Age and sex performance differences as measured by a new nonverbal visual perceptual test*

VIVIAN C. WOLF

University of Washington, Seattle, Wash. 98105

Six hundred and twenty-three Ss in Grades 1-6 and 11 were tested with a new nonverbal group-administered visual perceptual test, Wolf's Embedded Figures Test. The results indicated school and age differences at the .0001 level, which were virtually unmodified with the effects of IQ removed. Significant sex differences were found on the individually and group-administered versions and were accounted for by common variance with the spatial test, which has been shown to have high hereditary variance. All figures were unique; therefore, practice, as predicted from short- and long-term memory theory, did not reduce the sex differences. The embedded figures test loaded lowest on the factor with high loading on two fluency tests that are associated with creativity or divergent thinking, casting doubt on Witkin's theory.

One of the current emphases in education is the adjustment of curriculum to the individual characteristics and abilities of the learner. A new test was developed to measure one of these individual abilities, visual perception. Research was focused on the components that modify the results of different forms of the test. This test refinement was based on a review of the literature and was guided by current theory. The results of three separate trials of the test are summarized. The reader is referred to Wolf (1969) for a detailed account of this research.

BACKGROUND

One means of studying differences in visual perception is to put a small picture in a larger more complex picture and have the S try to find it. Witkin (1950) developed such a test by selecting some figures of Gottschalk's which correlated with tests (the rod-and-frame test, the tilting-room test, and the body-adjustment test) developed to study the individual's concept of the upright. Sex differences, in favor of males, were found in the results of all these tests. Witkin originally called the ability "visual independence," which emphasized the visual perceptual component. He later expanded his theory to a total personality theory termed "cognitive style." Witkin theorizes that the ability to find a simple picture in a more complex

picture develops from *child rearing practices* that make a child more "differentiated." By this he means that a child reared in a certain manner will have a more articulated view of the world and will be more capable of finding a little picture embedded in a complex picture. In order to test this theory, Witkin and his colleagues have done research on the relationship of mothers and sons (1962).

Two areas of research raise questions about the adequacy of Witkin's theory, and numerous studies raise questions about the variables that may affect embedded figures test performance. First, Witkin's theory does not explain why *practice* in taking his test or similar tests reduces sex differences to nonsignificance. Goldstein & Chance (1965) suggested that the sex differences found were due to a greater amount of practice that boys have with tasks requiring this ability. They were able to eliminate significant sex differences by giving 68 complex figures with 14 simple figures embedded in them, in eight separate trials. A similar reduction of sex differences to nonsignificance was found when the first and last half of Witkin's data were compared (Goldstein & Chance, 1965). A reduction was also found in a repeated measures longitudinal study using Witkin's Embedded Figures Test (Witkin, 1967). Witkin's test has 9 simple figures embedded in 25 complex figures. Some simple figures are repeated as many as five times. Witkin reports in a footnote (1950) that after having seen the simple figures some of his Ss were able to guess which simple figure was embedded in the complex figure as soon as they saw the complex figure and before they were shown the simple figure for that item. This

investigator's research hypothesizes that the long-term short-term memory model proposed by Atkinson & Shiffrin (1968) may explain these findings. The Atkinson-Shiffrin model proposes that sensations enter by a sensory register and go into short-term memory. Short-term memory is used to solve problems. The third unit in this memory system, long-term memory, is used to store information. If material is put into short-term memory frequently or held there longer by a mental control process, more of that information will go into long-term memory. On the basis of this model, it appears that when Witkin presents a simple figure the first time, the S is forced to solve the problem from short-term memory, but when he is shown the simple figure three other times or more, during the test, he may be able to retrieve the figure from long-term memory instead of having to work to solve the problem in short-term memory. If the figure is a common geometric form, the S is even more likely to have it in long-term memory. This analysis leads to the hypothesis that: an embedded figures test which did not repeat any of the simple figures would show no reduction in sex differences when performance on the first and the last half of the items was compared.

A second area of research that raises questions about the adequacy of Witkin's theory links embedded figures test performance to spatial perceptual ability. Meux (1960) found that good embedded figures test performance was basically a spatial-relations ability when he compared the results of embedded figures tests and spatial tests on an all-female sample. Significant sex differences in spatial perceptual ability in favor of males after the age of 6 is the usual finding (Smith, 1964; Maccoby & Maccoby, 1962). Stafford (1961) has suggested that the sex performance difference is due to an X chromosome recessive-linked gene. Studies of individuals with Turner's syndrome, an abnormal genetic condition in which the person has only one X chromosome or only one X chromosome with both short arms (Money, 1964), show that this sample has an abnormally poor spatial ability. However, the distribution of the spatial scores does not fit the logical implications of Stafford's particular model. Studies of the performance of monozygous and dizygous twins on spatial tests (Block, 1965; Bock & Vandenberg, 1967; Vandenberg & Loehlin, 1966; Vandenberg, 1966) indicate that a considerable amount of the sex difference is due to a component attributed to heredity. If heredity influences spatial perception,

*This research was supported in part by the Office of Education, U.S. Department of Health, Education, and Welfare, through the Chicago Early Education Research Center of the National Laboratory of Early Childhood Education while the author was a Nursing Research Fellow of the Nursing Division of Health, Education, and Welfare. Dr. Wolf is presently an assistant professor in medical-surgical nursing at the School of Nursing, University of Washington.

and if sex difference in performance on embedded figures tests is due to a component shared with spatial perceptual tests, then doubt is cast on Witkin's theory of child rearing as the sole or major basis for good performance in embedded figures tests.

DEVELOPMENT OF INSTRUMENT

On the basis of an analysis of the literature on embedded figures test performance, a new test, Wolf's Embedded Figures Test (1968), was developed. The test consists of 81 unique items. It can be scored either as a total test, or as three subtests to evaluate the effects of the variables that are felt to affect test performance. The subtest scores are: embeddedness of the complex figures (six levels are built in), three-dimensional vs two-dimensional figures, and colored vs uncolored complex figures. These were built into the test in a balanced design. For the first two trials of the instrument, the items were printed on Holerith (IMB) cards: two complex figures with a simple figure embedded in one or the other of them appeared on the front, and the simple figure alone on the back. Each S was given a testing folder with a pocket in the top. When testing began, all the cards were in the top pocket. The Ss were asked to take one card out at a time. They were told how long to look at each picture. They were to decide which of the complex pictures contained the simple figure. If they saw it on the left they were to put the card in the pocket on the bottom of the folder at the left. If they saw it on the right, they were to put it in the pocket at bottom right. If they could not see it, they were asked to try not to guess but to put it in a center pocket. The instructions for performing the test were tape-recorded so that all the Ss received the same directions and looked at each item the same amount of time. The instructions and testing folder were designed to test children 6 years of age or younger and avoided the terms *right* and *left*. The method of indicating response also avoided the use of fine muscle coordination.

MAJOR PROBLEMS INVESTIGATED

Many specific questions were investigated when three trials of the instrument were carried out. The major questions these trials addressed were: (1) How discriminating is this new instrument for group, age, and sex differences? (2) Will practice taking this test reduce sex differences? (3) If sex differences are found, will they be accounted for by the variance this test has in common with a spatial test? (4) How does the ability measured by

this test compare with the abilities measured by other tests such as IQ, creativity measures, and spatial tests?

Two trials of the instrument were made in communities which had been rated on social class characteristics by the same *Suburban Fact Book* (Northeastern Illinois Metropolitan Area Planning Commission, 1960). References to social class in the following two trials should be read with this qualification in mind. A sample of 104 lower-class black students and 102 middle-class white students, approximately half boys and half girls, in the sixth grades of three schools were tested in the first trial. All the methods of scoring showed school differences at or beyond the .0001 level, and sex differences at the .05 level on a step-down F test of the three-dimensional figures with the effects of the two-dimensional figures taken into account. An analysis of the means indicated that the middle-class white students were doing significantly better than the students from the lower-class black community. Social class differences on IQ test scores have been a common finding for years, so it is wise to ask if differences on visual perceptual scores are due to a difference in the IQ of the Ss. When the effects of Otis IQ scores available for all children were eliminated by analysis of covariance, the results were virtually unchanged. The reliability ranged from .80 to .90, depending on how the data were grouped.

The second trial of the instrument was on a sample of middle-class white children in Grades 1-6 in one school. Approximately 15 boys and 15 girls were tested at each level. Grade differences were significant beyond the .0001 level. None of the sex differences were significant. These results remained unchanged after an analysis of covariance with Lorge-Thorndike IQ scores. The means indicated that performance was improving with age.

The results of the first two trials indicated that the new test was highly discriminatory of age and group difference and was measuring an ability unrelated to the Otis and Lorge-Thorndike IQ tests. Since sex differences did not appear, a decision was made to try the test on an older sample, because sex differences in embedded figures performance have been shown to peak at Age 17.

The third trial was also designed to determine if sex differences might be associated with the method of scoring and test directions. Witkin's test is scored on the amount of *time* it takes a S to find a simple figure in a complex figure and to trace around it. In order to compare this method of administration with group

administration, which scores on finding the *correct* complex figure that has the simple figure embedded in it, two versions of Wolf's Embedded Figures Test were developed. One scored on choosing correctly which complex figure had the simple figure embedded in it, and the other on the amount of time it took to trace around the simple figure. An attempt was made to match these tests on item characteristics and level of difficulty as indicated by the trial with 12-year-olds.

Thirty-seven girls and 37 boys were chosen randomly from an entire 11th-grade class. The sample was classified as middle-class on the basis of information that could be obtained about their fathers' occupations and about the community. The data were too incomplete for a complete application of the Warner Scale (1960), The Index of Status Characteristics. The Ss were assigned by boy-girl pairs to four trained testers who tested them with an individually administered form of Wolf's Embedded Figures Test that was scored, like Witkin's, on the amount of *time* taken.

To determine if sex differences were decreasing as the Ss got more practice on the individually administered form of Wolf's Embedded Figures Test, the mean scores of girls and boys on the first seven items (first half) were compared with the mean scores on the second seven items (last half). The girls' mean for the first half was 71 sec and for the second half, 84.5. The boys' mean for the first half was 52 sec and for the second half, 60. The scoring on this test is the lower the time in seconds the better the performance of the individual. From this, one can see that the second half seems to be slightly more difficult for both groups than the first, but the sex difference goes up accordingly. The sex difference is 19 for the first half and 24.5 for the second half. The sex difference is not decreasing when unique figures are used. This casts doubt on the argument that practice in taking this type of test reduces sex difference and lends support to the idea that repeating the simple figure may reduce sex differences because it moves the task into long-term memory, while presenting unique figures may keep the task in short-term memory and the sex differences may remain. This point needs further study.

The entire 11th-grade class, including the students tested individually, was then administered a battery of group tests which were presented on slides and included: (1) a 40-item spatial visualization test (a revision of the Guilford-Zimmerman

Spatial Perceptual Test), (2) a 40-item vocabulary test selected from the Cooperative Vocabulary Test, (3) 33 items of Wolf's Embedded Figures Test, scored on the total number correct, (4) a 33-item crossmodal digit-span test which presented digits orally and asked for the answer in a visual mode, and (5) two concept fluency tests (one test asked for all the words the Ss could think of that started with a specific letter; the second asked them to name as many items as they could that belonged to a specified conceptual category). Instructions and timing of items were standardized on a stereotape recorder synchronized with a slide projector. School grades from courses that seemed related to the types of abilities tapped by the group tests, Henmon-Nelson Intelligence Test scores, and some of the Iowa Tests of Educational Development, were obtained.

Significant sex differences were found beyond the .01 level for both the individually administered and the group-administered form of Wolf's Embedded Figures Test. The sex differences remained significant for both forms when an analysis of covariance eliminated the effects of IQ and vocabulary. Sex differences became nonsignificant when an analysis of covariance eliminated the effects of spatial perception. Sex differences on the spatial perception test remained significant when an analysis of covariance removed the effects of the embedded figures test. All the sex differences on these tests were in favor of males.

A maximum likelihood factor analysis indicated that three factors accounted for the largest part of the variance. The first factor appears to be related to general ability; it is associated with IQ, vocabulary, spatial perception, and the group-administered version of Wolf's Embedded Figures Test. The second factor is associated mainly with the two fluency tests and the embedded figures test. It may be associated with creativity or divergent thinking. The group-administered version of Wolf's

Embedded Figures Test loaded the least on this factor, of all the three factors, in sharp contrast to Witkin's theory that embedded figures tests are a measure of flexibility and the ability to break sets. The third factor is negatively related to verbal ability and is represented by a high loading by the embedded figures test and spatial perceptual test followed with some loading by the digit-span test. It may represent a visualization ability or an ability to work in short-term memory.

CONCLUSIONS

This new nonverbal visual perceptual test was administered to 623 Ss in Grades 1-6 and 11. The results indicated school and age differences at the .0001 level, which were virtually unmodified with the effects of IQ removed. When an individually administered form was given to 74 11th-grade Ss, sex differences were significant and did not decrease when performance on the first half and the last half of the test was compared. This seems to lend support for the interpretation that having all figures unique confines the task to visual short-term memory. Performance on the new embedded figures test appeared to be virtually unrelated to IQ or vocabulary. The embedded figures test performance had a very low relationship to tests of creativity or divergent thinking, casting more doubt on Witkin's theory that embedded figures tests measure an extensive personality characteristic of flexibility or the ability to break sets. Sex differences on embedded figures test performance was accounted for by a common variance with spatial tests. At present, Wolf's embedded figures test is part of a battery of tests being used in a study of suburban middle-class families and their children, to see if a genetic model seems to account for a major portion of the sex difference found.

REFERENCES

- ATKINSON, R. C., & SHIFFRIN, R. M. Human memory: A proposed system and its control processes. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory*. Vol. 2. New York: Academic Press, 1968.
- BLOCK, J. B. Hereditary components in the performance of twins on the WAIS. Research report from the Louisville Twin Study Child Development Unit, No. 8, 1965.
- BOCK, R. D., & VANDENBERG, S. G. Components of heritable variation in mental test scores. Research report from the Louisville Twin Study Child Development Unit, No. 22, 1967.
- GOLDSTEIN, A. G., & CHANCE, J. E. Effects of practice on sex-related differences in performance on embedded figures. *Psychonomic Science*, 1965, 3, 361-362.
- MACCOBY, E., & MACCOBY, L. R. *Differential cognitive abilities*. Stanford: Stanford University, 1962.
- MEUX, M. O. The role of reasoning and spatial abilities in performance at three difficulty levels of the embedded figures task. Unpublished doctoral dissertation, Department of Psychology, University of Illinois, Urbana, 1960.
- MONEY, J. Two cytogenetic syndromes: Psychologic comparisons. 1. Intelligence and specific-factor quotients. *Journal of Psychiatric Research*, 1964, 2, 223-231.
- Northeastern Illinois Metropolitan Area Planning Commission. *Suburban Factbook, 1950-1960*. Chicago: Northeastern Illinois Metropolitan Area Planning Commission, June 1960.
- SMITH, I. M. *Spatial ability*. London: University of London Press, 1964.
- STAFFORD, R. E. Sex differences in spatial visualizing as evidence of sex-linked inheritance. *Perceptual & Motor Skills*, 1961, 13, 428.
- VANDENBERG, S. G. A twin study of spatial ability. Research report from the Louisville Twin Study Child Development Unit, No. 26, 1967.
- VANDENBERG, S. G., & LOEHLIN, J. C. Genetic and environmental components in the covariation of cognitive abilities: An additive model. Research report from the Louisville Twin Study Child Development Unit, No. 14, 1966.
- WARNER, L. W. *Social class in America: A manual of procedure for the measurement of social status*. New York: Harper & Row, 1960.
- WITKIN, H. A. Individual differences in ease of perception of embedded figures. *Journal of Personality*, 1950, 19, 1-15.
- WITKIN, H. A. Stability of cognitive style from childhood to young adulthood. *Journal of Personality & Social Psychology*, 1967, 7, No. 3.
- WITKIN, H. A., DYK, R. B., FATERSON, H. F., GOODENOUGH, D. R., & KARP, S. A. *Psychological differentiation*. New York: Wiley, 1962.
- WOLF, V. C. A study of the embedded figures test in relation to sex differences and some primary mental abilities. Unpublished doctoral dissertation, Department of Education, University of Chicago, 1969.
- WOLF, V. C. Wolf's embedded figures test. United States and International Copyright No. A27793, October 1968.