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The Influence of Verbal Mediation on Matrix Reasoning

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The Influence of Verbal Mediation on Matrix Reasoning

Abstract
The influence of verbal mediation on tasks of problem solving and abstract reasoning has been well-established in the literature. The Matrix Reasoning subtest of the WAIS-IV purports to measure perceptual reasoning and concept formation and is presented in a visuospatial format. Verbal mediation is not considered when interpreting MR test results, yet the literature has demonstrated that verbal mediation and reasoning is often utilized in similar tasks. The present study sought to examine the influence of verbal mediation on the MR subtest by correlating participants’ MR item scores with their scaled scores on the WAIS-IV Similarities subtest, as well as their Standard scores on the D-KEFS Verbal Fluency: Letter and Category subtest. Participants were 43 consecutive patients (23 male, 20 female) with a mean age of 30.35 years referred to a university doctoral clinical psychology training clinic for neuropsychological evaluation over a two-year period. Analysis using point-biserial correlations revealed that four MR items were significantly correlated with Verbal Fluency: Letter, while three MR items were significantly correlated with Verbal Fluency: Category. Six MR items were significantly correlated with the WAIS-IV Similarities subtest. Items dealing with the constructs of color and stimulus orientation were consistently correlated with verbal reasoning, suggesting that these constructs require more purposeful and deliberate thought, thereby necessitating higher levels of verbal mediation.

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THE INFLUENCE OF VERBAL MEDIATION ON MATRIX REASONING

A DISSERTATION

SUBMITTED TO THE FACULTY

OF

SCHOOL OF PROFESSIONAL PSYCHOLOGY

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Table of Contents

Abstract .............................................................................................................................................3

Acknowledgements ..........................................................................................................................4

List of Tables ...................................................................................................................................5

List of Figures ..................................................................................................................................6

Introduction ......................................................................................................................................8

   Verbal Mediation ..........................................................................................................................9

Development of the Wechsler Adult Intelligence Scale .................................................................14

The Matrix Reasoning Subtest .........................................................................................................15

The Similarities Subtest .....................................................................................................................20

The D-KEFS Verbal Fluency Subtest ...............................................................................................22

Differences between the WAIS-III and WAIS-IV .........................................................................27

Matrix Reasoning and Verbal Skills ...............................................................................................28

Aims of Current Study .....................................................................................................................29

Methods ..........................................................................................................................................30

   Participants ....................................................................................................................................30

   Measures .......................................................................................................................................30

Procedures .......................................................................................................................................30

Data Analysis ...................................................................................................................................31

Results .............................................................................................................................................32

Discussion .......................................................................................................................................50

References .......................................................................................................................................55
Abstract

The influence of verbal mediation on tasks of problem solving and abstract reasoning has been well-established in the literature. The Matrix Reasoning subtest of the WAIS-IV purports to measure perceptual reasoning and concept formation and is presented in a visuospatial format. Verbal mediation is not considered when interpreting MR test results, yet the literature has demonstrated that verbal mediation and reasoning is often utilized in similar tasks. The present study sought to examine the influence of verbal mediation on the MR subtest by correlating participants’ MR item scores with their scaled scores on the WAIS-IV Similarities subtest, as well as their Standard scores on the D-KEFS Verbal Fluency: Letter and Category subtest. Participants were 43 consecutive patients (23 male, 20 female) with a mean age of 30.35 years referred to a university doctoral clinical psychology training clinic for neuropsychological evaluation over a two-year period. Analysis using point-biserial correlations revealed that four MR items were significantly correlated with Verbal Fluency: Letter, while three MR items were significantly correlated with Verbal Fluency: Category. Six MR items were significantly correlated with the WAIS-IV Similarities subtest. Items dealing with the constructs of color and stimulus orientation were consistently correlated with verbal reasoning, suggesting that these constructs require more purposeful and deliberate thought, thereby necessitating higher levels of verbal mediation.
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List of Tables

Table 1 Descriptive Statistics for Patient Sample.................................................................32
Table 2 Means and Standard Deviations of Similarities and Verbal Fluency Scores...............32
Table 3 Number of Participants Completing Each Matrix Reasoning Item.............................33
Table 4 Correlations between D-KEFS Verbal Fluency: Letter Total Scores and MR Items......34
Table 5 Correlations between D-KEFS Verbal Fluency: Category Total Scores and MR Items...................................................................................................................................39
Table 6 Correlations between WAIS-IV Similarities Scaled Scores and MR Items...............43
List of Figures

Figure 1 Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and Matrix Reasoning Item 13.................................................................................................................................35
Figure 2 Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and Matrix Reasoning Item 17.................................................................................................................................36
Figure 3 Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and Matrix Reasoning Item 18.................................................................................................................................37
Figure 4 Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and Matrix Reasoning Item 23.................................................................................................................................38
Figure 5 Point Biserial Correlations between Verbal Fluency: Category Standard Scores and Matrix Reasoning Item 13..................................................................................................................40
Figure 6 Point Biserial Correlations between Verbal Fluency: Category Standard Scores and Matrix Reasoning Item 14..................................................................................................................41
Figure 7 Point Biserial Correlations between Verbal Fluency: Category Standard Scores and Matrix Reasoning Item 15..................................................................................................................42
Figure 8 Point Biserial Correlations between Similarities Scaled Scores and Matrix Reasoning Item 9....................................................................................................................................................44
Figure 9 Point Biserial Correlations between Similarities Scaled Scores and Matrix Reasoning Item 13....................................................................................................................................................45
Figure 10 Point Biserial Correlations between Similarities Scaled Scores and Matrix Reasoning Item 14....................................................................................................................................................46
Figure 11 Point Biserial Correlations between Similarities Scaled Scores and Matrix Reasoning Item 17....................................................................................................................................................47
Figure 12 Point Biserial Correlations between Similarities Scaled Scores and Matrix Reasoning

Item 20........................................................................................................................................48

Figure 13 Point Biserial Correlations between Similarities Scaled Scores and Matrix Reasoning

Item 23........................................................................................................................................49
The Influence of Verbal Mediation on Matrix Reasoning

Verbal mediation significantly predicts successful performance on a variety of tasks, including problem solving and memory-related activities (Chi, de Leeuw, Chiu, & LaVancher, 1994; Cole & Pheng, 1998; Silverberg & Buchanan, 2005; Welsh, 1987). Because of its utility in a plethora of situations, the influence of verbal mediation must be accounted for in order to interpret test results accurately, particularly in the area of intelligence testing. The Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Pearson, 2008) includes tests of both verbal and visuospatial intelligence, but the influence of verbal mediation is not considered in most of the visuospatial tests and one in particular, Matrix Reasoning (MR). The MR subtest was developed as a measure of fluid intelligence, concept formation, and perceptual reasoning in a visuospatial format. Given the literature demonstrating the widespread use of verbal mediation in problem-solving tasks, it may be hypothesized that many patients completing the MR subtest utilize verbal mediation. However, because verbal mediation is not accounted for when scoring MR, traditional interpretation of test results may be misleading when verbal mediation abilities are compromised. Therefore, it is necessary to determine what, if any, influence verbal mediation has on MR performance. The current study will compare item scores on MR to scores on the Similarities subtest, which is another subtest of the WAIS-IV that measures verbal concept formation and reasoning. Additionally, scores on the MR will be correlated with scores on the Verbal Fluency subtest of the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001), in an effort to describe the relationship between verbal fluency and verbal mediation of visuospatial reasoning on MR.
Verbal Mediation

Verbal mediation or reasoning may be defined as a self-regulating, mental mechanism that helps guide our behavior through the use of language (Vygotsky, 1986). When completing a task, we often talk ourselves through the process, either consciously or unconsciously, in an effort to make prudent choices that will maximize our chance of success. This behavior begins in early childhood as language ability develops. According to the language theory of Lev Vygotsky, the development of language has a direct impact on a child’s ability to think and reason. Vygotsky believed that young children learn new information and how to complete novel tasks by first performing them publically, that is, audibly processing the problem in the presence of other people. For example, the process of learning arithmetic is accomplished through verbal lessons with teachers and counting out loud, eventually leading to the ability to do arithmetic mentally. As children master the information or behavior, the process moves inward and they accomplish the task using “private speech,” that is, through mentally talking to themselves. The development of private speech is the foundation for verbal mediation.

Neuman, Leibowitz, and Schwarz (2000) conducted a study to examine the different components of verbal mediation. They randomly selected a group of 32 high school students ranging in age from 13.7 to 14.4 years and asked them to complete two algebra word problems, ordered by level of difficulty with the easiest problem presented first. The participants were asked to complete the problems while thinking aloud, and their answers were scored based on the process used as well as the final answer given. The self-explanations were divided into five categories, based on their content: clarification of the problem, inference of new knowledge from information given, justification for their responses, monitoring declarative knowledge, and regulating past, present, and future behavior. On the first problem, the self-explanation categories
used most frequently were inference, clarification, and justification. On the second problem, the self-explanation categories used differed between participants who correctly answered the problem and those who did not. The good problem solvers were more likely to have used regulation and justification, while the poor problem solvers used inferences and clarifications. The authors concluded that self-explanation was a statistically significant predictor of participant performance, with inference and clarification being the most frequently utilized categories, despite the fact that they were the most ineffective strategies.

Research has demonstrated the utility of verbal mediation for both children and adults. In an early study by Welsh (1987), 80 children with a mean age of 11.17 years were administered a test of figural matrices that included some items from Raven’s Standard Progressive Matrices (RSPM; Raven, 1938) while repeating single syllable words from an audiotape as quickly as possible. Raven’s matrix stimuli consist of abstract, nonrepresentational patterns that are missing a portion of the pattern. Different options for completing the pattern are given in multiple-choice format, and the patient must analyze the design in spatial, design, and numerical terms in order to determine which of the multiple options best completes the pattern. In the Welsh study (1987), participants were identified as reflective or impulsive using the Matching Familiar Figures Test (MFFT; Kagan et al., 1964), based on their total score on the MFFT as well as average response latency. The two groups were then randomly assigned to one of four conditions to complete the matrix task, which included five sets graded by level of difficulty: nonverbal cues, verbal cues generated by the experimenter, self-generated verbal labels, and controls. Welsh hypothesized that children in the two verbal cues conditions would utilize verbal mediation in order to solve the matrix problems. The use of verbal mediation would be demonstrated by a decrease in accuracy on the simultaneous word repetition task. Reflectives in the two verbal cued conditions
did exhibit a drop in accuracy on the word repetition task, $F(1,36) = 4.14, p < .05$. Impulsives did not exhibit the same drop in accuracy on the word repetition task. Importantly, even with interference of the word repetition task, reflectives were still more accurate than impulsives on the task ($F(1,70) = 31.97, p < .001$). Participants in the two verbal cue conditions were more accurate than those in the control and nonverbal cue conditions in two out of five matrix task sets ($F(12,280) = 1.98, p < .03$). Welsh concluded that the introduction or encouragement of verbal cues was responsible for superior performance on the matrix task (Welsh, 1987).

Chi, de Leeuw, Chiu, and LaVancher (1994) found similar results when participants were asked to self-explain, or talk to themselves, while learning novel information. Participants included 24 eighth grade students, divided into control and experimental groups. The students were charged with learning about the human circulatory system through reading a passage on the subject. To begin, all participants were interviewed in order to determine their baseline knowledge about the circulatory system. The experimental group was then presented with the passage and prompted to self-explain the passage to themselves as they read it. The control group was simply asked to read the passage to themselves, although they were not discouraged from self-explaining. Finally, participants were tested on their newly acquired knowledge. The researchers found that all participants gained significantly greater knowledge and understanding about the chosen topic, but the gain was greater for the experimental, self-explaining group than for the control, non-explaining group. The authors concluded that prompting the students to self-explain their way through the passage was responsible for improving their acquisition of knowledge, compared to students who did not self-explain.

Verbal mediation also has been shown to be useful in enhancing memory for figural designs. Silverberg and Buchanan (2005) presented 29 undergraduate students with 92
nonrepresentational figures on a computer screen and asked them to tell the examiner the “first thing that comes to [your] mind” (p. 201). Following the presentation of figures, participants completed a series of mazes for two minutes in order to reduce the recency effect. They then completed a forced-choice recognition task in which they were asked to identify the previously-presented figures from a group of 40 figures. Participants were able to correctly identify 90.5% of the figures that they had verbalized and only 74.6% of those that they had not verbalized.

Silverberg and Buchanan (2005) conducted a second experiment using the same stimuli with 75 undergraduate students, with the addition of distracter tasks. Participants were divided into three groups: a verbal interference group, a visual interference group, and a control group. The verbal interference group completed digit span tasks alternating throughout the test with presentation of the figures. They were first read a series of digits, then presented with a figure, then asked to recall the digits read. This process continued through 30 figures. In a similar manner, the visual interference group was presented with checkerboard patterns alternating between presentation of the 30 target figures. The control group was not given any distracter task and was simply presented with the figures. All participants were asked to complete the same maze task as those in the first experiment. They were then presented with a forced-choice recognition task using 60 figures, in which they had to identify the previously-presented target figures. A univariate ANOVA found that the control group recognized significantly more figures than the two distracter groups, and the visual interference group was superior to the verbal interference group in recognizing figures ($F(2, 73) = 14.83, p < .01$). The effect size was moderate ($d = 1.21$). The authors concluded that the addition of a verbal distracter was more detrimental to memory for figural designs because the verbal distracter interfered with verbal self-explanations of the designs (Silverberg & Buchanan, 2005).
Interestingly, verbal mediation may play a role in compensating for physical disabilities, such as visual impairment. Cole and Pheng (1998) compared the performance of partial sight and normal sight children aged 8 to 12 years on the Tower of Hanoi. Half of each group was assigned a verbal mediation strategy that prompted them verbalize their plans for each move, while the other half was assigned a visual mediation strategy which asked them to visualize their plans to complete the task prior to each move. The participants completed three trials of the test, one with two disks, one with three disks, and one with four disks. The authors hypothesized that the partial sight group would be more successful with the verbal mediation strategy, while the normal sight group would perform better with the visual strategy, in terms of response latency and number of moves, regardless of task difficulty. They found that the normal sight participants outperformed the partial sight participants on the easier two and three disk trials, but the two groups performed similarly on the four disk trial. Additionally, the verbal mediation participants were more successful than the visual mediation participants, regardless of their visual ability. The authors concluded that the use of verbal mediation strategies can compensate for visual impairments on visuospatial tasks (Cole & Pheng, 1998).

Based upon the research, it is clear that we use verbal mediation in many aspects of problem solving and learning and for many tasks, and it is superior to other types of mediation or self-regulatory strategies. Additionally, we may utilize verbal mediation without our conscious awareness, which can make it difficult to detect and describe. Based upon the literature, it is reasonable to assume that we utilize verbal mediation in both verbal and visuospatial tasks, such as those that are found on general intelligence tests. However, visuospatial tests do not purport to test verbal mediation and reasoning, and the influence of verbal mediation on test results is unknown. Because of this ambiguity, it is difficult to know how much of a patient’s verbal
mediation skill is contributing to his or her performance on a visuospatial task, making interpretation of test results difficult and possibly inaccurate for patients with below average verbal ability. Therefore, it is important that we be able to account for verbal abilities required to complete visuospatial tasks, particularly those included on tests of intelligence.

**Development of the Wechsler Adult Intelligence Scale**

The Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Pearson, 2008) is an intelligence test measuring both verbal and visuospatial intellectual abilities. The WAIS-IV was developed by David Wechsler and was first published as the Wechsler-Bellevue Intelligence Scale in 1939. Wechsler based much of his scale on tests used by the US Army to evaluate recruits for fitness for duty. The Wechsler-Bellevue was the first assessment battery to include both verbal and visuospatial tests of intelligence; prior to 1939, psychologists tended to favor verbal tests of intelligence, reserving nonverbal tests for patients who had specific difficulty with verbally-oriented tasks. Wechsler was also the first to utilize deviation scores, which are derived from aggregating subtest raw scores into one Standard score, based upon means and standard deviations for each age group. Earlier intelligence tests utilized the concept of mental age, which calculated intelligence by comparing one’s capacity to complete test items to their chronological age. Wechsler’s composite score of intelligence, including both verbal and visuospatial abilities, allowed for clearer interpretation of test results (Boake, 2002). The original verbal tests included Information, Comprehension, Arithmetic, Similarities, Digit Span, and Vocabulary. The nonverbal tests included Digit Symbol, Picture Completion, Block Design, Picture Arrangement, and Object Assembly (Lezak et al., 2004).

The Wechsler-Bellevue Intelligence Scale has been revised several times over the years, including as the Wechsler Adult Intelligence Scale (WAIS, 1955), Wechsler Adult Intelligence
Scale – Revised (WAIS-R, 1981), Wechsler Adult Intelligence Scale – Third Edition (WAIS-III, 1997), and WAIS-IV (2008). Prior to the release of the WAIS-IV, the WAIS-III was one of the most commonly given psychological measures of intelligence and is widely accepted as a valid and reliable test (Green, 2000).

Three tests were added to the WAIS-III from previous versions: Letter-Number Sequencing, Symbol Search, and MR (Lezak et al., 2004). MR was added in an effort to expand the ability of the WAIS-III to measure “fluid intelligence” (Kaufman & Lichtenberger, 1999), the ability to use insight to identify salient features of complex relationships present in stimuli and apply that knowledge to novel situations. Fluid intelligence is relatively independent from “crystallized intelligence,” which is largely developed through acquired knowledge and practiced skills. In contrast to crystallized intelligence, fluid intelligence is relatively unaffected by years of education and cultural factors (Lezak et al., 2004).

The Matrix Reasoning Subtest

The MR subtest was included in the Perceptual Organization Index on the WAIS-III and the Perceptual Reasoning index on the WAIS-IV, with an interfactor correlation of .61 (Pearson, 2008). The MR subtest is an adaptation of Raven’s Standard Progressive Matrices (RSPM; Raven, 1996), which was first published in 1938 and measures inductive reasoning through the presentation of visual patterns. As mentioned previously, the RSPM consists of nonrepresentational designs with one portion missing. Patients must choose the correct option to complete the pattern from six choices.

The MR subtest utilizes the same structure as the RSPM and is administered one-on-one with an examiner and stimulus book. The correlation between RSPM and MR is very strong ($r = .81$; The Psychological Corporation, 1997). MR may be used with patients with limited verbal
abilities and many researchers have described it as “culture-fair” because it can be essentially nonverbal (Tulsky, Saklofsky, & Zhu, 2003). It also does not require motor involvement, although pointing to chosen items is necessary for patients who have difficulty verbalizing their answers.

In order to determine the correct answer for each MR item, the patient must complete a series of steps. According to Primi (2002), the patient must first identify the rules that govern the pattern and hold those rules in working memory. Next, the patient must compare the rule of the stimulus pattern with the characteristics of the possible options. Once a match in rules is made, the patient applies the rule by choosing the correct answer. Carpenter, Just, and Schell (1990) found that the process of goal-management was integral to successful completion of the RPM, and therefore indirectly to completion of MR. Specifically, patients must identify and complete subgoals prior to choosing the final answer. This requires working memory abilities in order to keep in mind rules of the stimulus pattern as well as the larger goal of the targeted answer.

Four factors influence the difficulty and complexity of each item: the number of elements, the number of rules, the types of rules, and the perceptual organization of the design (Primi, 2002). The number of elements can vary widely across MR items, including shape, orientation, size, reversals, symmetry, and color. Accordingly, the first items of MR utilize one or two rules, while subsequent items use up to five rules. The type of rules and how they apply to the different elements of the pattern influences item difficulty, as well as the overall perceptual organization of the stimulus.

In order to determine the specific influence of different abilities on MR performance, Wang (2008) constructed a structural equation model using data collected from 334 Chinese students aged 12 to 15 years. Students were administered the Binary Number Working Memory
Test, Shape Working Memory Test, Figural Detection Test, Rule Induction Test, Rule Application Test, and MR. Wang found rule induction, rule application, and working memory to be the most salient factors defined in the model, with rule induction accounting for 13% of the variance, rule application accounting for 12% of the variance, and working memory accounting for 27% of variability in performance on MR. This finding is consistent with the data from the WAIS-III standardization data, which indicated that MR loads on the Working Memory index with a coefficient of $r^2 = .21$ (The Psychological Corporation, 1997). Thus, while MR was developed as a test of visuospatial perception, abstract thinking, inductive reasoning, concept formation and rule application, and problem solving, based upon Wang’s (2008) research, working memory accounts for a significant portion of the variance in MR performance.

Age appears to have a large effect on MR performance. Ardila (2007) analyzed the normative data used for the WAIS-III to compare age-related effects for each subtest. The third edition of the WAIS was normed on 2,450 North American adults divided into age cells from 16-17 up to 85-89 years of age. The vast majority of participants identified as Caucasian (79%), while 11.4% identified as African Americans, 7.4% as Hispanics, and 2.6% as Other (The Psychological Corporation, 1997). Ardila found that as age increased, heterogeneity on the subtests increased as well. Subtest scatter on Block Design, Object Assembly, and Information widened less than 20% as age increased, while subtest scatter on Letter-Number Sequencing, Digit-Symbol, Picture Completion, Picture Arrangement and MR increased over 200%. For MR, the age group of 16-17 had a mean of 17.5 points (SD = 4.0), while the 85-89 age group had a mean of 7.0 points (SD = 3.2). In all, scores on MR were the second most affected by age, with only Picture Arrangement producing greater differences. Ardila was quick to point out that while the drop in MR scores was significant as age increased, the dispersion in scores was much more
significant and not all participants of advanced age earned lower scores on MR (Ardila, 2007).

The influence of gender on WAIS performance is contested in the literature (Snow & Weinstock, 1990) and no consistent sex differences were found for subtests of the WAIS-R (which did not include MR). In a more recent study, Dugbarty, Sanchez, Rosenbaum, Mahurin, Davis, and Townes (1999) administered the WAIS-III including MR in addition to a range of other neuropsychological tests to a clinical sample consisting of 41 individuals (22 men, 19 women) with mean age of 38.2 years (SD = 12.10). No significant difference between genders was found on MR, however more research is needed to substantiate this conclusion.

Ethnicity and nationality does not seem to affect performance on MR, while tests of verbal ability are significantly affected, as evidenced by the following studies. Razani, Murcia, Tabares, and Wong (2006), analyzed the performance of 86 individuals on the Wechsler Abbreviated Scale of Intelligence (WASI; The Psychological Corporation, 1999), which is an abbreviated form of the WAIS-III. The intercorrelations are of the WAIS-III and WAIS-IV were as follows: Vocabulary ($r = .88$), Similarities ($r = .76$), Block Design ($r = .83$), and MR ($r = .66$). The intercorrelation between the Full Scale IQ (FSIQ) for each test was $r = .92$ (The Psychological Corporation, 1999). In this study, participants were divided into two groups: one ethnically diverse group included participants of Hispanic, Asian, or Middle-Eastern descent, and one non-diverse group, consisting of participants identifying as Anglo-Americans. Using a MANCOVA with age as a covariate, the researchers found a significant difference between the two participant groups on WASI subtest scores, with the Anglo-American group outperforming the ethnically diverse group on Vocabulary and Similarities. Interestingly, no differences were found between groups on either Block Design or MR. The authors concluded that race and ethnicity have little influence on WAIS visuospatial tests such as MR (Razani et al., 2006).
Research has demonstrated that MR is relatively insensitive to the effects of brain injury. Tranel, Manzel, and Anderson (2008), conducted an analysis of fluid intelligence (as measured by WAIS-III MR) and crystallized intelligence (as measured by WAIS-III Vocabulary) in a sample of 160 brain-injured patients. The sample included participants with brain injury caused by epilepsy, cardiovascular disease, hematomas, or herpes simplex encephalitis. Time post-injury ranged from 1.7 years to 8.2 years. The patients were grouped according to lesion area, including dorsolateral prefrontal cortex, ventromedial prefrontal cortex, and areas located outside of the frontal lobes. The researchers found that performance on MR was unaffected by injury to the brain regardless of lesion location in this sample. They also broke down the groups further to analyze differences between patients with lesions in the left hemisphere and those with right hemisphere lesions. Again, no difference was found in MR performance between these groups.

Ryan et al. (2005) conducted a study to analyze MR performance in patients with histories of stroke or dementia. In this study, researchers administered the WASI to 81 patients identified has having either a history of stroke or dementia, including Alzheimer’s disease, Parkinson’s disease, and Dementia NOS. They computed estimated pre-injury Full Scale IQs using the Wechsler Test of Adult Reading (WTAR; The Psychological Corporation, 2001). Across participants, MR scores were highest of all the WASI subtest scores, and MR mean scores were significantly higher than the means for Vocabulary or Similarities. While all of the subtest means suggested a drop in cognitive functioning compared to estimated pre-injury scores, the change in MR scores was the smallest, leading the authors to conclude that MR, and indirectly fluid intelligence, is less affected by stroke or dementia than are other abilities (Ryan et al., 2005).
The Similarities Subtest

The Similarities subtest of the WAIS-III (The Psychological Corporation, 1997) involves more abstract reasoning than the other verbal subtests, as it requires the patient to describe relationships or similarities between two words. The words consist of both objects and concepts and increase in difficulty throughout the test, requiring greater levels of abstract reasoning as the test proceeds. Forms of the Similarities subtest were included in many early tests of intelligence, including the Stanford-Binet Intelligence Scale (Terman, 1916) and the Army Alpha test in the form of analogies. The Similarities subtest on the WAIS-IV is composed of 18 items, 6 of which are carried over from the WAIS-III. Items are scored using a 0 to 2-point scale, with two points being given for describing an abstract relationship and one point being given for describing a concrete relationship (Tulsky et al., 2003).

Age has an influence on Similarities performance. In Ardila’s (2007) previously mentioned study analyzing normative data for the WAIS-III, mean scores on Similarities decreased as participant age increased. However, Similarities scores were highest for participants in the 30-59 age range, decreasing thereafter so that mean scores for participants aged 85-89 were about 30% lower than for those aged 30-59.

However, in an earlier study, Kaufman, McLean, and Reynolds (1988) analyzed the standardization data from the WAIS-R and found that years of education was a mitigating factor in the effects of age. They analyzed data from 1,800 adults divided into four age groups and correlated years of education with performance on Similarities. They found moderate correlations between years of education and performance on Similarities, with coefficients ranging from $r = .32$ for the 16-19 age group to $r = .56$ for the 55-74 age group (Kaufman et al., 1988). Also, in a review of the literature on years of education and age, Matarazzo (1972) found...
that correlations between scores on the WAIS and education were higher than those between WAIS scores and age. Therefore, it is likely that the effects of age are confounded with education level, particularly since there are significant cohort effects in educational experiences.

Gender does not appear to have an effect on Similarities performance. In Kaufman et al.’s (1988) previously-described study, researchers analyzed gender differences in Similarities performance according to age group using the standardization data from the WAIS-R. No significant differences were found between genders regardless of age group. Heaton, Taylor, and Manly (2003) analyzed standardization data from the WAIS-III and found similar results. The effects of gender were nonsignificant overall, with the largest differences found in Processing Speed (favoring females) and Verbal Comprehension (favoring males).

Kaufman et al. (1988) also analyzed the difference between Caucasian American and African American groups on Similarities scores within age groups. Across all age groups and subtests of the WAIS-R, Caucasians produced higher scores than did African Americans. The difference between the means of Caucasians and African Americans on Similarities scores were intermediate in size, with different effect sizes ranging from .68 to .81 standard deviations within various age groups. Block Design produced the greatest differences between the racial groups, while Digit Span produced the smallest (Kaufman et al., 1988). However, it should be noted that research has found that the IQ gap between African Americans and Caucasian participants has significantly decreased over the past 40 years (Dickens & Flynn, 2003).

Heaton et al. (2003) analyzed the standardization data from the WAIS-III and WMS-III to measure the effects of ethnicity and found similar results. When they compared the data for factors derived from WAIS-III and WMS-III subtests, rather than specific subtests, small overall differences were found between ethnic groups. Effect sizes ranged from 0.01 to 0.1, with
Caucasians scoring highest across all indices, Hispanics falling in the middle, and African Americans scoring lowest on the continuum of scores.

Traumatic brain injury and other neurological disorders often have negative effects on performance on the Similarities subtest. Heaton et al. (2003) analyzed the standardization data for the WAIS-III/WMS-III and found that patients with Alzheimer’s disease were most impaired on tests of the Verbal Comprehension Index (of which Similarities is a component subtest) with a sensitivity estimate of 64.7, while patients with Korsakoff’s syndrome were least impaired with a sensitivity estimate of 22.2. Traumatic brain injury was associated with the second greatest drops in scores, with a sensitivity estimate of 57.1. However, it is important to note that decreases on Verbal Comprehension subtests were smaller than decreases on subtests of Perceptual Organization, Processing Speed, and Working Memory indices (Heaton et al., 2003). This is consistent with the longstanding theory that Verbal Comprehension subtests are often the least sensitive to neurological disorders and may be good indicators of premorbid functioning (Matarazzo, 1979). However, this is inconsistent with Ryan et al.’s (2005) findings using the WASI that verbal intelligence scores dropped more than scores on visuospatial processing, such as MR. These discrepant findings warrant future research using the most recent edition of the WAIS.

The D-KEFS Verbal Fluency Subtest

The Verbal Fluency subtest of the D-KEFS (Delis, Kaplan, & Kramer, 2001) is composed of three parts: letter fluency, category fluency, and category switching. This measure is used in the assessment of verbal fluency, word retrieval speed, and cognitive flexibility when switching responses. In the first portion of the standard version, letter fluency, participants must quickly name words beginning with the letters F, A, and S in three trials. In category fluency,
participants name boys’ names and animals. In the final section, category switching, participants must alternate between naming fruits and pieces of furniture. Each section is scored separately, according to the total number of words named, save for repetitions and set-losses. An additional score is calculated based upon the participant’s switching accuracy in the category switching trial.

The relationship between age and performance on tasks of verbal fluency is somewhat mixed. Analysis of normative data from Canadian participants ranging in age from 15 to 40 years (mean age = 24.7) with a mean education level of 14.5 years indicate both age and education to be significantly correlated with FAS (letter fluency) performance (FAS), with $r = .44$ (Yeudall, Fromm, Reddon, & Stefanyk, 1986). Bolla, Lindgren, Bonaccorsy, and Bleecker (1990) analyzed the relationship between performance on an FAS task and participant age in a sample of 199 adults, ranging in age from 40 to 89 years (mean = 64), with a range of 8-22 years of education (mean = 14.7). However, no significant correlation was found between age and FAS performance.

Other researchers have demonstrated significant differences in verbal fluency between age groups, based on the type of task. Kozora and Cullum (1995) found that age (but not education) was significantly correlated with performance on a category fluency task but not with performance on a letter fluency task, with the oldest participants providing the fewest number of responses on the category fluency task. In another study, Tombaugh, Kozak, and Rees (1999) analyzed the relationship between age and verbal fluency performance in a sample of 1300 adults with a range of 0-21 years of education, divided into three age groups: 16-59 years ($n = 522$), 60-79 years ($n = 554$), and 80-95 years ($n = 224$). The researchers found that letter fluency scores decreased with advancing age, accounting for 12% of the variance. Similarly, category fluency
scores were lower in the older age groups when compared to the younger age group, accounting for 23.4% of the variance in category fluency scores. In sum, though the research findings on age and verbal fluency were somewhat variable, increased age did appear to be associated with poorer verbal fluency performance, particularly on category fluency tasks.

Years of education has been found to be positively correlated with performance on verbal fluency tasks, particularly on letter fluency tasks. Indeed, education appears to be a stronger predictor of verbal fluency performance than age, overall (Gladsjo, Schuman, Evans, Peavy, Miller, & Heaton, 1999). Using a sample of 403 Caucasian and African American adults with a mean age of 52.12 years and mean years of education of 14.09 years, Gladsjo and colleagues reported that education and ethnicity accounted for more variability in both letter and category fluency performance than did age. In a previously mentioned study, Yeudall et al. (1986) found years of education to be significantly correlated with performance on a letter fluency task. This finding was confirmed by Tombaugh and colleagues (1999), who reported that performance on a letter fluency task was more sensitive to years of education, while the opposite was true for category fluency, on which age accounted for a greater percentage of variability.

The research on gender and verbal fluency is somewhat variable, but it appears that gender has a minimal effect, if any, on verbal fluency performance. In Yeudall et al.’s (1986) research, both age and education were significantly correlated with performance on a letter fluency task, but gender was not. Kozora and Cullum (1995) administered letter and category fluency tasks to a sample of 174 adults aged 50 to 90 years. In this study, female participants generated significantly fewer responses on the category naming task, although the authors note that the females had a lower mean level of education. Tombaugh et al. (1999) reported that
gender accounted for less than 1% of the variance in both letter and category fluency in their study.

There is limited research on the effect of ethnicity on verbal fluency performance. As previously noted, Gladsjo and colleagues (1999) demonstrated a significant relationship between ethnicity and performance on verbal fluency tasks across all age and education-level groups. In a study by Johnson-Selfridge, Zalewski, and Aboudarham (1998), 600 male veterans aged 31 to 46 years (mean = 37.9) were self-divided into three groups: Caucasian, African American, and Hispanic. Participants were administered letter and category fluency tasks, as well as a general achievement test. The authors found significant main effects for ethnicity on both letter and category fluency tasks, even when controlling for years of education and achievement test scores. In this study, the Caucasian participants generated more responses on both tasks than either of the other ethnicity groups. Additionally, the African American group provided significantly more responses on the letter fluency task than the Hispanic group, but both performed similarly on the category fluency task. This research is particularly notable because it highlights that norms developed on predominantly Caucasian American participants may lead to overdiagnosis of impairment among non-Caucasians.

Deficits in verbal fluency are associated with a wide variety of neurological syndromes and insults. In general, verbal fluency is reliably negatively affected following damage to the frontal lobe (Henry & Crawford, 2004), particularly in the left hemisphere. There is some evidence to suggest that damage to the right prefrontal cortex may produce greater deficits in category fluency performance than in letter fluency performance, which may indicate that the underlying neural systems of each task are dissimilar (Stuss et al., 1986). In a study of verbal fluency and Alzheimer’s disease, Cerhan and colleagues (2002) examined the performance of 40
participants with Alzheimer’s disease and 221 controls on letter and category fluency tasks. The letter fluency task utilized was the Controlled Oral Word Association Test (COWAT; Spreen & Benton, 1969) and the category task was comprised of three different trials of category naming (animals, fruits, and vegetables). The Alzheimer’s patients performed significantly poorer than controls on both letter and category fluency tasks \((p = .00001; p < .00001,\) respectively). The participants with Alzheimer’s disease generated relatively more words on the letter fluency task, while the controls named more words on the category fluency task. The researchers found that any person who earns a raw score of \(\leq 25\) on the letter fluency task is 2.1 times more likely to be diagnosed with Alzheimer’s disease than those who score over 25. On the category fluency task, people who earned a raw score of \(\leq 25\) were 24.5 more likely to be diagnosed with Alzheimer’s disease. This suggests that category fluency is substantially more sensitive than letter fluency in discriminating between healthy controls and Alzheimer’s patients.

Deficits in verbal fluency performance have also been found in patients diagnosed with frontotemporal dementia and corticobasal syndrome (CBS). Huey et al. (2009) administered the D-KEFS battery to 51 patients with FTD and 50 patients with CBS. Overall, they found that deficits on the Verbal Fluency (VF) subtest were associated with decreased gray manner volume in the left frontal operculum. In FTD patients, lower VF scores were found for those with damage to the dorsofrontal cortex, the parietal cortex, and the temporoparietal cortex. Those diagnosed with CBS demonstrated verbal fluency deficits associated with damage to the thalamus as well as to the aforementioned areas. Overall, patients with FTD performed significantly poorer than did patients with CBS, which confirms the hypothesis that verbal fluency is mediated by the frontal lobes in particular.
Differences between the WAIS-III and the WAIS-IV

The correlations between the WAIS-III and the WAIS-IV indices are high, with an $r$ of .91 for the Verbal Comprehension Index, .85 for the Perceptual Organization Index/Perceptual Reasoning Index, .86 for the Working Memory Index, and .86 for the Processing Speed Index (Pearson, 2008). Based upon these correlations, it is reasonable to generalize the research conducted using the WAIS-III to the WAIS-IV.

The normative sample for the WAIS-IV decreased to 2200 participants, compared to 2450 adults used for the WAIS-III sample. (Pearson, 2008; The Psychological Corporation, 1997). However, the WAIS-IV added 90-year-old participants, while the WAIS-III normative sample included participants only up to 89 years old. Within both tests participants were divided into five levels of education, ranging from $\leq 8$ years to $\geq 16$ years. For both versions, males and females were equally represented up to age 65 for both versions, after which the number of females was disproportionate to males. The proportions of Caucasians, African Americans, Hispanics, Asians, and other racial groups were said to be representative of the racial/ethnic composition of the U.S. population for both versions. Both tests divided geographic areas into West, North Central, Northeast, and South regions.

With regards to MR, both versions include the subtest in the Perceptual index (called Perceptual Organization in the WAIS-III and Perceptual Reasoning on the WAIS-IV). The correlation between the WAIS-III and WAIS-IV version of MR is high, $r = .71$. Both versions of the subtest contain 26 items. Twelve items from the WAIS-III were retained in the WAIS-IV version, and the rest of the items on the WAIS-IV are new. The WAIS-III version included three sample problems, while the WAIS-IV contains only two. According to the WAIS-IV Technical Manual, two items types are included on the new edition, compared with four item types on the
WAIS-III, in an effort to facilitate “effective and efficient teaching” (p. 14). However, a description of the item types is absent (The Psychological Corporation, 1997; Pearson, 2008). It is possible that this change in item types may be an effort to purify the types of abilities tested by MR.

The Similarities subtest is included in the Verbal Comprehension Index on both versions of the WAIS. The correlation between the two versions is high, \( r = .74 \). Both versions contain 18 items; six were carried over from the WAIS-III, while the remaining 12 are new to the WAIS-IV. The administration is the same for the two versions but the scoring rules have changed in order to extend the test floor. The WAIS-IV also includes an additional sample item, allowing for more opportunities for feedback and correction if needed.

**Matrix Reasoning and Verbal Skills**

Dugbarty et al. (1999) conducted a study examining the relationships between verbal abstract reasoning and verbal fluency with performance on MR. These researchers administered cognitive tests to 41 individuals referred for neuropsychological evaluation. In addition to the WAIS-III, tests administered included the Controlled Oral Word Association Test (COWAT; Spreen & Benton, 1969), the Trail Making Test (Army Individual Test Battery, 1944), the Rey-Osterrieth Complex Figure Test (Osterrieth, 1944; Rey, 1941), and the Halstead Category Test (Reitan & Davidson, 1974). Using multiple regression analysis, the researchers found that tests of phonemic and semantic verbal fluency, the WAIS-III Verbal Comprehension Index, and the Comprehension subtest of the WAIS-III significantly predicted performance on MR (\( F(4, 36) = 10.52 \), with an adjusted \( r^2 \) of .49.

The same relationship was demonstrated in a second study using non-English speakers as participants (Dugbarty et al., 1999). In this study, 14 non-English speaking clinical patients were
administered the Comprehensive Test of Nonverbal Intelligence (CTONI; Hammill, Pearson, & Wiederhold, 1997), the Animal Fluency subtest of the COWAT, and MR in their native language. A significant correlation was found between the Animal Fluency scores and MR ($r = .76$). The authors concluded that verbal mediation and verbal reasoning are important contributors to successful performance on MR for both English and non-English speakers, although it is important to note that the number of non-English participants was quite low. Additionally, they posited that the description of MR as a “nonverbal” test, based on the fact that it is visually presented, is misleading, and that the correlation between verbally-mediated tests and the MR strongly suggests that subvocal verbal problem solving strategies are probably being used.

Therefore, it appears that the MR and Similarities subtests are similar in that they are both tests of abstract reasoning, differing only in the method of presentation. Both require the identification of rules that govern the problem and both require abstract analysis in order to arrive at the correct answer. It may be hypothesized, based upon this information, that similar processes are contributing to performances on the MR and Similarities subtests.

**Aims of the Current Study**

The purpose of the present study was to identify the influence of verbal abstract reasoning ability (as measured by Similarities and D-KEFS Verbal Fluency) on non-verbal abstract reasoning tasks (as measured by MR). It was hypothesized that scores on Similarities and D-KEFS Verbal Fluency: Letter and Category would predict scores on MR items differentially, depending on the type of reasoning required for different items. Additionally, in order to extend the research of Dugbarty et al. (1999), the association between verbal fluency (as measured by D-KEFS VF) and non-verbal abstract reasoning was measured.
Methods

Participants

Participants were 43 consecutive patients (23 male, 20 female) referred to a university doctoral clinical psychology training clinic (Pacific Psychology Clinic in Portland, OR) for neuropsychological evaluation over a two-year period. The referral base was comprised of clients referred for predominantly academic purposes, including learning disability, Attention-Deficit/Hyperactivity Disorder, and cognitive disorder evaluations. The mean age for the group was 30.35 years (SD = 11.14) and mean years of education was 13.63 years (SD = 2.25).

Measures

The WAIS-IV (Pearson, 2008) is an intelligence test composed of 10 core subtests and five optional subtests designed to measure four cognitive domains: verbal comprehension, perceptual reasoning, processing speed, and working memory. Additionally, the compilation of all 10 subtests yields a full-scale IQ score. The paper-and-pencil test is administered individually with an examiner.

Procedure

Participants were administered the WAIS-IV (Pearson, 2008) as part of standard comprehensive neuropsychological assessment. Prior to testing, clients were informed that their data may be used in future research. The clients who agreed to such use of their information signed an informed consent form to that extent. The Institutional Review Board at Pacific University approved this use of client data. Prior to data analysis, all data were deidentified and entered into a computer research database.
Data Analysis

Point-biserial correlations were used to analyze the relationship between participants’ MR item scores (0 or 1) and their total Similarities score, with a Bonferroni correction applied to reduce an inflated familywise error rate due to multiple analyses. The goal of this analysis was to determine which items on MR correlated most highly with scores on Similarities, testing the hypothesis that verbal mediation has a strong influence on some visuospatial reasoning tasks, such as are included on MR. In order to further evaluate the relationship between verbal mediation and visuospatial reasoning, scores on MR also were correlated with the phonemic (Letter) and categorical (Category) scores from the Verbal Fluency subtest of the D-KEFS using point-biserial correlations.
Results

Table 1 displays the means and standard deviations for participant age and years of education.

Table 1
Descriptive Statistics for Participant Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age (sd)</th>
<th>Education Level (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n = 23)</td>
<td>31.61 (10.16)</td>
<td>13.61 (2.74)</td>
</tr>
<tr>
<td>Females (n = 20)</td>
<td>28.90 (12.27)</td>
<td>13.65 (1.57)</td>
</tr>
<tr>
<td>Total (n = 43)</td>
<td>30.35 (11.14)</td>
<td>13.63 (2.25)</td>
</tr>
</tbody>
</table>

Table 2 displays the mean scaled scores for Similarities and mean Standard scores for Verbal Fluency: Letter and Category for all 43 participants. There were no significant differences in subtest scores between genders.

Table 2
Means and Standard Deviations of Similarities and Verbal Fluency Scores

<table>
<thead>
<tr>
<th>Variable</th>
<th>Similarities</th>
<th>Letter Fluency</th>
<th>Category Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scaled Score (sd)</td>
<td>Standard Score (sd)</td>
<td>Standard Score (sd)</td>
</tr>
<tr>
<td>Males (n = 23)</td>
<td>11.96 (3.36)</td>
<td>105.45 (25.26)</td>
<td>106.14 (18.12)</td>
</tr>
<tr>
<td>Females (n = 20)</td>
<td>12.25 (3.29)</td>
<td>104.50 (16.30)</td>
<td>106.75 (13.88)</td>
</tr>
<tr>
<td>Total (n = 43)</td>
<td>12.09 (3.29)</td>
<td>105.0 (21.21)</td>
<td>106.43 (16.05)</td>
</tr>
</tbody>
</table>
Out of the 43 participants, 24 completed all 26 items of the Matrix Reasoning subtest. Participants were not administered items after they met the discontinue rule. Table 3 displays the number of participants who completed each MR item. It should be noted that analyses were conducted both using only items completed and also assigning a zero for items not completed. The results were identical.

Table 3

<table>
<thead>
<tr>
<th>Item</th>
<th>Participants (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 4</td>
<td>43</td>
</tr>
<tr>
<td>Item 5</td>
<td>43</td>
</tr>
<tr>
<td>Item 6</td>
<td>43</td>
</tr>
<tr>
<td>Item 7</td>
<td>43</td>
</tr>
<tr>
<td>Item 8</td>
<td>43</td>
</tr>
<tr>
<td>Item 9</td>
<td>42</td>
</tr>
<tr>
<td>Item 10</td>
<td>42</td>
</tr>
<tr>
<td>Item 11</td>
<td>41</td>
</tr>
<tr>
<td>Item 12</td>
<td>41</td>
</tr>
<tr>
<td>Item 13</td>
<td>41</td>
</tr>
<tr>
<td>Item 14</td>
<td>41</td>
</tr>
<tr>
<td>Item 15</td>
<td>40</td>
</tr>
<tr>
<td>Item 16</td>
<td>37</td>
</tr>
<tr>
<td>Item 17</td>
<td>35</td>
</tr>
<tr>
<td>Item 18</td>
<td>35</td>
</tr>
</tbody>
</table>
First, point-biserial correlations were used to examine relationships between MR items and Standard scores for D-KEFS Verbal Fluency: Letter. Using a Bonferroni correction with an adjusted alpha level of .002, no significant correlations were found. However, several trends were noted. Four MR items were found to have correlations with Letter Fluency Standard scores with a \( p \) of less than .05. Table 4 displays the resulting correlation coefficient and probability values for each of these analyses. Figures 1-4 display boxplots for point biserial correlations between Letter Fluency Standard scores and these four MR items.

### Table 4

**Correlations between D-KEFS Verbal Fluency: Letter Standard Scores and MR Items**

<table>
<thead>
<tr>
<th>MR Item</th>
<th>Correlations with D-KEFS Verbal Fluency: Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 13 ((n = 40))</td>
<td>( r = .335, p &lt; .05 )</td>
</tr>
<tr>
<td>Item 17 ((n = 34))</td>
<td>( r = .482, p &lt; .01 )</td>
</tr>
<tr>
<td>Item 18 ((n = 34))</td>
<td>( r = .375, p &lt; .05 )</td>
</tr>
<tr>
<td>Item 23 ((n = 28))</td>
<td>( r = .403, p &lt; .05 )</td>
</tr>
</tbody>
</table>
Figure 1

*Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and MR Item 13*
Figure 2

*Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and MR Item 17*
Figure 3

*Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and MR Item 18*
Figure 4

*Point Biserial Correlations between Verbal Fluency: Letter Standard Scores and MR Item 23*
Second, point-biserial correlations were used to examine relationships between MR items and Standard scores for D-KEFS Verbal Fluency: Category. Using a Bonferroni correction with an adjusted alpha level of .002, no significant correlations were found. However, several trends were noted. Three MR items were found to have correlations with Category Fluency Standard scores with a \( p \) of less than .05. Table 5 displays the correlation coefficient and probability values for each of these. Figures 5-7 display boxplots for point biserial correlations between Category Fluency Standard scores and each of these three MR items.

Table 5

*Correlations between D-KEFS Verbal Fluency: Category Standard Scores and MR Items*

<table>
<thead>
<tr>
<th>MR Item</th>
<th>Item correlations with D-KEFS Verbal Fluency: Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 13 ( (n = 40) )</td>
<td>( r = .349, p &lt; .05 )</td>
</tr>
<tr>
<td>Item 14 ( (n = 40) )</td>
<td>( r = .388, p &lt; .05 )</td>
</tr>
<tr>
<td>Item 15 ( (n = 39) )</td>
<td>( r = .317, p &lt; .05 )</td>
</tr>
</tbody>
</table>
Figure 5

*Point Biserial Correlations between Verbal Fluency: Category Standard Scores and MR Item 13*
Figure 6

*Point Biserial Correlations between Verbal Fluency: Category Standard Scores and MR Item 14*
Figure 7

*Point Biserial Correlations between Verbal Fluency: Category Standard Scores and MR Item 15*
Lastly, point-biserial correlations were used to examine the relationships between MR items and WAIS-IV Similarities scaled scores. Using a Bonferroni correction with an adjusted alpha level of .002, no significant correlations were found. However, several trends were noted. Six MR items were found to have correlations with Similarities scaled scores with a $p$ of less than .05. Table 6 displays the correlation coefficient and probability values for each of these analyses. Figures 8-13 display boxplots for point biserial correlations between Similarities scaled scores and these six MR items.

Table 6

*Correlations between WAIS-IV Similarities Scaled Scores and MR Items*

<table>
<thead>
<tr>
<th>MR Item</th>
<th>Item correlations with WAIS-IV Similarities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 9 ($n = 42$)</td>
<td>$r = .42, p &lt; .01$</td>
</tr>
<tr>
<td>Item 13 ($n = 41$)</td>
<td>$r = .44, p &lt; .01$</td>
</tr>
<tr>
<td>Item 14 ($n = 41$)</td>
<td>$r = .38, p &lt; .05$</td>
</tr>
<tr>
<td>Item 17 ($n = 35$)</td>
<td>$r = .57, p &lt; .01$</td>
</tr>
<tr>
<td>Item 20 ($n = 33$)</td>
<td>$r = .44, p &lt; .05$</td>
</tr>
<tr>
<td>Item 23 ($n = 29$)</td>
<td>$r = .66, p &lt; .01$</td>
</tr>
</tbody>
</table>
Figure 8

*Point Biserial Correlations between Similarities Scaled Scores and MR Item 9*
Figure 9

Point Biserial Correlations between Similarities Scaled Scores and MR Item 13
Figure 10

*Point Biserial Correlations between Similarities Scaled Scores and MR Item 14*
Figure 11

Point Biserial Correlations between Similarities Scaled Scores and MR Item 17
Figure 12

*Point Biserial Correlations between Similarities Scaled Scores and MR Item 20*
Further inspection revealed that MR item 13 was significantly correlated with all three comparison tests. Items 17 and 23 were significantly correlated with D-KEFS Verbal Fluency: Letter and WAIS-IV Similarities. Item 14 was significantly correlated with D-KEFS Verbal Fluency: Category and WAIS-IV Similarities. All other items were correlated with only one verbal subtest.
Discussion

The influence of verbal mediation on tasks of problem solving and abstract reasoning has been well-established in the literature (Chi et al., 1994; Cole & Pheng, 1998; Neuman et al., 2000; Silverberg & Buchanan, 2005; Welsh, 1987). Yet verbal mediation of non-verbal tasks is seldom accounted for in cognitive test interpretation. The Matrix Reasoning subtest of the WAIS-IV (Pearson, 2008) purports to measure perceptual reasoning and concept formation and is presented in a visuospatial format. Verbal mediation is not considered when interpreting MR test results, yet the literature has demonstrated that verbal mediation and reasoning is often utilized in similar tasks. The present study sought to examine the influence of verbal mediation of the MR subtest by correlating participants’ MR item scores with their scaled scores on the WAIS-IV Similarities subtest, as well as their Standard scores on the D-KEFS Verbal Fluency: Letter and Category subtest (Delis et al., 2001).

Participants were 43 consecutive patients (23 male, 20 female) referred to a university doctoral clinical psychology training clinic for neuropsychological evaluation over a two-year period. The mean age for the group was 30.35 years (SD = 11.14) and mean years of education was 13.63 years (SD = 2.25). The mean Similarities scaled score was 12.09 (SD = 3.29). Mean Verbal Fluency: Letter Standard score was 105.0 (SD = 21.21), and mean Verbal Fluency: Category was 106.43 (SD = 16.05). Twenty-four of the 43 participants completed all 26 items on the MR subtest. All participants successfully completed the first eight items. Qualitative analysis suggests that items 16 and 24 were particularly difficult in that multiple people met the discontinue criteria after those items.

Using a Bonferroni correction with an adjusted alpha level of .002, no significant correlations were found between MR items, Similarities scaled scores, or Verbal Fluency
Standard scores. However, several trends were noted. For Verbal Fluency: Letter, four MR items were found to have a $p$ of less than .05: items 13, 17, 18, and 23. Item 13 required perceptual orientation in which the participant had to track the movement of a portion of the stimulus across a series of stimuli and choose the correct option to complete the sequence. Item 17 utilized shape, color, and number and required participants to recognize the relationship between two parts of the stimulus and choose an option that followed the same pattern. Item 18 required participants to track both number and orientation of the stimulus, while item 23 utilized the color, number, shape, and orientation of the stimulus. Use of numerical concepts is required in three of the four items.

Point-biserial correlations for MR items and Verbal Fluency: Category Standard scores resulted in three items were found to have a $p$ of less than .05: items 13, 14, and 15. As previously mentioned, item 13 tested the participant’s ability to recognize changes in the orientation pattern of the stimulus. Item 14 deals with color and orientation changes in the stimulus, while item 15 utilizes changes in patterns of color and orientation. The consistent construct throughout these three items is orientation of the stimulus, which might indicate that verbal mediation is specifically utilized on tasks requiring manipulation of perceptual orientation. However, it should be noted that there were MR items that included perceptual orientation that were not correlated with Verbal Fluency Category Standard scores.

Point-biserial correlations for MR items and Similarities scaled scores resulted in six items with a $p$ of less than .05: items 9, 13, 14, 17, 20, and 23. Item 9 deals with orientation of the stimulus, as does item 13. Item 14 tests the participant’s ability to recognize the pattern of color and orientation. Item 17 includes color, shape, and number, while item 20 examines changes in number, color, and orientation. Item 23 tests all four modalities: color, number, shape,
and orientation. Perceptual orientation is analyzed in five of the six correlations, while color patterns are included in four of the six correlations. This suggests that orientation and color of the stimulus lend themselves most strongly to verbal mediation, but not all MR items dealing with orientation or color were significantly correlated with Similarities.

Notably, item 13 was strongly correlated with Similarities scaled scores as well as both Verbal Fluency Standard scores. Both items 17 and 23 are correlated with Similarities and Verbal Fluency: Letter, while item 14 is correlated with Similarities and Verbal Fluency: Category. Of these four items, three deal with orientation (items 13, 14, and 23) and three utilize color patterns (items 14, 17, and 23). However, these results should be interpreted in context, since there were many other MR items that dealt with the same constructs but were not correlated with Similarities or Verbal Fluency scores. However, these results do suggest that verbal mediation may be specifically required or useful for visuospatial abstract reasoning tasks with patterns utilizing color and stimulus orientation.

It is unclear why these constructs may be specifically influenced, compared to shape or number. Perhaps color and orientation present more of a challenge with respect to pattern recognition. For example, participants might utilize more purposeful thought and subsequently higher levels of verbal mediation to follow changes in patterns when orientation and color are involved. Conversely, perhaps number and shape are more easily recognized and do not require as much deliberate thought when considering the patterns involved.

More MR items were correlated with Similarities scores than with either of the Verbal Fluency tasks. Similarities is thought to examine verbal abstract reasoning, while Verbal Fluency deals more specifically with language and verbal generativity. Based on these results, it may be surmised that verbal generativity is less important in visuospatial perceptual reasoning and
concept formation, at least when language is intact. Thus, these results suggest a logical specific association between verbal abstract reasoning and visuospatial abstract reasoning, while visuospatial abstract reasoning is not necessarily associated with more basic language and verbal skills.

The results of this study are largely consistent with the literature asserting the significant relationship between verbal mediation and visuospatial abstract reasoning (Chi et al., 1994; Cole & Pheng, 1998; Neuman et al., 2000; Silverberg & Buchanan, 2005; Welsh, 1987). These results are also consistent with Dugbarty et al. (1999) findings that there is a significant relationship between MR and verbal fluency, although to a lesser degree than verbal abstract reasoning. Although the number of analyses and subsequent application of the Bonferroni correction limited power in this study, the trends do suggest that certain MR items lent themselves more strongly to verbal mediation than do others. No other study to date has compared these tests using the WAIS-IV. It is noteworthy that even after item changes in the WAIS-IV MR subtest, the significant relationship between MR items and tasks of verbal abstract reasoning and fluency continues to exist.

It is likely that tasks of visuospatial abstract reasoning draw on verbal mediation skills at least to some extent. It also is possible that these two abilities are irrevocably confounded due to the overlap in abstract reasoning and our natural tendency to verbally mediate a variety of tasks. It is also possible that tasks such as the current MR subtest are poor measures of visuospatial abstract reasoning alone, but perhaps there is a better way to measure that ability. Future research might focus on developing a version of MR that does not include those items found to correlate significantly with Similarities and Verbal Fluency. Additionally, it should be explored to what extent the changes in MR items between versions of the WAIS-III and WAIS-IV may affect the
association between MR items and verbal subtests. To this extent, future researchers might compare the correlations between WAIS-III MR items and WAIS-IV MR items to determine if changes in items have affected the relationship between the task and the verbal ability subtests.
References


