school related tasks, there is much disagreement concerning the nature of the differences between middle-SES and low-SES children. While SES levels serve as useful index variables to locate proportionately larger groups of children demonstrating one kind of performance or another, their utility is much reduced when individual predictions are to be made. Yet, until the nature of the variables associated with SES is established that would allow, for example, the accurate individual prediction of school success then effective intervention training techniques will be difficult to discover.

In an attempt to specify the nature of the variables, Jensen has proposed a two-level model of mental abilities. Jensen has suggested that group performance differences reflect two types of qualitatively different cognitive abilities (Jensen, 1969, 1970, 1973). These different abilities, in turn, reflect two "...genotypically distinct basic processes...(Jensen, 1969, p. 110)". The first process, Level I, represents associative learning during which little stimulus transformation is made resulting in a high degree of correspondence between the stimulus input and the response output. This process is exhibited through performance on paired-associates tasks or "trial-and-error learning with reinforcement (feedback) for correct responses" (Jensen, 1969, p. 111). The second process, Level II, involves higher-order conceptualization, problem solving, and "self-initiated elaboration and transformation of the stimulus input before it eventuates in an overt response" (Jensen, 1969, p. 111). This process is demonstrated through mastery of tests of general intelligence that have a high general intelligence loading (g) and especially those of non-verbal, fluid-intelligence, culture fair variety, for example the Raven Coloured Progressive Matrices.

Level I and Level II are hypothesized to be genotypically distinct yet functionally interdependent. While individual abilities can range from low to high for each process, only those with high Level I will develop high Level II.

Differences in performance between SES levels are accounted for by a hypothetically different distribution of Level II as a function of SES level, i.e. Level II and SES are positively correlated. Since most educational information requires Level II middle-SES children consistently outperform low-SES children.

Jensen's argument, then, suggests that both SES levels may demonstrate Level I abilities which are fully developed by about six years of age. However, Level II abilities, are exhibited at a significantly lower level by low-SES children than by middle-SES children, and are not fully developed until adulthood. Yet it is the Level II skills, the development of which accelerates between six and eight years, that are necessary for the acquisition of skills such as reading and arithmetic as they are now taught. Jensen's solution to the problem of poor low-SES performance is to develop teaching techniques which are consistent with low-SES Level I abilities.

"The educational system was never allowed to evolve in such a way as to maximize the actual potential for learning that is latent in these children's patterns of abilities. If a child cannot show that he 'understands' the meaning of 1 + 1 = 2 in some abstract, verbal, cognitive sense, he is, in effect, not allowed to go on to learn 2 + 2 = 4. I am reasonably convinced that all the basic scholastic skills can be learned by children with normal Level I learning ability, provided the instructional techniques do not make g (i.e., Level II) the sine qua non of being able to learn (p. 117)."

While Jensen orders tasks along a continuum ranging from Level I to Level II, it is clear that some tasks may be solved by either process. In fact, Jensen notes, "Some tasks lend themselves to being learned on an associative level or on a conceptual level, and different learners may prefer one or the other approach" (Jensen, 1970, p. 3). It seems reasonable that such a task would be useful in determining both the nature and developmental course of the predominant processing modes of low-and middle-SES children. One task that seems appropriate is a matrix completion training task.

The evidence suggests that matrix completion skills develop along much the same course as Jensen has hypothesized for Level II (e.g., Overton, Wagner, & Dolinsky, 1971; Parker & Day, 1971; Siegel & Kresh, 1971). Very young children (4-5) operate at about chance level with no indication of either perceptual or cognitive solutions being applied to a variety of matrix manipulations. Older children (6-7) seem to be developing the skills necessary for successful performance. However, these children are susceptable to a variety of task and procedural variables such as stimulus dimensions, response demands, information feedback, and instructions. Children in the 8 - 9 bracket seem to demonstrate nearly maximal performance across a variety of different matrix completion tasks. When SES levels are compared (Overton & Brodzinsky, 1972), a developmental divergence is noted between 6 - 7 and 8 - 9. While the middle-SES children continue to improve in performance, the low-SES children do not.

In addition, the literature suggests that such skills can be trained, thereby providing a task that assesses current learning proficiency rather than previously acquired knowledge (Guinaugh, 1969; Parker, Sperr, & Rieff, 1972; Turner, Hall, & Grimmett, 1973).

The studies which include SES as a variable reveal some important results. Guinaugh (1969) identified high and low Level I, low Level II Ss from low-SES black, low-SES white, and middle-SES white third grade populations. Successful training effects (indicated by increased Raven Progressive Matrices scores) were found for both white samples but not for the black sample. While clearly demonstrating that training the prerequisite skills improves performance on the Raven, Guinaugh's study raises some questions. There is no indication on which items, the trained groups demonstrated the most gain. Since the Raven items vary both in the nature of their composition and in their difficulty, analysis of performance on specific items might yield important information. For example, significant training effects might be shown to have been effective for only relatively easy items of one particular format.

In a study designed to provide training in Level II abilities, Turner, Hall, & Grimmett (1973) provided three kinds of elaborative feedback to low- and middle-SES white kindergarten Ss. All trained groups demonstrated higher Raven performance than did a non-trained control group, yet none of the training procedures was differentially effective. In addition, the middle-SES group had higher mean scores than the low-SES group. Analysis of six-types of items represented in the Raven indicated that no SES level X training condition interaction was significant, i.e., neither SES group showed differential performance on any of the item-types as a function of training. The training differences appeared to be in the nature of the responses made. Few perceptually or "logically" unusual errors were made by the trained groups thus reducing the size of the set of possible alternative choices from which they were selecting and thereby increasing the probability of a correct choice even when guessing. Training effects for this very young group were minimal, supporting the developmental literature for this age group.

It can be concluded from these studies that differences exist between SES levels on matrix completion skills as early as five years of age but that training can be effective in changing performance. Whether or not those changes reflect the acquisition of Level II skills or the further refinement of Level I skills on the part of the low-SES groups cannot be determined from these studies, however.

The purpose of the present study was to develop a matrix completion training task that could be mastered by either Level I or Level II processing. The different modes of processing should be reflected in three kinds of performance differences. Those Ss possessing Level II should demonstrate higher mean pre-test scores by solving some of the items using skills transferred to the task rather than responding randomly. Those with Level II skills should require fewer learning trials to reach criterion performance since they should abstract and apply the necessary rules for correct solution to the other items rather than rotely learning the solution to each individual item. Finally, those with Level II skills should solve more post-test transfer items by applying the rules just learned rather than learning new associations. An improvement from the pre-test to post-test set of matrices by the subjects using Level II processing coupled with no comparable change in performance by subjects using Level I processing should result in a significant trial by SES level interaction.

It is unclear whether these differences should occur at both grade levels. The middle-class first graders may not have yet developed Level II processes to a higher degree than the lower-class first graders. Jensen says that Level II abilities "develop slowly at first, attain prominence between four and six years of age, and show increasing difference between SES groups with increasing age (Jensen, 1967, p. 115)". This hypothesized rapid acceleration of Level II abilities for middle-class third grade children could lead to an interaction between grade and social class.

Method

Subjects

The subjects were 80 white male middle-SES and lower-SES first and third graders. The middle-SES subjects were randomly selected from three first grade and three third grade classrooms in a suburban school serving middle-class families, while the lower-SES subjects were randomly selected from three first grade and three third grade classrooms in an urban school serving lower-class families. School records indicated that at least one parent of the middle-SES subjects had received a college degree while none of the low-SES parents had more than a high school education with the majority reporting junior high school education or less. The mean ages of the middle-SES first and third graders were 8[illegible] and 106.4 months with ranges of 74-91 and 99-115 months respectively. The lower-SES mean ages were 83.9 months for the first grade and 111.9 months for the third grade. The ranges for these groups were 78-107 and 99-128 months.

Task

In order to test the above hypotheses the authors identified four types of 2 X 2 matrix items, each of which required a different principle or rule for determining a correct solution.

The first, and least difficult, item-type was a simple identity that varied in shape either from row to row or column to column. The second item-type consisted of an entire pattern that needed closure. The third item-type was a double classification item that varied in shape from row to row and column to column. The fourth item type was designed as a variant of the third. It was also a double classification item but involved additions instead of shape. Components were added from row to row and from column to column. This item-type was included to determine differences between groups on their ability to transfer the matrix solving skills to a unique item type after being trained on three item types (See Figure 1).

Insert Figure 1 about here

The authors included more than one item type to top Level II performance on different rule types since each-item type has different kinds of rules required for its solution. While item-type 1 requires a simple identity rule, item-types 3 and 4 require the more complex double classification principle. That is, rather than simply changing from row to row or column to column, item types 3 and 4 involve both changes simultaneously. Item type 2, on the other hand, requires both reasoning and perceptual skills. The subject must know what the total pattern should look like, what the missing part should look like, and that it is the missing part that is needed for a correct solution.

All of the items were constructed according to one basic form: three parts of the matrix presented with the lower right quadrant empty and four alternatives presented below. The decision about which incorrect alternatives to include was based on previous research (Hall & Kleinke, 1971) which revealed four Raven error types that were most often selected by subjects that were the same age as those in the present study. Those error types chosen were duplicates of the upper left, upper right, and lower left parts of the matrix as well as a representation of half or the entire matrix as it would appear with no missing part. For some items two additional error types were used; the figure was wrongl oriented and the figure is contaminated by irrelevancies or distortions.

Eight different items of each type were constructed on standard unlined paper (21.5 X 28cm.) and randomly divided into two 16-item sets (four items for each type of matrix). These forms were arranged so that each item type was grouped together in the order of type 1, type 2, type 3, and type 4. These forms were used for the pre-test and post-test.

In addition, multiple copies of each item type were constructed so that the correct alternative appeared in different positions. These copies, which were used for training, were arranged in three random orders within each item type.

Procedure

Each child was tested individually in an empty classroom. He was told that he was looking at a puzzle that was missing a part. There were four possible parts below for the puzzle and it was his job to select what he thought was the correct missing part. The child then proceeded to respond to the entire task, answering each question without receiving feedback.

Next, the child was told that he would do the puzzles again, only this time the experimenter would tell him when he was right or wrong. His job was to keep answering until he could get all of the items correct. The child was then presented with the training copies of the items. The child proceeded at his own rate selecting what he though to be the correct answer, and being told "right" or "wrong" after each choice. This continued until the child reached a criterion of either two perfect trials, or 20 trials for each item type. It was hypothesized by the authors (and confirmed by post hoc examination) that attention and performance would tend to degenerate if more than 20 trials were used. When the child reached criterion on an item-type, its presentation was terminated and the child responded only to the remaining item types.

Immediately after the child had reached criterion or 20 trials on each item type he was presented with the alternate form. This time, he was told, these were some new puzzles which he would have to do without being told whether he was right or wrong.

With this procedure it was possible to obtain three scores for each subject on item-types 1, 2 and 3. These scores were (1) initial or pre-test performance (2) trials to criterion and (3) transfer or post-test performance. In addition, it was possible to acquire pre-test-post-test gain scores for item-type 4. Experimenters and forms were counterbalanced.

Results

Initially, a 2 (experimenters) X 2 (forms) analysis of variance was computed for each dependent measure on each item type. There were no significant main effects or interactions for any item type on pre-test or post-test performance. For the remainder of the analyses these scores were collapsed across forms and experimenters. For trials to criterion there was a significant form effect on the first and second item-types but no other significant main effects or interactions were found. Since the forms were counterbalanced across groups and there was no significant interactions this score was also collapsed across forms and experimenters for the remainder of the analyses.

The means and standard deviations for all of the dependent measures are included in Tables 1 and 2.

Insert Tables 1 and 2 about here

Next, a 2 (SES level) X 2 (grade level) X ±4 (items) repeated measures1 analysis of variance was computed for the pre-test scores. This resulted in a significant grade effect (F=3.8, df=1/76, p <.05), and a significant SES level by grade level interaction (F=7.9, df=1/76, p <.01). The third grade Ss had higher pretest scores than the first grade Ss while the middle-SES third grade Ss had the highest scores of the four groups.

In addition, a significant items effect (F=40.2, df=3/228, p <.0001), and significant grade level by items (F=3.36, df=3/228, p <.01) and SES level by grade level by items (F=3.1, df=3/228, p <.05) interactions were revealed.

Because of the higher order interaction, separate 2 (SES level) X 2 (grade level) analyses of variance were computed for each item type. For item-type 1, this resulted in a grade main effect (F=10.8, df=1/76, p <.01). The third graders had higher scores than the first graders regardless of SES level. On item-type 2, a significant grade X SES level interaction was revealed (F=5.2, df=1/76, p <.05). The middle-class third grade Ss had higher scores than all of the other groups. Similar results were found for item-type 3. A significant grade X SES level interaction (F=11.2, df=1/76, p <.01) revealed that, again, the middle-SES third grade _Ss_ had the highest mean score. There were no significant main effects or interactions for item-type 4 on the pre-test analysis.

To assess the different learning abilities for each group, a 2 (grade level) X (SES level) X ±4 (items) repeated measures1 analysis of variance was computed using the number of trials-to-criterion. A significant grade effect (F=20.21, df-1/76, p <.001), a significant SES level effect (F=17.42, df=1/76, p <.001), and a significant grade X SES level interaction (F=5.13, df=1/76, p <.05) were found. The third grade and middle-SES group required the fewest, trials to learn the task.

I In addition, a significant items effect (F=10.54, df=2/152, p <.001) was found. A Newman-Kuels post hoc analysis revealed that the mean number of trials needed for the enclosure items was significantly higher than for the other two items.

Table 3 was generated as an initial attempt to assess the differences between groups in the ability to abstract and transfer the principles necessary to correctly solve the matrices. In this contingency table _Ss_ are categorized according to both their criterion learning and their transfer performance. Since no child who failed to reach criterion on a particular item-type was able to then correctly solve all of the transfer items for that type, and since not all children who reached criterion transferred, it seems that reaching criterion was a necessary but not sufficient condition for transfer. Therefore analysis of only those who learned the task was needed to determine whether what was learned was different.

Insert Table 3 about here

A 2 (SES level) X 2 (grade level) X ±2 (pre-post tests) X 4 (items) repeated measures1 analysis of variance was computed using the scores of those

Ss who reached criterion and, therefore, learned the task. These analyses employed a least-squares solution for unequal n (Winer, 1962, p. 374).

A significant SES effect ($F=4.34$, $df=1/71$ $p<.05$) and grade effect ($F=14.73$, $df=1/71$, $p<.001$) were revealed. The middle-SES and third grade Ss had higher mean scores respectively. In addition, an SES by grade level interaction was found ($F=12.91$, $df=1/71$, $p<.001$) was found. The third grade middle-SES group had a higher mean score than the other three groups.

A significant items effect ($F=66.09$, $df=3/161$, $p<.001$), a significant SES level by items interaction ($F=66.09$, $df=3/161$, $p<.05$), and a significant grade level by items interaction ($F=7.09$, $df=3/161$, $p<.001$) were revealed. Newman-Kuels post hoc analyses were performed to determine the nature of the effects. The mean transfer scores for the identity and enclosure items were significantly higher than the mean transfer scores for the double and complex-double classification items, but neither pair was different from each other.

The middle-SES mean transfer score for the enclosure item was significantly higher than the low-SES score on the complex double classification item while the low-SES scores on the enclosure was not. However, the low-SES mean score on the identity item was significantly higher than that group's score on the double classification item while the middle-SES score on the identity item score was not different.

A significant trials effect ($F=63.02$, $df=1/171$, $p<.001$), a significant grade level by trial interaction ($F=4.89$, $df=1/71$, $p<.05$), and a significant items by trial interaction ($F=2.92$, $df=3/161$, $p<.05$) were also discovered. There was a significant gain from the pre-test to the post-test. Newman-Kuels analyses revealed that the third grade group gained more from pre-testing to post-testing than did the first grade group. For the enclosure item, the post-test scores were significantly higher than the pre-test scores. In addition, the enclosure post-test scores were higher than the pre-test scores for the double and complex-double classification items.

Discussion

The purpose of the present study was to determine whether low- and middle-SES Ss would demonstrate different modes of processing when confronted with a task that could be learned by using either Level I or Level II. Different modes were hypothesized to result in different performance on three kinds of tasks: one assessing the Ss ability to solve matrices without specific training; another assessing the ability to learn the correct solutions to matrix problems; and a third determining the ability to transfer the rules and/or solutions to new items.

The results indicate that differences between groups varied with the kind of item being trained. For the identity item (1), the significant differences were primarily between grade levels. Third graders had significantly higher pre-test scores, took fewer trials to criterion, and for those students who reached criterion, continued to perform better on the post-test. Although no one group improved significantly more on the post-test, it can be determined from examining Table 3 that a larger percentage of third graders (58%) than first graders (21%) who reached criterion were able to correctly answer all of the transfer items. Only for the trials to criterion score was there a significant SES effect.

The enclosure item (2), on the other hand, generally was easier for the middle-SES group. The middle-SES group took fewer trials to criterion, and for those who reached criterion, continued to perform better on the post-test.

Of particular interest for this item type was the superior performance of the third grade middle-class group. Perhaps one reason why this item-type was so difficult is that several of the distractors used (upper right, upper left, and lower left) could be perceived as rotations of the correct answer. Thus, one component ability necessary for obtaining the correct solution is not unlike the ability to discriminate between d, b, p, and q. Interestingly enough, 10 of the 36 items on the Raven are of this type. The subjects must recognize that orientation is important in obtaining the correct answer.

Both grade and social class were important predictors of performance on the double classification item (3). Again, the middle-class third graders performed higher than the other groups on initial performance. Both third grade and middle-class subjects took significantly fewer trials to criterion. Of those who reached criterion, third graders and middle-class subjects maintained their superior performance. This is the only item-type on n which one group demonstrated more transfer than another group. The third graders improved more than the first graders from pre-test to post-test regardless of social class.

It was surprising that all children performed so well on item-type 3. However, several of the children who solved the problem were quick to point out when quizzed after testing was complete, that they solved the problem by noting that the correct answer was completely different from any of the distractors and did not appear as one of the above parts (as did most of the other distractors). This strategy, which concentrated on the distractors rather than upon completion of the above matrix, was evidently easier than the solution intended by the authors. In future research this alternative solution will be eliminated by changing distractors.

Item-type 4, introduced as an attempt to determine whether some groups would be able to transfer to a new item type significantly better than others, was the only item-type for which there was a significant trials X social class X grade interaction (for those who reached criterion on item type 3). That is, while all groups improved significantly from the pre-test to the post-test, the third grade middle-class group improved more than the other groups. Also, this was the only item-type on which there were no significant pre-test differences. Although this item type was a variant of item type 3, it is impossible to determine from the present design whether or not this improvement was due to practice on matrices items in general or specific transfer from practice on item-type 3.

With regard to Jensen's position, the only prediction which was consistently correct across item-types was the significant class effect on trials to criterion. In addition, for two item types, the third grade middle-class group performed better than all other groups on the pre-test. For those subjects who reached criterion, however, the middle-class groups did not improve more on the post-test than other groups (except for item-type 4).

These findings suggest that although there are social-class differences in rate of acquisition (which would result in higher initial scores and fewer trials to criterion) once criterion has been reached there is considerably less evidence that what has been learned is different for different social class group: At the very least there is good evidence that some relatively high level transfer occurred for all groups. This brings into question the suggestion that different groups should be trained in different ways. Rather it seems that the important individual differences variable for the type of learning required in the present study may be rate of acquisition or degree of mastery.

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Figure 1 Caption

Examples of the Four item-types used in the matrices training task.

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Table 1

Means (and Standard Deviations) of Pre-test and Post-test Scores for All Subjects

Item Type	First Grade Middle-SES	First Grade Low-SES	Third Grade Middle-SES	Third Grade Low-SES
(1) Pretest Mean	1.55	1.35	2.35	2.00
SD	(.76)	(.99)	(1.14)	(1.03)
Posttest Mean	1.65	2.15	3.15	3.05
SD	(1.31)	(1.14)	(1.49)	(1.00)
(2) Pretest Mean	.80	1.05	1.75	.90
SD	(1.11)	(.89)	(1.25)	(1.02)
Posttest Mean	1.95	1.60	3.05	1.95
SD	(1.43)	(1.27)	(1.05)	(1.19)
(3) Pretest Mean	.55	1.05	1.30	.15
SD	(.76)	(1.19)	(1.66)	(.37)
Posttest Mean	1.00	1.05	2.70	1.30
SD	(1.12)	(1.05)	(1.42	(1.41)
(4) Pretest Mean	.25	.40	.50	.30
SD	(.64)	(.68)	(.76)	(.92)
Posttest Mean	.85	.75	1.80	.75
SD	(1.14)	(1.07)	(1.15)	(1.12)

Footnote

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Table 3

Individual First-Grade and Third-Grade Subjects' Transfer Performance as a Function of Reaching Criterion on the Learning Task

Item-Type 1

	Middle-SES Reached Criterion		Low-SES Reached Criterion	
Transferred	Yes	No	Yes	No
Yes	3 (12)	0 (0)	4 (9)	0 (0)
No	16 (7)	1 (1)	11 (8)	5 (3)

Item-Type 2

Transferred	Yes	No	Yes	No
Yes	4 (9)	0 (0)	1 (0)	0 (0)
No	9 (10)	7 (1)	8 (11)	11 (7)

Item-Type 3

Transferred	Yes	No	Yes	No
Yes	1 (8)	0 (0)	0 (2)	0 (0)
No	18 (12)	1 (0)	12 (17)	8 (1)

Item-Type 4

Transferred	Yes	No	Yes	No
Yes	1[a] (2)	0 (0)	0 (1)	0 (0)
No	18 (18)	1 (0)	12 (18)	8 (1)

[a]Criterion based on performance on Item-Type 3.

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Table 2

Means and Standard Deviations for Trials to Criterion for Each Group on Each Item-Type

	First Grade		Third Grade	
Item Type	Middle-Class	Lower-Class	Middle-Class	Lower-Class
(1) Mean	11.80	13.30	6.75	10.60
SD	4.63	6.49	4.79	3.05
(2) Mean	14.75	16.50	7.15	16.25
SD	5.85	4.74	4.44	4.88
(3) Mean	13.25	15.05	8.00	12.10
SD	4.81	6.09	5.50	5.50