



Introduction to the
Miller Analogies Test

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Introduction

The *Miller Analogies Test* (MAT) is developed and administered by Pearson. It has been used as a graduate school admission test for more than 70 years in university programs throughout the United States. The information presented in this paper is intended to familiarize graduate school admission directors, deans, and faculty with the MAT and to describe how the test is structured and administered. This paper also explains how the test results can be interpreted and used in admission decisions, provides information about the current norms, and discusses evidence regarding the reliability and validity of the MAT.

The MAT is a high-level mental ability test requiring the solution of problems stated as analogies. Psychologists suggest that the analogy format represents an efficient and effective way to sample reasoning processes and to measure verbal comprehension and analytical intelligence (Gentner and Markham, 1997; Holyoak and Thagard, 1996; Lohman, 2004; Sternberg, 1977, 1985, 1988). Robert Sternberg (1985) suggests that all of the information-processing components involved in inductive reasoning are required to solve analogy problems:

- Encoding—comprehending relevant information
- Inference—relating given concepts to other concepts
- Mapping—recognizing common rules shared by concepts
- Application—applying inferred rules to new concepts
- Comparison—choosing options that conform to ideals
- Justification—judging the reasonableness of choices
- Response—demonstrating choices made by inductive reasoning

In a meta-analysis of the MAT, Kuncel, Hezlett, and Ones (2004) conclude that the analogical reasoning involved in the test involves all the principles of cognition, and that the MAT represents a valid predictor of performance in both academic and work settings.

The MAT Analogy

An analogy is a way of showing that two situations share a relational structure. Solving MAT analogies first involves recognizing a relationship between two given terms, a base analogue, and then looking for the same relationship between a third given term and one of four possible answer options, a target analogue. The correct answer must be selected by inferring the relationship between the two terms in the base analogue and mapping this relationship onto the one given term and the option used to complete the target analogue. Mapping—correctly seeing the relationship between relationships—is the essence of solving the MAT analogy.

The Structure of an Analogy Item

A MAT analogy is a statement suggesting that two terms are related to each other in the same way that two other terms are related to each other. MAT analogy items are written as equations in the form “A : B :: C : D,” which can be read either as “A is related to B in the same way that C is related to D” or as “A is related to C in the same way that B is related to D.” An MAT analogy item is never written so that “A is related to D in the same way that B is related to C.”

In a MAT item, one term in the analogy is missing and has been replaced with four options, only one of which correctly completes the analogy. Regardless of the order in which terms in an analogy are presented, there must be only one valid and logical relationship that exists between the two pairs of terms.

MAT analogies involve both content knowledge and analytical reasoning. Content knowledge is required to understand the meanings of the terms in the item, and analytical reasoning is necessary to recognize the analogical relationship between terms. For an analogy item to be effective in assessing analytical reasoning, it must involve recognizing relationships between terms in addition to understanding the meaning of the terms involved. To accomplish this, all the terms in the item must be familiar to the examinee. The difficulty of an analogy item is not only related to the difficulty of the terms involved, but also involves the subtlety of the relationship between the terms.

An Example of an Analogy Item

One term in each MAT analogy item has been replaced with four options, only one of which is correct. The examinee is expected to select the option that creates a valid analogy, as illustrated in the following example:

TABLE : BILL :: (a. chair, b. direct, c. gesture, d. shelve) : MOTION

The first step in solving this item is to decide which two of the three terms in the stem form a complete pair—either “Table is related to Bill” (the first term is related to the second term) or “Bill is related to Motion” (the second term is related to the fourth term).

In this example, it may seem difficult to identify any relationships between these three terms, particularly if the terms are considered as nouns. However, each of these words can also be used as a verb: to table or postpone something for later consideration; to bill or invoice a customer for a purchase; to motion or gesture to someone. Looking at the item this way may not help much, either, until it is seen as a combination of nouns and verbs.

Thus, the analogy is “Table is to bill as motion is to shelve.” To table a legislative bill is to delay consideration of it and, similarly, to delay consideration of a motion is to shelve it. The two terms in each pair are related in the sense that one term is an action taken with regard to the other. You will also notice that each incorrect option has some relationship to one or more of the three given terms but does not form a valid analogy. As this example illustrates, effective MAT analogies involve an analytical reasoning process in the context of a specific content area in this case, social science.

What the MAT Measures

In studies of human intelligence and reasoning, researchers have found that verbal, quantitative, and figural analogies are among the best measures of verbal comprehension and analytical intelligence (Gentner and Markham, 1997; Holyoak and Thagard, 1996; Sternberg, 1977, 1985, 1988). Many cognitive psychologists also suggest that the cognitive process involved in creating analogies and recognizing conceptual similarities despite surface differences has practical benefits, including skill at solving problems, constructing explanations, and building arguments. The MAT has been designed to measure the same cognitive processes.

The Structure of the MAT

The MAT is administered in 60 minutes, and each test form is composed of 120 analogy items, 100 of which count toward examinees' scores that are reported on personal Score Reports to the examinees and on Official Transcripts to institutions. The remaining 20 items are experimental and do not count toward examinees' scores. These items are being field-tested for possible use on future forms and are embedded within each test form so that examinees are unable to identify them.

Selecting Items for MAT Test Forms

Analogy items for MAT test forms are selected to be effective measures of both content knowledge and analytic reasoning. This is accomplished by selecting items according to very specific criteria:

- Solving analogy items requires subject matter and vocabulary knowledge that most American college students can reasonably be expected to have acquired through undergraduate general education and through general reading and experience.
- The correct answer to each analogy item involves recognizing a specific type of analogical relationship within the context of a specific content area.
- Each of the three incorrect answer options logically or semantically relates to at least one of the three terms in the stem, is consistent in structure with the other incorrect options and with the terms in the stem, and differs from the others in subtle ways that require fine semantic, logical, or relationship distinctions to determine that it is not the correct answer.
- Items must reflect appropriate psychometric properties and must represent a range of statistical difficulty comparable to items on the current MAT forms.

The MAT Content and Relationship Objectives

In addition to the cognitive processes involved in correctly solving MAT analogies, each item has been designed to also require background knowledge critical to the commencement of study in graduate school. To ensure this, MAT analogies contain content from the humanities, social sciences, natural sciences, mathematics, and language usage and vocabulary, as well as general knowledge commonly acquired through general reading and life experience.

The MAT test forms are composed of analogy items that reflect the content and relationship objectives listed in Figure 1.

MAT Content Objectives	
General (life experience, culture, work)	
Humanities (archaeology, art history, comparative religion, ethics, history, literature, modern and classical languages, philosophy, music, visual arts)	
Language (composition and rhetoric, grammar, word connotations, word meanings, word parts, word pronunciations and sounds)	
Mathematics (algebra, arithmetic, finance, geometry, numbers, probability, statistics)	
Natural Sciences (astronomy, biology, chemistry, earth science, ecology, environmental science, geology, physical geography, physics)	
Social Sciences (anthropology, civics, criminology, economics, education, geography, political science, psychology, public health, sociology)	
MAT Relationship Objectives	
Semantic (word meanings)	<ol style="list-style-type: none"> 1. Similarity/Contrast (synonyms, definitions, similarities, antonyms, contrast, differences) 2. Intensity (relative sizes, degrees, magnitudes, extents) 3. Completion (parts of expressions, split phrases, words)
Classification (hierarchical relationship, classification, inclusion)	<ol style="list-style-type: none"> 1. Category (member/class, class/member, subordination, superordination) 2. Membership (members of same class or category, coordination) 3. Whole-Part/Part-Whole
Association (characteristic, predication, affiliation)	<ol style="list-style-type: none"> 1. Object/Characteristic (attribute, description, lacking quality, source, component, location, setting) 2. Order (sequence, reciprocal, by-product, transformation) 3. Agent/Object (cause/effect, creator/creation, function of, action taken by, purpose for, tool used by)
Non-Semantic (logical/mathematical)	<ol style="list-style-type: none"> 1. Equality (logical/mathematical equivalence, numerical fractions, multiples) 2. Negation (logical/mathematical negation) 3. Letter/Sound (letter patterns, sound patterns, rhymes, homophones, similar sounds)

Figure 1. MAT Analogy Objectives

MAT Test Administration and Score Reporting

MAT Test Administration

The MAT is administered through a network of hundreds of Controlled Testing Centers (CTCs) that have been established at colleges and universities throughout the United States and Canada (as well as at a few overseas sites) to serve their own students and candidates from the local area or region. When approved by Pearson, each CTC is given the software necessary to administer computer-based versions of the MAT and a complete supply of printed test materials to administer paper-and-pencil versions of the test. All testing materials must be maintained in a secure environment at all times and are inventoried annually by Pearson.

Candidates make arrangements to take the MAT directly with the CTC most convenient to them. The CTC may administer either a computer-based or a paper-and-pencil version of the MAT individually or in groups. All CTC examiners are provided with a manual of directions to ensure adherence to the standardized administration procedures established for the test.

Reporting Test Results

Within 15 business days of the time Pearson receives an examinee's test materials, the results are mailed to the examinee and to all designated score recipient institutions. Each personal Score Report sent to an examinee and Official Transcript sent to a graduate school or program includes a scaled score and two percentile ranks: a Total Group percentile rank comparing the examinee's scaled score to scores earned by the total norm group, and a percentile rank based on the intended major indicated by the examinee at the time of testing.

The MAT scaled scores range from 200 to 600 with a mean of approximately 400. MAT scaled scores have remained unchanged since October 2004, making them especially useful for longitudinal tracking. MAT percentile ranks range from 1 to 99 and are based on performance relative to the current norm group—over 152,000 first-time MAT candidates tested between January 1, 2004 and December 31, 2007. Percentile ranks are particularly useful for explaining an individual's performance relative to others.

Official Transcripts are sent to accredited institutions of higher education and approved fellowship or scholarship organizations that are requested by the examinee. To ensure score authenticity, institutions should accept only Official Transcripts sent by Pearson. Scores listed on the Official Transcript indicate all MAT scores obtained during the five years previous to the date of the examinee's most recent attempt at the MAT.

An examinee's personal Score Report is marked, "This is not an Official Transcript," to indicate that under no circumstances should an institution accept a personal Score Report as an Official Transcript. Examinees who take a computer-based version of the MAT immediately receive a Preliminary Score Report. The report clearly states that it is not an official score, that a personal Score Report will be mailed to the examinee, and that Official Transcripts will be mailed directly to the requested institutions.

Using MAT Scores in Graduate Admission Decisions

The current edition of the MAT Technical Manual contains complete information regarding the use and interpretation of MAT test scores for graduate school admissions. The MAT Technical Manual is available by request from Pearson for university officials involved in graduate school admissions decisions.

Though research has shown the MAT to be a strong predictor of subsequent academic performance (Kuncel, Hezlett, and Ones,

2004), MAT scores should never be used as the only criterion for admission, nor should rigid cut scores be used with MAT or any other admissions instrument. MAT scores are only one among several criteria to consider in admissions decisions, and rigid cut score limits may inadvertently exclude otherwise worthy candidates.

Pearson does not establish or suggest passing scores for individual MAT scores. *Each school is responsible for determining how it uses MAT scores.* When used along with other information available to admissions committees, MAT scores represent a valuable tool for evaluating applicants to graduate programs. No single test score can possibly assess all of the requisite knowledge and skills necessary for success in a graduate program. However, MAT scores can contribute significantly to

the quality of the admissions process when used as part of an application package that consists of information from multiple sources about that candidate's academic achievement and potential. The MAT is intended to fairly and accurately reflect certain abilities acquired through individuals' educational experiences over an extended time. MAT scores should always be evaluated in the context of these experiences.

The Current MAT Norm Group

The current MAT normative sample consists of all first-time examinees who took the test between January 1, 2004 and December 31, 2007. Data from all MAT forms used with the normative sample have been combined to produce the new percentile ranks.

Table 1 shows data for the 2004–2007 norm group and includes the number of examinees (*n*), the means (*M*) and standard

deviations (*SD*) of scaled scores, and the minimum and maximum observed scaled scores for the total group and for examinees' intended field of graduate study. For a complete list of scaled scores and percentile ranks for the total group and for each intended field of study, and for scaled score means for individual majors within the fields of study, please refer to the current MAT Technical Manual.

Table 1. Distribution of Scaled Scores by Intended Field of Study and Total Group for the 2004–2007 Normative Sample

INTENDED FIELD OF STUDY & TOTAL GROUP	<i>n</i>	Scaled Score			
		<i>M</i>	<i>SD</i>	Min. Score	Max. Score
Business	8,464	391.6	24.3	325	527
Education	86,790	399.9	24.4	315	542
Humanities	4,491	411.6	26.3	323	551
Natural Sciences	11,478	402.4	23.3	326	535
Social Sciences	17,437	397.8	25.5	310	519
Other ¹	12,960	404.0	28.1	315	521
Undecided	605	397.5	26.9	336	501
Total Group	152,903	399.8	25.2	237	551
Note: ¹ The "Other" group includes all majors that are not categorized under any other field of study.					

Evidence of Reliability

The reliability of a test’s scores is the extent to which they are consistent. Reliability is expressed as a correlation coefficient that represents the expected correlation between two administrations of a test, if there were no practice effects and if the person’s underlying ability did not change. Reliability coefficients can range from 0.00 (completely unreliable) to 1.00 (perfect). Because the graduate school admissions process is so important, reliability coefficients of 0.90 or greater are typically expected from admissions tests.

A method commonly used to estimate test reliability when examinees take a single test form is internal consistency reliability. Also related to the reliability of a test is the standard error of measurement (*SEM*), which represents the amount

of error present in test scores. The lower the *SEM*, the closer candidates’ test scores are to their actual ability, and the greater degree of certainty that the obtained score represents the examinee’s true ability.

Table 2 presents the Cronbach’s alpha reliability coefficients (α) (a commonly used formula for estimating the reliability of a test based on internal consistency) and standard errors of measurement (*SEM*) for the seven paper-and-pencil forms (PPT) and 12 computer-based forms (CBT) in use during the 2004–07 normative sample period. The reliability coefficients shown in Table 2 are satisfactorily high, and the standard errors of measurement are reasonable compared to the overall standard deviation (25).

Table 2. Cronbach’s Alpha (α) and Standard Error of Measurement (*SEM*) by MAT Test Form (1–15) and Format (PPT and CBT)

MAT Test Format	Ave. α	Ave. SEM	<i>n</i>
PPT	0.92	7.19	94,517
CBT	0.92	7.32	58,367
Note: SEMs were calculated at the 68% confidence interval and are reported in scaled score units			

Evidence of Validity

The validity of a test’s scores may be defined as the degree to which evidence supports inferences made from those scores. One of the most important ways of evaluating the validity of scores on a test is to determine its criterion-related or predictive validity—how well its scores predict indicators of subsequent success (e.g., graduate school grades, professor ratings, degrees awarded, departmental evaluations).

Many studies conducted over the years have shown positive correlations between MAT scores and subsequent academic performance. The most extensive and comprehensive analysis conducted to date is a meta-analysis of MAT research done by Kuncel, Hezlett and Ones (2004), involving 127 studies and more than 20,000 participants. In this study, the researchers found

the MAT to be a valid predictor of several aspects of graduate student performance, job performance, potential, and creativity. They found that the MAT correlated highly with the GRE-Verbal section, with other cognitive ability tests from educational and work settings, and with the acquisition and demonstration of knowledge and skill. The authors found that correlations between MAT scores and first-year GPA were slightly higher than for overall graduate GPA, that correlations with faculty ratings of graduate student performance were positive, and that correlations between MAT scores and comprehensive examination scores were the highest. Correlations with degree attainment and time to degree attainment were moderately positive, possibly moderated by motivational variables other than cognitive ability.

Table 3 shows predictive validity data for the academic criteria included in the meta-analysis of MAT research by Kuncel, Hezlett, and Ones (2004, p. 155) and from an earlier meta-analysis by the same researchers (2001, p. 169) of the GRE and entering undergraduate GPA. As shown in Table

3, validity data for MAT scores compare quite favorably to validity data for GRE scores and undergraduate GPA, suggesting the relative value of MAT scores for predicting graduate school performance.

Table 3. Predictive Validity Data by Academic Criteria for the MAT, GRE, & Undergraduate GPA

Criterion	MAT ^a			GRE ^b						UGPA ^b		
				Verbal			Quantitative					
	N	k	p	N	k	p	N	k	p	N	k	p
Graduate GPA	11,368	70	0.39	14,156	103	0.34	14,425	103	0.32	9,748	58	0.30
1st-year Graduate GPA	2,999	34	0.41	45,615	1,231	0.34	45,618	1,231	0.38	42,193	1,178	0.33
Degree Attainment^a	3,963	20	0.21	6,304	32	0.18	6,304	32	0.20	6,315	33	0.12
Faculty Ratings	1,909	25	0.37	4,766	35	0.42	5,112	34	0.47	3,695	22	0.35
Comprehensive Exam Scores^{cd}	987	10	0.58	1,198	11	0.44	1,194	11	0.26	592	6	0.12
Time to Complete^e	1,700	5	0.35	160	3	0.28	160	3	-0.12	629	5	-0.08

Notes: MAT = Miller Analogies Test, GRE = Graduate Record Examinations; UGPA = undergraduate grade point average; n = number of cases; k = number of studies; p = estimated true score validity for MAT, and estimated operational validity for GRE and UGPA (calculated by the researchers to correct for sampling error, restriction of range, and measurement error in the data analyzed from the various studies). The six criteria presented in this table include only those with data available for all three predictors—MAT, GRE, and UGPA.

^a From Kuncel, Hezlett, and Ones (2004, p. 155). ^b From Kuncel, Hezlett, and Ones (2001, p. 169). ^c Not corrected for criterion unreliability but with restricted range-restriction distribution (MAT); not corrected for range restriction (GRE and UGPA). ^d Not corrected for criterion unreliability. ^e GRE data only from the social sciences.

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The same comparisons shown in Table 3 were reported and expanded in a more recent comparison of meta-analyses of several standardized tests commonly used for graduate school admissions (Kuncel and Hezlett, 2007a, 2007b). In this study, the researchers found nearly identical correlations (corrected for measurement unreliability and restriction of range) between first-year graduate GPA and MAT scores (0.39), GRE Total scores (0.41), and GMAT scores (0.41). They also found overall graduate GPA to correlate slightly higher with MAT scores (0.39) than with either GRE Total scores (0.37) or GMAT scores (0.35 corrected).

The correlations found in these and other studies are comparable to correlations typically found in similar types of analyses, where the predictor variable is a standardized test scaled score with a large range of score points and the outcome variable is a grade point average (Kuncel and Hezlett, 2007a, 2007b). Regardless of the limitations inherent in such correlation analyses, consistently similar results found over many years suggest that the MAT continues to have value in predicting graduate program GPAs, particularly for the first year of graduate study, as well as other important academic and non-academic performances.

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