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Abstract

This study examined the differences between the Raven's Standard Progressive Matrices scores obtained using the European (Raven, Court & Raven, 1977) and U.S. (Raven, 1986) normative samples and the Matrix Analogies Test-Expanded Form (MAT-EF) (Naglieri, 1985b). The sample of 34 hearing-impaired students (26 males and 8 females) with a mean age of 13 years 7 months (SD of 2 years, 2 months) attended a state residential school for the deaf. Raven's and Naglieri's matrices tests were administered in counterbalanced order in one session. Results indicated that the sample earned similar mean scores on the Raven's U.S. norms and Naglieri's MAT-EF, but both these tests' results were significantly lower than the scores obtained from the Raven's European norms. Analysis of the difference between the derived scores earned by the Raven's U.S. and European norms revealed considerable inconsistency by age and percentile point (IQ level) despite high and significant correlations among these measures. These results suggest that practitioners should use caution when choosing between the Raven's European and U.S. norms and may find the MAT-EF a suitable alternative.

The assessment of hearing-impaired children's level of intelligence presents special problems, because standard intelligence tests, such as the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974), involve considerable verbal communication on the part of the examiner and subject (Levine, 1974; Moores, 1981; Sattler, 1988). In addition, much of the content of intelligence tests involves the use of verbal concepts that require typical language experiences. This involvement of language and emphasis on oral communication is a major obstacle to assessing intelligence of hearing-impaired persons, using standard IQ tests (Levine, 1974).

Psychologists have used nonverbal sections of major intelligence tests, such as the Performance Scale of the Wechsler, to meet the special demands of assessing the mental ability of hearing impaired-students. Tests such as the Leiter International Performance Scale and Hiskey-Nebraska Test of Learning Aptitude (Hiskey, 1966) have also been used with this population, despite concerns about their norm samples and other technical characteristics (Naglieri & Prewett, 1989). Additionally, nonverbal tests such as the Draw-A-Person (Harris, 1963; Naglieri, 1985a), and progressive matrices tests (Naglieri, 1985b, 1985c; Raven, 1986) have also been used in the assessment of hearing-impaired persons.

Progressive matrices tests such as those developed by Raven (1956) and more recently by Naglieri (1985b, 1985c) provide a potentially useful approach to the measurement of intelligence for hearing-impaired persons. These tests utilize abstract figural diagrams (matrices) to measure nonverbal intelligence, have minimal oral directions, and allow for non-verbal responses (subjects point to the correct options). Factors such as these make matrices tests appropriate for use with individuals with language and/or hearing limitations and are especially useful for culturally and linguistically diverse populations.

There are three Raven's Progressive Matrix tests which are frequently included to measure intelligence for hearing impaired children. These are the Standard Progressive Matrices, the

Coloured Progressive Matrices, and the Advanced Progressive Matrices. The Standard Progressive Matrices (SPM) is the most widely used of the Raven's tests (Mathews, 1986) despite criticisms about its technical characteristics. For example, Anastasi (1982) noted that Raven's manual lack vital information on reliability and validity, and Sattler (1988) cites the lack of U.S. norms as a problem. A recent data collection has been conducted in the United States (Raven, 1986) to obtain U.S. normative data to address some of the problems; however, many of the criticisms remain about Raven's manual and about the scores the test yields.

In order to meet the need for a well normed, well constructed nonverbal test of intelligence, the Matrix Analogies Test-Expanded (MAT-EF) was developed (Naglieri, 1985b). This test was developed to provide a viable system of measuring intelligence using the nonverbal format that is especially appropriate for assessment of hearing-impaired persons. There have been, however, no research reports that compare that MAT-EF with Raven's new U.S. norms and no comparison of Raven's European and U.S. norms for this or any other population. Our study was conducted to meet this need.

Method

Subjects

The sample was comprised of 34 hearing-impaired children enrolled in the Ohio School for the Deaf, a state residential school in Columbus, Ohio. There were 26 males (76%) and 8 females (24%) who ranged in age from 9 to 16.8 years (mean age of 13 years 7 months, SD of 2 years 2 months). There were 31 white (91%) and 3 nonwhite (9%) subjects in the sample. Pure tone hearing levels for both ears ranged from 73 dB to 110 dB (mean = 97.5 dB, SD = 11.5). By hearing loss category, eight had severe hearing losses, and 26 were profoundly hearing impaired.

All testing was conducted by an advanced graduate student in school psychology who individually administered Raven's Standard Progressive Matrices (RSPM) (Raven, 1938) and Matrix Analogies Test-Expanded Form (Naglieri, 1985b) to each student in one session. The tests were administered in counterbalanced order to control for practice effects or fatigue that may have influenced the scores (17 students were administered the RSPM followed by MAT-EF, and 17 were administered MAT-EF followed by RSPM). Raven raw scores were converted to percentile ranks using Table SPM XIV (Raven, Court & Raven, 1977, p. 31) to obtain derived scores in comparison to the European norms, and Table RS3SPM6 (Raven, 1986, p. 15) to obtain U.S. normative data. Percentile rank scores for the Raven's European norms were interpolated when necessary because the tables provide percentile ranks for only a limited number of points over the distribution (i.e. raw scores are only provided for the 5, 10, 25, 50, 75, 90 and 95 percentile points). Percentiles were then converted to IQ score (mean = 100, SD = 15) using a standard conversion table (Sattler, 1988, p. 997).

Instruments

Raven's Standard Progressive Matrices Test was designed to measure mental ability as represented by Spearman's principle of 'g' (Spearman, 1927) using abstract figural matrices. The test is intended to assess a person's capacity to see the relationships between abstract figures, "conceive the nature of the figure completing each system of relations presented, and, by so doing, develop a systematic method of reasoning" (Raven, Court & Raven, 1977, p. 2). The individual's task is to uncover these relationships and determine which option best fits the missing location in the matrix. The Raven Standard Progressive Matrices (RSPM) contains five sets of twelve matrices for a total of 60 items, presented one item per page. This test has been normed in Europe and in the United States.

The validity of Raven's matrices has been supported by researchers who have found significant correlations between the Coloured Progressive matrices and the Wechsler Scales for normal persons (Burke & Binghamn, 1969; Rock & Nolen, 1982) and for hearing-impaired persons (James, 1984). Other studies have supported the use of the matrix test with Hispanic and Native American Navajo students (Corman & Budoff,

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1974; Poweres, Jones & Barkan, 1986; Sidles & MacAvoy, 1987). The Raven's has also been found to correlate significantly with the California Achievement Test-Reading, Language, and Math scales for Anglo (Powers, Jones & Barkan, 1986) and Hispanic (Powers & Barkan, 1986) students as well as the Comprehensive Test of Basic Skills-Reading, Spelling, Language, and Mathematics Scales for Native American Navajo students (Sidles & Mac Avoy, 1987).

Naglieri's Matrix Analogies Tests include two forms, the Matrix Analogies Test-Expanded Form (MAT-EF) (1985b) and the Matrix Analogies Test-Short Form (MAT-SF) (1985c). The MAT-EF (Naglieri, 1985b) is comprised of 64 items (including 34 items from the Short Form) which are printed one per page (in black, white, blue and yellow). The MAT-SF is intended to be used as a group screening test. The Expanded Form was designed for individual use.

The MAT-EF was standardized using a total sample of 5,718 American students between the ages of 5 and 17 years, stratified according to age, sex, race, geographic region, community size, and socioeconomic status. The test was normed, using a system of equating the scores of 1,250 students individually administered the entire 64 item test, with 4,468 students administered the MAT-SF. The MAT-SF was standardized on a sample of 4,468 American students between the ages of 5 and 17 years and stratified according to age, sex, race, geographic region, community size, and socioeconomic status. According to Naglieri (1985b) the standardization sample used to norm the MAT-EF closely matches the characteristics of the U.S. population according to the 1980 Census data.

Items on the MAT-Expanded Form are divided into four groups on the basis of the method required to solve each of the matrices. These are Pattern Completion (requires the individual to choose the option which accurately completes the pattern), Reasoning by Analogy (requires the student to see how the change or changes in one figure relates to the analogous change or changes in another), Serial Reasoning (requires the individual to discover the order in which items appear throughout the matrix), and Spatial Visualization (requires the individual to imagine how a figure would look when two or more designs are combined).

In the MAT-EF manual, Naglieri (1985b) provided evidence that both the short and expanded forms yield similar scores for matched samples of American blacks and whites and males and females, and was useful for assessment of American Indian children's ability. Other studies have found that Greek and Canadian children earned mean scores similar to the American norm group on the MAT-SF (Naglieri & Bardos, 1988). Naglieri (1985b) reported significant correlations between the MAT-EF with the WISC-R Performances IQs for samples of normal (r=.41), hearing-impaired (r=.71) and Native American (r=.43) students. Similarly, significant correlations with Raven's Coloured Progressive Matrices are reported for samples of normal (r=.71) and Native American (r=.64) students in grades 1-5. Finally, Naglieri (1985b) reports significant correlations between the MAT-SF and reading (median r=.52 across age groups) and math (median r=.58 across age groups) for a sample of 3,022 students in grades 4-12, as well as significant correlations with achievement for hearing impaired children (MAT-SF) with Stanford Achievement Test Reading and Spelling scores. The MAT-EF has also been found to correlate significantly with the WRAT Reading (.45) and Stanford Reading (Literal comprehension .42 and Inferential Comprehension .34) (Stutzman, 1986).

Naglieri (1985b) provided evidence that the MAT-Expanded Form has excellent internal reliability. The median Cronbach alpha for the Total Test score is .93 (range=.88 to.95 for the 13 age groups included in the standardization sample). Similarly, the MAT-SF median internal reliability is .83 (range=.63 to .89 for the 13 standardization age groups). One month test-retest reliability coefficients of.77 for the MAT-Expanded Form Total Test and .78 for the MAT-Short Form are also reported by Naglieri (1985c; 1986).

Data Analyses

Pearson product-moment correlations between the two Raven's standard scores and the MAT-

EF Total Test standard scores were computed. A one-way repeated measures Analysis of Variance (ANOVA) was conducted to test the differences between the three standard scores; Scheffé F tests were used in post hoc analyses. Raven's European and U.S. norms were compared at seven percentile points (5, 10, 25, 50, 75, 90 95) presented in Table SPM XIV (Raven, Court, & Raven, 1977) to determine the differences between the raw scores obtained corresponding to each percentile point.

Results

Repeated measures ANOVA conducted on the scores earned by the hearing-impaired students on the Raven SPM test using the European and U.S. norms and the MAT-EF indicated significant variation ($F(2,66)=7.8$, $p<.001$). Scheffe F-tests revealed that the MAT-EF (mean = 84.5, SD, 16.4) and Raven's U.S. norms (mean = 84.7, SD, 15.8) were each significantly different (Scheffe $F=6.0$ and 5.6 $p<.05$, respectively) from the Raven's European norms (mean = 89.7, SD, 14.0). There was no significant difference between the Raven's U.S. and MAT-EF mean scores (Scheffe $F=0.1$).

Pearson product-moment correlations among the matrix tests indicate that the Raven's European and U.S. scores correlated .98 ($p<.01$) and the MAT-EF correlated .79 ($p<.01$) with both versions of Raven's matrices. These results indicate that although there are differences between the Raven's U.S. and European norms, as well as the MAT-EF and Raven's European norms, there is much consistency between these tests on the basis of correlations.

The similarity between the MAT-EF and Raven's U.S. norms with respect to mean scores and correlations appears to suggest that the tests will yield similar scores, but this finding is in contrast to that reported by Naglieri (1985b). He found the Raven's Coloured Progressive Matrices to yield a higher mean score (by eight points) for a sample of 200 students in grades 1 and 2 as well as a sample of 114 Native American students. Analysis of the difference between the U.S. and European norms provides some insight into this issue.

The differences between raw scores that correspond to the same percentile points from Raven's European norms (Table SPM XIV, Raven, 1949, p. 31) and Raven's U.S. norms (Table RS3SPM6, Raven, 1986, p. 15) were computed. These values, which are presented in Table 1, are the difference between the raw scores corresponding to the same percentile scores from Raven's European and U.S. norms. The magnitude of these differences are inconsistent in size and sign across the age groups and percentile points. At the 5th percentile, the European norms consistently equalled or exceeded the U.S. values from age 8 to 13, but above age 13 the opposite was true. At the 10th percentile, the U.S. values were either equal to or larger than the European values (at the upper ages the differences were as large as seven raw score points). At the 25th, 50th, 75th, and 90th percentiles, the European values exceeded the U.S. values 28 times, the opposite was true 42 times, and no difference was found 10 times. At the 95th percentile the European scores were equal to or larger than the U.S. raw scores except above age 14.5 where the opposite was true. By age, the European values were typically lower than the U.S. raw scores from age 8 to about age 10 and at age 15 to 16.5 while the European values were more often higher than the U.S. scores at ages 10.5 to 14.5. In total, much inconsistency between the Raven's European and U.S. norms by age and by percentile level is apparent.

Conclusions

The present findings of similar MAT-EF and Raven's U.S. scores should not, therefore, be generalized to students of other ages or IQ levels. The present sample was of low intellectual functioning (mean standard score of 84 falls at about the 15th percentile) and at the upper age limits (the mean age was 13 years) where the European values equalled or exceeded the U.S. raw scores. Based on the values in Table 1, it could be expected that a different finding would result had the sample been of average intelligence and at about age 10 years, or at the same intellectual level but at age 16.5. At these levels,

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the European norms were approximately five points below the U.S. values.

The present findings indicate that 13 year old hearing-impaired children whose IQ scores fall at about the 25th percentile will likely earn scores on the MAT-EF and Raven's U.S. norms that correlate significantly and do not differ substantially. Generalization of this finding should be limited because of the varying differences between Raven's U.S. and European norms as presented above. Further research is needed to assess the relationships among these tests at several levels of intelligence and age and in contrast to other instruments. These results also suggest that professionals who choose between these nonverbal tests should do so based on findings like the present ones in relation to other relevant issues such as the quality of the test's materials, standardization, reliability, and validity. Practitioners should use caution when choosing between the Raven's European and U.S. norms and may find the MAT-EF a suitable alternative.

TABLE 1
DIFFERENCES BETWEEN RAVEN'S EUROPEAN AND U.S. RAW SCORES AT SEVERAL PERCENTILE RANKS

	Percentile Ranks						
Age Group	95	90	75	50	25	10	5
8	1	-3	-4	-2	0	-1	1
8.5	0	-2	-5	-4	-1	0	1
9	0	-1	-5	-4	-2	-1	1
9.5	1	0	-4	-5	-3	-1	1
10	0	-1	-3	-5	-4	-1	0
10.5	2	1	-1	-5	-3	-1	0
11	1	1	-1	-3	-3	-2	0
11.5	2	2	0	-1	-3	-2	1
12	4	2	2	0	-3	-2	0
12.5	2	3	2	2	0	-1	2
13	2	4	2	3	2	0	1
13.5	2	3	1	2	1	-1	-1
14	0	2	0	1	0	-2	-2
14.5	0	2	0	0	-1	-3	-3
15	-1	1	-1	-1	-2	-4	-4
15.5	-1	0	-2	-2	-3	-5	-4
16	-2	-1	-3	-3	-4	-6	-5
16.5	-2	-2	-4	-4	-5	-7	-6

Note: The difference = European - U.S. raw scores at each percentile (see text for further explanation).