A CONSTRUCT COMPARABILITY ANALYSIS OF COGNITIVE ABILITY TESTS IN DIFFERENT LANGUAGES

by

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ABSTRACT

This research studies the construct comparability of the Woodcock-Johnson Battery – Third Edition Tests of Cognitive Ability (WJ III COG; Woodcock, McGrew, & Mather, 2001) and the Batería III Woodcock-Muñoz: Pruebas de Habilidad Cognitiva - Third Edition (Batería III COG; Woodcock, Muñoz-Sandoval, McGrew, Mather, & Schrank, in press-b), which are the English and Spanish versions of the same battery, respectively. These are measures of cognitive functioning that purport to be direct counterparts of one another. This study examined the degree of comparability and sources of incomparability of seven tests of cognitive ability that were translated from English to Spanish. The purpose of this study was to determine: (1) whether the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG were the same; (2) whether there were specific items from the selected tests of the WJ III COG and Batería III COG that function differentially for English- and Spanish-speaking examinees; and (3) whether the sources of differences in constructs being assessed for the two language groups could be identified. Answers to the research questions stated above contributed to evidence relevant for determining the comparability of the inferences based on these test scores for two different language versions. Between the two language versions of the tests, at the scale as well as the item level, the results indicated that there were different levels of psychometric similarities and differences for some of the seven tests that may jeopardize the comparability of scores from these versions.

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CHAPTER 1: INTRODUCTION

Overview

With the increase in language and cultural diversity in North America, having comparable measures of skills and abilities in different languages offers a number of benefits, including assessing students in their first language. The Woodcock-Johnson Battery – Third Edition Tests of Cognitive Ability (WJ III COG; Woodcock, McGrew, & Mather, 2001) and the Batería III Woodcock-Muñoz: Pruebas de Habilidad Cognitiva - Third Edition (Batería III COG; Woodcock, Muñoz-Sandoval, McGrew, Mather, & Schrank, in press-b) are the English and Spanish versions of the same test battery. According to the authors, these tests are direct counterparts and they measure the same constructs in each of the populations (Woodcock, Muñoz-Sandoval, McGrew, Mather, & Schrank, in press-a). Further these tests have been designed to be used in combination with one another in order to allow practitioners to compare individuals' scores when the tests have been administered in the two different languages. The present study is designed to examine the comparability of scores and the validity of inferences drawn from the two versions of these cognitive test batteries.

Problem

The assessment of cognitive ability and achievement by means of standardized, norm-referenced measures is a fact of modern society (Reschly & Grimes, 2002; Samuda, 1998). Norm-referenced assessment procedures are used to draw inferences about an individual's performance relative to a defined population of individuals or groups (e.g., their age or grade peers). Such assessment tools are helpful in determining and describing an individual's strengths and weaknesses in a particular domain, as well as assisting in classification, whether for educational classification, placement or diagnosis. The validity of interpretations based on such

assessments depends on the conceptual (i.e., the theoretical bases for the measure, how the construct is defined and operationalized), as well as the technical aspects of the test, including the appropriateness of the reference group as a basis for comparison for a particular individual. Therefore, the appropriateness of inferences based on such assessments for language minority groups, such as Spanish-speakers, is a crucial aspect of the validity of a particular measure.

Assessing any minority group or subpopulation comes with the challenge of finding an appropriate measure and drawing valid inferences from the scores obtained. Beyond the normal psychometric requirements of an assessment measure, the challenge of ensuring that the test is appropriate for the particular population must be met. For language-minority individuals, finding appropriate measurement tools requires one to consider the language of administration or language demands of test items and instructions. Historically, the choice of non-English measures has been limited, and statistical procedures to examine test properties as they pertain to minority groups were also limited, compared to today's standards. That is, test selection did not hinge on whether a measure was appropriate in terms of language; instead, test use was based on what was available. As a result, there has been a misuse of tests with non-English speaking test takers, and even inappropriate inferences or placements based on such test use, including the overrepresentation of minorities in special education (e.g., Scheuneman & Oakland, 1998).

Concerns about fair testing procedures have triggered a number of events. For example, there have been a number of court challenges to the use of cognitive functioning tests with children from sub- or minority populations, which has led to new legislation [e.g., Individuals with Disabilities Act (IDEA: 1990)], which specifically addresses issues pertaining to the selection and use of tests when investigating whether special education programming is necessary for a specific student (Scheuneman & Oakland, 1998). This law states that every child

has a right to a comprehensive assessment of the nature and degree of his or her specific disability (Flanagan, Andrews, & Genshaft, 1997), and that tests be "validated for the specific purpose for which they are used" (Scheuneman & Oakland, p. 92). Further, the development of *Standards in Educational and Psychological Testing* (American Educational Research Association [AERA], American Psychological Association [APA], National Council on Measurement in Education [NCME], & Joint Committee on Standards for Educational and Psychological Testing (U.S.), 1999) and the *Guidelines for Educational and Psychological Testing* (Canadian Psychological Association [CPA], 1987) require test developers to construct technically adequate measures, and test users to be responsible and conscientious in the way they choose and administer tests, and subsequently interpret test scores. Lastly, *The Code of Fair Testing Practices in Education* (Joint Committee on Testing Practices, 1988) addresses the roles of test developers and users, and states the major obligations of each of these bodies. The Code presents standards for educational test developers and users in four areas: developing and selecting tests, interpreting scores, striving for fairness, and informing test takers. Moreover, the APA Ethical Principles of Psychologists and Code of Conduct (APA, 2002) lists ethical standards (enforceable rules for conduct as psychologists) for test construction (Standard 9.05) and interpretation of assessment results (Standard 9.06) requiring psychologists to "use appropriate psychometric procedures and current scientific or professional knowledge for test design, standardization, validation, reduction or elimination of bias, and recommendations for use" (p. 1072), as well as consider characteristics of the person being assessed that affect the accuracy of test interpretations, including linguistic differences. Each of these resource guidelines emphasizes the importance of a number of critical issues associated with appropriate test development and use.

The research presented here is a construct comparability study designed to examine the equivalence of results from cognitive ability tests administered in two languages. Specifically, this study focused on the Woodcock-Johnson Battery – Third Edition Tests of Cognitive Ability (WJ III COG; Woodcock, McGrew, & Mather, 2001) and the parallel Spanish version, the Batería III Woodcock-Muñoz: Pruebas de Habilidad Cognitiva - Third Edition (Batería III COG; Woodcock, Muñoz-Sandoval, McGrew, Mather, & Schrank, in press-b). It is important to investigate the construct comparability for these measures for at least three reasons. First, because the language of administration is different, there are reasons to expect that there might be differences in the psychometric properties of the test. Are the ideas and content translatable? Was the translation process done well? Second, and more importantly, while such measures are administered in two different languages and the target populations for use are also different, the types of inferences that are drawn are the same and are intended to be used in the same context. For example, in an educational setting one or the other test will be chosen for assessment purposes to match the language spoken by the student. The consequences based on the respective scores will be the same; this assumes that a score of x on the WJ III COG is equivalent to a score of x on the Batería III COG. But what are the implications if these scores are not equivalent? Lastly, demonstrating that a measure provides useful and meaningful inferences based on test scores for individuals and groups and across settings or contexts is an ongoing empirical question (Messick, 1995).

Purpose of Study and Research Questions

This study begins the investigation of the construct comparability of the WJ III COG and the Batería III COG, which are English and Spanish versions of the same battery, respectively. The research presented here represents a first step toward determining the degree of

comparability of these measures, because no other studies investigating this question have been conducted. Using statistical as well as qualitative evaluations this study examined the degree of comparability and sources of incomparability of seven tests of cognitive ability that were translated from English to Spanish. The three research questions for this project were:

1. Are the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG the same? Are the test items in each test related to each other and the overall construct being assessed in the same way for both language versions?
2. Are there specific items from the selected tests of the WJ III COG and Batería III COG that may be functioning differentially between English- and Spanish-speaking examinees? Are there items that are easier or more difficult for examinees from a particular language group (when matched on ability)? If so, which items are they?
3. What are the sources of differences in constructs being assessed for the two language groups? Are there item characteristics that might be associated with the differential functioning of the items? Are there problems associated with translation of the items?

By examining the comparability of the WJ III COG and the Batería III COG, this study identified unique issues in the comparability of these two language versions. Further, this study contributes to evidence about the validity of the comparisons between these two measures, generating information important to understanding and using the English and Spanish versions of these widely used cognitive ability tests. Finally, the current study exemplifies a sophisticated approach to comparability assessment that may be employed with other translated measures.

Preview of Chapter II

Recent advances in test development have provided professionals with assessment options that previously did not exist, including tests available in other languages (Alvarado, 1999). Today there exist a number of translated tests that compare individual or group performance across languages and cultures. However, it cannot be assumed that the psychometric properties of a translated test are the same as the "original" version. In fact, the translated test is going to have its own unique psychometric properties, and the degree to which the test is comparable to the "original" version is an empirical question. The literature that will be presented as part of the foundation for this research project will focus on issues and considerations about establishing the degree to which inferences based on test scores from WJ III COG and Batería III COG are comparable.

CHAPTER II: LITERATURE REVIEW

Standards for Test Development and Test Use and Issues of Validity

Developments in the educational measurement field, including advances in statistical procedures and methodologies, as well as theoretical views of what constitutes "good measurement" and how one demonstrates that, has pushed test developers and users to build instruments with good psychometric qualities and be thoughtful about assessment procedures, respectively. In this section, literature about what constitutes a "good" test and testing practices, as outlined by major theorists in the measurement field will be presented, as well as related standards and guidelines as put forth by national organizations in measurement, education, and psychology. This section highlights the importance of developing and selecting measures with good psychometric qualities, interpreting scores, and fairness in testing practices.

Validity as a Unitary Construct

The work of Samuel Messick (1989a; 1989b; 1995) has been seminal in furthering how validity is conceptualized and demonstrated. Traditionally, validity was evaluated by investigating and demonstrating three separate and distinguishable types of validity; content, criterion, and construct validity. Messick (1989a) criticized this fragmented and incomplete view and, instead, presented a unified concept of validity that integrates both the social meaning and social values in test interpretation and test use into a comprehensive theory of construct validity. Further, this comprehensive theory was to be used as a general criterion with which to make an overall evaluative judgment of the degree to which evidence (empirical and theoretical rationales) support the adequacy and appropriateness of the inferences and actions based on test scores (1989a). In this way, rather than investigating and presenting compartmentalized types of validity, Messick called for an evaluative summary of evidence for the actual, as well as

potential, consequences of score meaning and utility. Furthermore, Messick's view focused on the validity of the *meaning* or *inferences* of the test scores, rather than validity as a property of the test, because scores are a function of the items, but also the examinees and the context of the assessment.

Messick (1989a) conceptualized the construct of validity to be a unitary concept and encompass evidence and rationales to support the interpretations of scores in terms of explanatory concepts that address both test performance and score relationships with other variables. For this, he presented a framework that contains six distinguishable aspects that highlight the central issues implicit in the notion of validity as a unified concept. These aspects of construct validity were: *content, substantive, structural, generalizability, external* and *consequential*. With these six aspects of construct validity Messick (1995) maintains that, together, they provide a means to address the "multiple and interrelated validity questions that need to be answered to justify score interpretation and use" (p. 746). Further, most score-based interpretations and action inferences either "evoke these properties or assume them, explicitly or tacitly" (Messick, 1995, p. 747).

Messick (1995) identified two threats to construct validity that can occur in all assessments. The first threat occurs when the assessment's design is too narrow and does not include important dimensions of the construct, called *construct underrepresentation*. The second threat occurs when the assessment's design is too broad and includes reliable variance irrelevant to the interpreted construct, called *construct-irrelevant variance*. There are two types of construct-irrelevant variance; *construct-irrelevant difficulty* and *construct-irrelevant easiness*. It is *construct-irrelevant difficulty* for "individuals and groups that can be a major source of bias in

test scoring and interpretation and of unfairness in test use" (Messick, 1995, p. 743) and which differential item functioning methods are used to identify.

Messick's notion of a unitary concept of construct validity, in which an evaluative judgment of the validity of the inferences of scores is drawn, provides a useful and practical means with which to ascertain the degree of construct comparability between two measures. This framework provides a foundation for specific procedures and statistical methods to investigate the available aspects of construct validity in order to evaluate and determine the degree to which the inferences based on scores are valid. It is this conceptualization of validity that is the foundation for the selection of procedures and types of evidence that are investigated within this study.

The Standards for Educational and Psychological Testing

Messick's work delineates a theoretical framework in which construct validity is construed as a unitary concept, where facets of evidence are accumulated to develop a scientifically sound argument about the adequacy and appropriateness of inferences and actions based on test scores. His conceptualization of construct validity has been accepted as state of the art, so much so that the *Standards for Educational and Psychological Testing*[1] (AERA et al., 1999), the recognized authority on educational testing, have produced a practical guide for test development and test use in which the section that speaks to validity is modeled after his approach. While the *Standards* (AERA et al.) also include information and guidelines about other important and fundamental testing issues, what follows is a summary of the pertinent information contained with respect to validity and in relation to the research presented herein.

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[1] For brevity, I will henceforth refer to them as the *Standards*.

The *Standards* (AERA et al., 1999) present five sources of validity evidence, each of which is presented and briefly described. One source of validity evidence is providing logical or empirical analyses between the *test's content* and the construct it is intended to measure. Examining the processes that an examinee uses when responding to an item or set of items is another source of validity evidence. Investigating *response processes* usually comes from analyses of individual responses and can provide evidence of the degree of fit between the construct and the anticipated responses, and the actual responses. Investigating the *relationship of test scores to external variables* (i.e., a criteria variable, other test scores) is another source of validity evidence. For this, analyses seek convergent and discriminant evidence (how test scores relate to other measures of similar and dissimilar constructs). In other words, what is their accuracy in predicting a criterion performance, or generalize a test-criterion performance to a new situation? Validity evidence concerned with the intended and unintended *consequences of testing* involves distinguishing between evidence that relates directly to validity issues and those of social policy. Lastly, analyses of the *internal structure* of a test provide evidence about the degree to which the relationships among the test items and test components conform to the construct of interest. The nature of how the test will be used determines the specific types of analysis and their interpretations. For example, whether it is important to provide empirical evidence about the unidimensional nature of a measure, or confirm that items increase in difficulty within a test component, or show whether items function differently for different subgroups, will dictate the appropriate analyses, as well as provide the context for interpretations. Another acceptable approach to investigating this source of validity evidence is to use qualified experts that can evaluate the representativeness of the chosen items. This source of evidence can be important, particularly when addressing questions about differences in the

interpretation of test scores across examinee subgroups. For example, the use of qualified experts can help identify whether construct underrepresentation or construct irrelevant components advantaged, or disadvantaged, one or more of the examinee subgroups.

The *Standards* (AERA et al., 1999) also include information and guidelines about fairness in testing and test use. The term fairness can be used in multiple ways. *Fairness* can be described in relation to equitable treatment in the testing processes. That is, fair treatment of examinees requires consideration of the test, as well as the context and purpose of testing and the manner in which the test scores will be used. This would include that all examinees be given an opportunity to demonstrate their standing on the construct the test is intended to measure. The *Standards* (AERA et al.) also relate fairness to the *lack of bias,* where bias represents the situation in which deficiencies in a test, including construct-irrelevant components, or the way it is used, results in different meanings for scores earned by different identifiable groups (AERA et al.). Evidence for the potential sources of bias may be sought through: (a) the comparison of the internal structure of test responses for different groups (i.e., Differential Item Functioning) in order to determine whether the response patterns for members of different groups, matched on ability, is the same or different, (b) judgmental reviews to follow up Differential Item Functioning (DIF) in order to examine test content for explanations for statistical difference based on language, level of familiarity, etc., and (c) the comparison of the internal structure of the test responses for different groups of examinees (i.e., factor analysis) in order to determine whether the construct being measured has the same underlying dimensions for both groups.

With respect to *translated or adapted* tests, two of the standards seem especially relevant, and are central in providing a framework for the proposed study. Standard 9.7 states the need to provide "empirical and logical evidence for score reliability and the validity of the translated

test's score inferences for the intended uses" (AERA et al., 1999, p. 99). Standard 9.9 relates to the comparability of multiple language version of a test, and states the importance of reporting evidence that "the different language versions measure equivalent or similar constructs, and that the score reliability and the validity of inferences from scores from the two versions are comparable" (AERA et al., 1999, p. 99). Further, the *Principles for Fair Student Assessment Practices for Education in Canada* (1993), a set of principles and guidelines related to fair assessment practice within the Canadian education context, state that developers should provide evidence that an assessment method translated into a second language is valid for use with the second language, as well as provide evidence of the comparability of different instrument forms.

As with Messick (1989a; 1989b; 1995), the *Standards* (AERA et al., 1999) clearly articulate that validity is the degree to which a coherent integration of various pieces of evidence supports the intended inferences of test scores for specific uses. This argument can then be the bases for refinement, revisions, or suggestions about areas of further study. Taken together the work of Messick and the guidelines set out by the *Standards* (AERA et al.) provide both a theoretical and practical framework from which to base the procedures and methodologies of this research study in order to evaluate the comparability of the WJ III COG and the Batería III COG.

Construct Comparability

Increasingly, educational and psychological tests are being translated in order to compare individual or group performances across languages and cultures for the purposes of cross-cultural research, international research programs, comparing the proficiency of a bilingual student's first and second language abilities, and in order to test students in their first language (Woodcock & Muñoz-Sandoval, 1993). But how does one determine whether or not inferences based on translated test scores mean the same thing as scores from the original measure? This section

presents and reviews research in the area of construct comparability and equivalence, including the procedures and methods used to determine the degree to which measures are comparable, as well as research results that provides insights on the degree and the types of problems that can occur with test translations. Presently, published research results from construct comparability studies are sparse, because this is an emerging area of study. Guidelines proposed in the early nineties (i.e., Geisinger, 1994; Hambleton, 1994), including the Guidelines for Adapting Educational and Psychological Tests, developed by the International Test Commission (summarized by Van de Vijver & Hambleton, 1996) review problems related to translating and adapting tests and provide suggestions for maximizing construct equivalence across languages. These guidelines were developed because "technical literature for guiding the test translation and adaptation process appeared to be incomplete at the time and scattered through a plethora of international journals, reports, and books – and there was substantial evidence that current practices were far from ideal" (Hambleton, 2001, p. 164). Further, while complex measurement methods (e.g., item response models) appeared to be useful for establishing the equivalence of scores from different language versions of tests, these methodological advances were not being used (Hambleton, 2001; Hulin, 1987; van de Vijver & Leung, 1997). Included in these guidelines are requirements that test developers (or researchers) apply appropriate statistical techniques to establish the equivalence of the different language versions of the test and identify problematic components or aspects of the test that may bias the test for one of the language groups (e.g., factor analysis and DIF procedures). The research presented below provide examples of the type of research that these guidelines call for, and mark what is sure to be the beginning of a growing body of literature.

Establishing Construct Comparability

The research presented here investigates three aspects of construct comparability. The first aspect relates to the structure of the construct for which statistical evaluations (i.e., factor analysis) are required as evidence of construct equivalence. A second aspect of construct comparability is to determine that items function similarly in both the translated, or adapted, and source language versions of the test (Hambleton, 2002). This is accomplished through the statistical evaluations of DIF. The third and final aspect of construct comparability is concerned with why items are performing differently between groups. The following sections present research that addresses these aspects of construct comparability.

Statistical Evaluations of Construct Equivalence

There are two main reasons to investigate the structural equivalence of translated tests between language groups. First, as part of the determination of construct equivalence, evidence that that the construct is represented and measured the same way in both languages is necessary (Hambleton & Patsula, 1998) . In other words, it is important to demonstrate that the test is measuring the same thing in both languages. And second, the item level investigation of translation effects, or differential item functioning analyses, uses a total score as the matching criteria, and in order to use this total score construct bias must be ruled out (Sireci & Allalouf, 2003).

Allalouf, Hambleton, and Sireci (1999) investigated the equivalency of different language versions of the verbal subtests of the Psychometric Entrance Test (PET), a high stakes test used for admissions to universities in Israel. As part of their study they included analyses investigating the structural equivalence of the verbal subtest scores across two language groups, differential item functioning, and a review panel of translators to analyze the type and content of identified

DIF items to discover the potential causes of DIF. Details of the dimensionality analysis are presented in Sireci, Xing, Bastari, Allalouf, and Fitzgerald (1999). Exploratory factor analysis (EFA), Multidimensional Scaling (MDS), and Confirmatory Factor Analysis (CFA) were used to evaluate the structural equivalence of four of the five content areas composing the Verbal Reasoning subtest of the Hebrew and Russian language versions. Results from the EFA suggested that there were five factors for the Hebrew version and six for the Russian version. For both the Hebrew and Russian data, separate factors corresponded to each of the four content areas, however each data set required two factors for the reading comprehension content area (corresponding to two different reading passages). Further, the Russian data required two factors for the analogy content area, one for items related to vocabulary analogies, and the other for "logic-type" analogies. Using MDS, a five-dimensional solution best represented the data, with the first three dimensions essentially representing the content areas, and the last two dimensions segregating two sets of logic items from one another, and logic items from sentence completion. For the CFA, four separate four-factor models were fit to the data, with the factor loadings for the items specified in accordance with their content areas. All models produced goodness-of-fit indices of about .96, suggesting reasonable fit to the data. The researchers concluded that the structural analyses are complimentary, and in general support the conclusion that the content structure of the PET was similar across the Hebrew and Russian versions of the test. The differences in the factor structure of the EFA were thought to be related to the presence of a large degree of differential item functioning across the two language versions (discussed subsequently).

Statistical Evaluations of DIF

Research on test translation and adaptation supports that there are indeed problems associated with translating tests into other languages. In this section, research as it relates to the comparability of test items across different groups is presented. One of the methods used in examining construct comparability in multiple language versions of assessments is differential item functioning (DIF) analyses. DIF represents a set of analyses that attempts to sort whether group differences are the result of item impact or item bias (AERA et al., 1999). In other words, are differences in performance between groups the result of true group differences or is there construct-irrelevant variance present that biases one group over the other? Items are said to be functioning differentially for different groups when examinees from one group have a different probability or likelihood of answering an item correctly when matched on ability. The research presented below highlights that the amount of DIF on some translated tests is large.

Allalouf et al.'s (1999) investigation of the different language versions of the verbal subtest of the Psychometric Entrance Test (PET) included a statistical examination of DIF. The verbal subtest of the PET contains multiple-choice items of various types, including: analogies, sentence completion, logic and reading comprehension. This 125-item subtest was developed in Hebrew and translated into a number of languages; however Allalouf et al. only report results that compare a Russian translation to the original Hebrew version. Sample sizes for the two language groups ranged from 1,485 to 7,150 for examinees who took the Russian and Hebrew test versions, respectively. DIF results using the Mantel-Haenzsel procedure (Holland & Thayer, 1988) indicated that 34% of the items exhibited moderate or large amounts of DIF. DIF was found most frequently in analogy questions and sentence completion questions. Low levels of DIF were found for the logic and reading comprehension items.

Ercikan (1998) examined the equivalence of test items and the comparability of scores from tests in different languages using different large-scale assessment measures. First, using assessment data from the 1984 International Association for the Evaluation of Educational Achievement (IEA) Science Study (Population 2, 14-year-olds), Ercikan compared 70 common items of the English- and French versions of this test with Canadian students. The sample sizes were 5,543 students and 2,358 students for the English and French language groups, respectively. Of the common items, 26% were identified as displaying DIF. The second large-scale assessment measure Ercikan investigated was the International Assessment of Educational Progress (IAEP) conducted by Educational Testing Services (ETS) in February 1988. This set of analyses focused on a French-speaking Quebec sample and an English-speaking American sample of 13-year old students who were administered this mathematics and science achievement test (60 items were common to the different language versions). The DIF analyses, completed using the Mantel-Haenzsel (Holland & Thayer, 1988) procedure, indicated that 47% of items displayed DIF, which is 26% more than the results from the IEA study. Ercikan suggested possible explanations for the differences in the proportion of DIF items for the two groups. One explanation was differences between comparison groups, with the IEA comparing two language groups (English and French) both from Canada, whereas the IAEP study compared the same language groups, although the English-speakers were from the US and the French-speakers were from Canada. As a result, the curricula and cultural differences are likely to be greater for the IAEP study than the IEA study. Another explanation concerned the quality of the translation processes for the different studies, possibly contributing to the finding a higher percentage of DIF items in the IAEP study.

In a later study, Ercikan and McCreith (2002) investigated the effects of test adaptations on the comparability of English and French versions of the Third International Mathematics and Science Study (TIMSS: Martin & Kelly, 1996). This is an international assessment that surveyed 13-year-olds students' mathematics and science achievement in 45 countries; however, the focus of the investigation of item equivalence was on the English and French versions of the test. Four countries (England, Canada, France, and the US) allowed for 3 sets of comparisons between the English and French versions of items (i.e. England vs. France, US vs. France, and English and French administrations in Canada), as well as comparing the English and French versions when cultural differences were expected to be minimized (i.e., English and French administrations in Canada). By completing three sets of comparisons the consistency, or replication, of DIF could be examined. That is, if DIF was replicated in two or more comparisons, the authors suggested that this provided evidence to support that differences might be due to translation related problems, rather than curricular or cultural differences.

Analyses included 154 to 156 mathematics items and 139 to 149 science items (the number of items varied depending on the countries used in the comparisons), with sample sizes ranging from 2,935 to 10,945 for the various language and country administrations. Results from the Linn and Harnisch (LH) (1981) DIF detection procedure indicated that there were large numbers of items identified as DIF. For mathematics, 14% to 59% of the items were identified as DIF, with far fewer DIF items for the Canadian English and French comparison (14%), than either the US-France (59%), or England-France comparison (39%). For science, 37% to 65% of the items were identified as DIF, with far fewer DIF items for the Canadian (37%) and England-France (39%) comparison, than the US-France (65%) comparison.

In yet another study Ercikan, Gierl, McCreith, Puhan, and Koh (in press) used data from the English and French versions of Canada's national examination, the School Achievement Indicators Program (SAIP). SAIP is used to assess 13- and 16-year old students in the areas of Language Arts, Mathematics, and Science. Specifically, Ercikan et al. present DIF results for the Mathematics, Reading, and Science assessments for each of the two age groups. The range of sample sizes for the various assessments for the 13-year-old samples was 3,230 to 9,029 and 1,097 to 3,509 for the English- and French-speakers, respectively, and for the 16 year-old samples was 2,296 to 8,263 and 904 to 2,719 for the English- and French-speakers, respectively. Analyses of the Reading assessment (22 items) focused on only the multiple-choice questions (the only questions that were comparable across different language versions of the test). However, the Mathematics (125 items) and Science tests [students completed two out of three forms; everyone completed Form A (12 items), and based on the results from this form students were directed to complete either Form B (66 items) or Form C (66 items)] contained both multiple-choice and constructed response questions that had been translated or adapted into another language. To verify and confirm DIF results, Ercikan et al. used two DIF detection methods to identify items in Reading and Science (the multi-stage administration design for Mathematics created a sparse data matrix that was not compatible with one of the chosen DIF detection methods). These methods were LH (Linn & Harnisch, 1981) and Simultaneous Item Bias Test (SIBTEST; Shealy & Stout, 1993).

The degree of DIF detected varied with subject area. For Reading, 36% (32%)[2] and 45% (41%) of the items were identified as DIF for the 13- and 16-year-old students, respectively. For Mathematics 38% and 32% of the items were identified as DIF for the 13- and 16-year-old

[2] Linn-Harnisch results are presented first, and SIBTEST results are presented in parentheses.

students, respectively. Lastly, across all three science forms, 55% (38%) and 48% (35%) of the items were identified as DIF for the 13- and 16-year-old students, respectively.

In another illustration of this type of research, Gierl and Khaliq (2001) used test results from a Mathematics and Social Studies Achievement Test administered in Alberta. In this study 3,000 English and 2,115 French Immersion students were randomly selected from 38,000 English and 3,000 French Immersions students at two grade levels, 6 and 9. English-speaking students represented students who were receiving instruction in English, whereas French Immersion students represented students who were receiving instruction in French, but for whom French was not there first language. The Grade 6 version of the test contained 50 multiple choice mathematics questions and 50 multiple-choice social science questions. The Grade 9 version of the test contained 43 multiple-choice mathematics questions and 55 multiple-choice social science questions. Gierl and Khaliq report that 14% and 21% of the Math Achievement test were identified as DIF for the Grade 6 and 9 students, respectively, whereas 58% and 31% of the Social Studies Achievement test were identified as DIF for the Grade 6 and 9 students, respectively.

The results of the studies presented above demonstrate that translation DIF spans different assessment measures, content areas, language and age groups, and that the degree or presence of DIF can be large. There are, however, some differences in the pattern of results (i.e., the degree of DIF for similar content areas varies between studies). Potential reasons for differences could include quality of translations between the different assessment programs, and sample selection procedures, neither of which is under the control of the researchers completing research with these data sets. Another possible reason could be the sensitivity to detect DIF of the different DIF detection methods. For example, while the DIF procedure of Mantel-Haenzsel

(Holland & Thayer, 1988) is a popular DIF method, it only detects *uniform* and not *non-uniform* DIF, and therefore DIF results may be an under estimate of the amount of DIF items, whereas the LH procedure (Linn & Harnisch, 1981) can detect both uniform and non-uniform DIF.

The most basic premise of construct comparability research is to investigate the degree to which *inferences* based on test scores are valid. The research reviewed communicates that the degree of DIF is large, but what does this mean in terms of test scores and inferences? Ercikan (1998) provides an illustration about the impact of DIF on the comparability of scores for the IEA study. Differences in the total number-correct scores because of DIF were calculated for each language group by examining the differences in item difficulties (item *p*-values) for the two groups, conditioned on ability level. Results suggest that high level DIF items could lead to 0.32 to 1.28 number correct score points in favour of the English-speaking group and 0.16 to 0.64 number correct score points in favour of the French-speaking group. Ercikan states that these differences seem small for a 70-item test, but that indeed these differences could lead to different rankings of countries in international comparisons.

The information presented above illustrates that DIF is indeed present in translated and adapted tests. However, the identification of DIF provides no information about why these items are a problem. In the following section, research results investigating the *sources* of DIF are presented.

Qualitative Evaluations of DIF

The process of a judgmental review of items is to discover why items are performing differently between groups, whether that be to identify problems made during the translation process, or identify cultural or educational differences between groups that cause performance differences, or to establish guidelines or procedures that will inform future translations or

adaptations. What follows is a presentation of research on the use and results of judgmental review procedures used for the purposes of establishing construct comparability.

As part of their investigation of the equivalency of different language versions of the verbal subtest of the Psychometric Entrance Test (PET), Allalouf et al. (1999) used a two-stage procedure for identifying possible causes of DIF. First, a blind review of 60 items (42 of which were identified as DIF items) by a panel consisting of five Hebrew-Russian translators was completed, where the panel predicted for each item whether it displayed DIF, which group did the item favour, the degree of DIF (moderate or large), and potential causes of DIF. Secondly, in a committee review session, which included the five translators as well as three Hebrew researchers, the DIF results were shared with the translators, and translators were asked to defend their predictions and causes for DIF, and then reach consensus about the causes of DIF for each of the 42 items.

Based on the reviews by the translators as well as the consensus committee four main causes for DIF were identified. These were, (1) changes in difficulty of words or sentences, (2) changes in content (the meaning of the item changed in translation), (3) changes in format (one language version of the sentence is much longer), and (4) differences in cultural relevance (the translation was appropriate, however the content of the item interacted with culture).

Gierl and Khaliq's (2001) substantive procedures to investigate potential sources of DIF used a Mathematics and Social Studies Achievement Test administered in Alberta. The substantive analysis began with an 11-member review committee consisting of bilingual and monolingual test translators and test developers, psychometricians and directors for test development reviewing the English and French versions of items identified as DIF from the previous years administration of the Grade 6 Mathematics and Social Studies Achievement Test.

The committee, which was blind to the DIF status of items, was asked to identify any translation problems or differences, describe the source of the difference, and specify the direction of DIF (i.e. which group would the item favor) for each item. Discussion continued until there was consensus on each of these three points. Four different sources of differences were identified by this panel: (1) omissions or additions of words, phrases or expressions that affected meaning, (2) differences in words or expressions inherent to language or culture, (3) differences in words or expressions *not* inherent to language or culture (these were differences that appeared to be linked to poor choices in the translation process), and (4) format differences (for example, differences in punctuation, typeface or item structure). These sources were then validated by another review of DIF items. This time, items from the 1997 Mathematics and Social Studies Achievement Test, which were statistically flagged as DIF, were reviewed by translators, first independently, using the sources of translation generated by the 11 person committee, and then together to discuss and reach consensus on the items where there were disagreements.

The overlap between the categories developed by the review committee in the study completed by Gierl and Khaliq (2001) and those presented in Allalouf et al. (1999) is considerable, and noted by the authors. However, there are some differences in how sources of differences were categorized. For example, in Gierl and Khaliq (2001) the second identified source of DIF includes language differences *and* cultural differences, which Allalouf et al. have separated into two categories (change in word difficulty and differences in cultural relevance). These similarities, and differences, suggest that there exists some notable common sources to translation problems, but that there exists nuances to how independent reviewers "label" differences. This area of research is in its infancy in terms of developing methods around

conducting reviews to determine sources of DIF. A clearer understanding of translation DIF, as well as procedures to investigate it would benefit from clear operationalized categories.

Ercikan (1998) examined the 18 items (26% of the total test) that were identified as displaying DIF from the assessment data from the 1984 International Association for the Evaluation of Educational Achievement (IEA) Science Study (Population 2, 14-year-olds), for potential causes of DIF using guidelines to help with translations to English proposed by Brislin, Lonner and Thorndike (1973). The eight observations cited as possible causes for DIF reflect similar results as Allalouf et al. (1999), in that problems with translations were linked to changes in difficulty of words or sentences, changes in content, and changes in format. Of the 18 identified DIF items, eight had explanations related to translation problems.

Ercikan and McCreith's (2002) investigation of translation effects on the comparability of English and French versions of the TIMSS (Martin & Kelly, 1996) employed three strategies to identify the sources of DIF. One strategy was to use a judgmental review process, whereby four translators bilingual in English and French examined the two language versions of the test for potential differences. If differences were identified, the translators would evaluate the degree to which the differences would change the meaning of the item. Further, these translators were used to interpret differences that were identified to be differentially functioning.

In the review of all items by the translators they identified 22% (64 items) of the total number of items (mathematics and science) as having problems related to translation. The types of problems described included differences in the specificity of the vocabulary, the clarity of the questions statement, vocabulary difficulty, clues that were expected to guide examinee thinking processes, and the number of words in an item (item length). Of these 64 items, 34% were flagged as DIF in the Canadian comparison. In other words, of the items flagged as having

potential translation problems, approximately a third of them were identified as functioning differently for the two language groups.

The judgmental review and investigation of translation and curricular interpretations of DIF suggest that 17% (4 items) of the mathematics items and 27% (14 items) of the science items flagged as DIF had translation related interpretations, while 17% (4 items) of the mathematics items and 13% (7 items) of the science items flagged as DIF had curricular related explanations. This leaves a large portion of DIF items that could not be attributed to translation related or curricular differences.

In their examination of the English and French versions of the Reading, Mathematics and Science test of SAIP, Ercikan et al. (in press) had four bilingual French-English translators complete a blind review of the items for identifying potential sources of DIF and adaptation problems. Reviewers were required to identify differences between the two language versions, as well as make judgments regarding whether the differences were expected to lead to performance differences for the two language groups as well. The review process consisted of three stages: (1) group review of sample of items to discuss and understand criteria involved in reviewing the items; (2) independent review of each item by four reviewers; and (3) group discussion and consensus for rating adaptation differences between the two language versions of the items. Form A of the Reading items, a random sample of Mathematics items, which included all Mathematics DIF items, and all of the Science items were reviewed. The results of the review process indicated that all of the Reading DIF items were identified to have adaptation related differences; for Mathematics, nine (35%) of the common 26 DIF items for both age groups were identified to have adaptation related differences and 45% to 54% (depending on the age group) of the DIF items were interpreted to have adaptation related differences. In other words, the

review of the different language versions identified 35% to 100% of DIF items to have differences due to adaptations in the three content areas and across two age groups.

The presentation of the above research point out that there are common problems that can occur in the process of translating a test to another language and that, in addition to being statistically identified, a review panel can also identify these problems. Moreover, when identified by a panel of reviewers, the information about the source of the problems is potentially identified, and as a result can be rectified.

Summary

The research results presented in this chapter illustrate that when investigated, the degree of construct comparability between translated tests can be quite low. Further, given the consensus on the value of construct comparability research, the theoretical underpinnings of Messick (1989a, 1989b, 1995) and the requirements of the *Standards* (APA et al., 1999), beginning to investigate the psychometric properties and the comparability of the WJ III COG and the Batería III COG is warranted. Further this review highlights the important psychometric aspects that need to be investigated when determining the degree of comparability between translated measures, as well as the appropriate methods with which to complete this investigation. Hence, the purpose of this study was to investigate the structural equivalence, item level equivalence, as well as evaluate the qualitative equivalence of seven tests of cognitive ability from these measures. As outlined in the next chapter, these investigations and evaluation were completed using factor analytic methods, item response theory analyses, including differential item functioning, as well as a judgmental review of items and instructions.

CHAPTER III: METHOD

As shown in the previous chapter, a number of different methodologies have been used to investigate the psychometric properties and comparability of translated achievement tests. However, these methods have yet to be used to examine the construct comparability of different language versions of cognitive ability tests. In this chapter, the measures, data sources, and test analysis models, as well as their respective procedures are described. It includes information about the measures and the specific tests that are the focus of this study, including technical properties, task descriptions, and the translation process. Further, the procedures and analyses performed are described. The four-stage procedure used for addressing the research questions is outlined, and information about each stage and the analyses performed is documented. The selection of procedures was based on theoretical conceptions of validity, and accompanying methods used to establish validity, the *Standards* (AERA et al., 1999), as well as guidelines and previous research results related to establishing construct equivalence between translated and/or adapted tests. The purpose of this study was to determine: (1) whether the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG were the same; (2) whether there were specific items from the selected tests of the WJ III COG and Batería III COG that function differentially for English- and Spanish-speaking examinees; and (3) whether the sources of differences in the constructs being assessed for the two language groups could be identified.

Measures

The WJ III COG and the Batería III COG are individually administered measures of cognitive functioning aligned with a stratified model of intellectual abilities defined and refined by Cattell, Horn, and Carroll, referred to as CHC theory of cognitive abilities, and therefore

share the same complex structure (Woodcock et al., 2001; Woodcock et al., in press-a). CHC theory is based on two major sources of research on the structure of human cognitive abilities, (a) *Gf-Gc* theory (Horn & Cattell, 1966), and (b) Carroll's three-stratum theory (1997).

The Batería III COG was developed as the Spanish version parallel to the WJ III COG; the tests included in the Batería III COG are translated or adapted Spanish versions of the WJ III COG tests. The test authors claim that the information from these tests, including an individual's score on both tests, can be directly compared because the Batería III COG has been equated to the WJ III COG (Woodcock et al., in press-a). That is, tasks underlying each Spanish test are rescaled, or equated, to the WJ III COG according to the empirical difficulty of counterpart tasks in English (Woodcock et al.). In other words, the performance of subjects on the Spanish version of the test is equated to corresponding levels of ability and difficulty on the English version of the test.

The WJ III COG, and hence the Batería III COG, are designed to measure general and specific cognitive functions. Each of these test batteries is comprised of 20 tests divided equally between a standard and extended battery. With the revision of the WJ III COG and the Batería III COG in 2001 and 2004, respectively, a number of new tests were added to these test batteries, two of which are included in this study: *Decision Speed* and *Rapid Picture Naming*.

A number of derived scores are available with the WJ III/Batería III scoring system including, grade and age equivalents, percentile ranks, discrepancy scores, and scores reported on various scales developed for the WJ III. In addition, two indices of general cognitive functioning (i.e., intelligence) by means of the General Intellectual Ability (GIA) score and the Brief Intellectual Ability (BIA) score are provided.

Selection of Tests

All of the tests included on the Batería III COG have been either translated or adaptated from the original versions of the tests on the WJ III COG (Woodcock et al., in press-a). There is a clear distinction between a *translated* and *adapted* test. For test translations, the item(s) remains exactly the same, and only the directions are translated from English to Spanish; whereas for test adaptations, the item(s) have been altered in some way (Woodcock et al.). For the purposes of this study, the focus was on 7 of the 10 common tests that were *translated*[3]. Translated tests were chosen so that for each test every item would be comparable. This would not have been the case had the adapted tests been chosen, because for these tests the items were changed in some way. For instance, all of the stimuli for *Auditory Attention* are different between the two languages (Woodcock et al., in press-a), and hence item level comparisons are not possible. At the outset of this project, the Batería III COG was unpublished and completing collection of the calibration data, and access to the materials was not possible until a research agreement had been made between the researcher and test authors and publisher. As such, it was impossible to determine the degree of adaptation, and hence the degree with which the two language versions for these tests would be comparable. Thus, a criterion for test selection was if the test was translated.

The number of tests to be investigated was limited from 10 for several reasons. First, there were limitations regarding the availability of some of the data from the test publisher. Specifically, data from the WJ III COG was unavailable for the *Pair Cancellation* test. This test

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[3] The tests were identified as translated or adapted by the test author (Muñoz-Sandoval, personal communication, September 13, 2002).

was introduced late in the project and the overall sample size was small, as well as the scoring and scaling was handled slightly differently when compared to the Batería III COG (K.S. McGrew, personal communication, February 3, 2004). Second, it was decided to exclude *Numbers Reversed* as part of this research study. This decision was based on the nature of the stimuli, which is auditory. For all the other tests that are included in this study, the presentation of stimuli is visual. Lastly, *Planning* was excluded from this project because of its unique scoring scheme. For this test, *number of errors* are scored and used to determine a person's ability. That is, a score on this test represents the number of incorrect responses. This would present unique challenges for data analyses that were deemed beyond the scope of this project, and as such, this test was excluded from this study.

A complete list of tests and the format of the stimuli and response required of the test, as well as what the tests purport to measure is presented in Tables 1 and 2.

Table 1

Stimulus and Response Required for the Translated Tests of the WJ III COG and Batería III COG[4]

Test	Stimuli	Response Required
Spatial Relations	Visual (drawings)	Oral (letters) or motoric (pointing)
Concept Formation	Visual (drawings)	Oral (words)
Visual Matching	Visual (numbers)	Motoric (circling)
Picture Recognition	Visual (pictures)	Oral (words/letters) or motoric (pointing)
Analysis-Synthesis	Visual (drawings)	Oral (words)
Decision Speed	Visual (pictures)	Motoric (circling)
Rapid Picture Naming	Visual (pictures)	Oral (words)

[4] Table modified from information presented in the WJ-III COG Technical Manual (McGrew & Woodcock, 2001).

Table 2

Task Description of the Translated Tests for the WJ III COG and Batería III COG[5]

Test	Test Requirement
Spatial Relations	Measures the ability to visually match and combine shapes. The subject must identify and select from a series of shapes, the component parts to construct a whole shape.
Concept Formation	Measures the ability to identify, categorize, and determine the rule for a concept about a set of colored geometric figures when shown instances and non-instances of the concept. This is a "learning" test with corrective feedback and reinforcement of correct answers provided to the subject.
Visual Matching	Measures the ability to rapidly locate and circle the two identical numbers in a row of six numbers. The task proceeds in difficulty from single-digit numbers to triple-digit numbers.
Picture Recognition	Measures the ability to recognize a subset (1 to 4) of previously presented pictures within a field of distracting pictures.
Analysis-Synthesis	Measures the ability to analyze the components of an incomplete logic puzzle and identify the missing components. This is a "learning" test with corrective feedback and reinforcement of correct answers provided to the subject.
Decision Speed	Measures the ability to rapidly scan a row of pictures and decide which two drawings, from a set of seven, are the most similar conceptually. The decisions become slightly more abstract as the test progresses.
Rapid Picture Naming	Measures the ability to rapidly recognize then retrieve and articulate the names of pictured common objects. The stimulus pictures are presented in rows of five.

[5] Table modified from information presented in the WJ III COG Technical (McGrew & Woodcock, 2001) and Examiner's Manual (Mather & Woodcock, 2001), as well as the *Essentials of WJ III Cognitive Abilities Assessment* (Schrank, Flanagan, Woodcock, & Mascolo, 2002).

Woodcock-Johnson III Tests of Cognitive Ability

The general characteristics of the WJ III COG norming sample and standardization procedure are summarized in the Technical Manual (McGrew & Woodcock, 2001). To summarize, the data for the WJ III norms were collected from a large, nationally representative sample (based on the 2000 U.S. census projections) of 8,818 participants (consisting of 1,143 preschool-aged children, 4,783 students in kindergarten through 12th grade, and 1,843 adult participants) that represents 100 geographically diverse U.S. communities. Subjects were randomly selected within a stratified sampling design that controlled for 10 specific community and subject variables (census region, community size, sex, race, Hispanic, type of school, type of college/university, education of adults, occupational status of adults, occupation of adults in the labor force) (Note: All variables were not relevant at all levels of the norming sample). English language learners were also included if they had one year or more of experience in regular English-speaking classes. All participants were administered tests from both the WJ III COG and the WJ III Achievement by research assistants who were well trained and closely supervised. Data were collected from September 1996 to August 1999.

The technical manual presents reliabilities for each test for various age groups. For most tests, reliabilities were calculated using a split-half procedure in conjunction with the Spearman-Brown correction to adjust for published test length. For speeded tests, as well as those with multiple-point scoring, reliabilities were calculated by Rasch (1960) analysis procedures. The age groups are based on one-year age groupings from 2 to 19[6], and then 10-year age groupings from 20 to 80. The reliabilities range from 0.61 to 0.98 for the tests selected in this study and

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[6]Where available, for some tests reliabilities are not reported for the youngest age groups (i.e., 2, 3, and 4).

across these age groups. A table of the range of reliabilities and median reliability for each test is presented in Table 3.

Table 3

Reported Reliabilities for the Selected Tests of the WJ III COG

Test	# of Items	Reliability Range	Median Reliability
Spatial Relations	33	.68 - .92	.81
Concept Formation	40	.75 - .97	.94
Visual Matching	60	.84 - .96	.91
Picture Recognition	24	.61 - .85	.76
Analysis-Synthesis	35	.81 - .95	.90
Decision Speed	40	.78 - .92	.87
Rapid Picture Naming	120	.91 - .98	.97

Batería III Woodcock-Muñoz: Pruebas de Habilidades Cognitiva

The general characteristics of the Batería III COG calibration sample and procedure are summarized in the Batería III Technical Abstract (Woodcock et al., in press-a). To summarize, the data for the calibration of the Batería III were collected both inside and outside of the United States. Calibration data were collected from 1,413 native Spanish-speaking participants from several Spanish-speaking regions including; Mexico, Puerto Rico, Cuba, Spain, Guatemala, Colombia, Argentina, South Africa, Venezuela, Nicaragua, Ecuador, Panama, Chile, Honduras, Costa Rica, Dominican Republic, and Uruguay. Two hundred and seventy-nine of these participants resided in the United States, although many of them were born in another country. Participants were selected for inclusion in the calibration sample if they were monolingual Spanish speakers, based on an informant's opinion.

Translation Process

The following information about the translation process for the Batería III COG was obtained from the Batería III Technical Abstract (Woodcock et al., in press-a). Given that the Batería III COG represents a third version of this test battery, many of the tests included were translated or adapted during the development of the earlier editions.

Particular attention was paid to ensure that items and test instructions were appropriate for all Spanish speaking regions, thus professionals from several different Spanish-speaking regions were involved in the preparation of the test items and instructions for all tests (Woodcock et al., in press-a). At the early stages of the history of the Batería development, a board of consulting editors was established to review and advise on all aspects of the project including the item content and Spanish language usage. Approximately 30 examiners from five Spanish-speaking countries were trained to gather norming data. These examiners were also responsible for critically reviewing the tests and answer keys for possible Spanish-language problems based on their regional perspective. Further, the item calibrations were completed separately for each of the five regions. If there was a significant difference when comparing regional item difficulties with item difficulties obtained for the total sample, the item was assumed to be regionally biased, and was dropped from the item pool.

The Batería III COG contains 12 new tests, for which test translation and adaptation was performed by, or under the direction and supervision of, Dr. Ana Munoz-Sandoval (this included two professional translators and a consulting translator). Each of these individuals was a professionally certificated Spanish translator and a native Spanish-speaker. Once again, additional information about the suitability of item content, test translation and adaptation across different Spanish-speaking regions (including, Mexico, Puerto Rico, Spain, Argentina, Panama,

Costa Rica, Columbia, and the United States) was gathered by Batería III standardization examiners.

The Batería III Technical Abstract (Woodcock et al., in press-a) does not provide any information about the method of translation (i.e., whether the translation occurred through back or forward translation). In their review of sources of error associated with adapting tests, Hambleton and Patsula (1998) state that "backward translation designs are popular but forward translations designs provide stronger evidence of test equivalence because both the source and target language versions of the test are scrutinized" (p. 161). Further, Standard 9.7 of the *Standards* and the states "the test translation methods used need to be described in detail" (AERA et al., 1999, p. 99), a practice also supported by the APA (APA, 2001).

Equated US Norms

One of the reasons the authors claim that the WJ III COG and Batería III COG are comparable is because the Batería III has been equated to the WJ III. That is, the tasks for each test in the Batería III COG have been scaled to their empirical difficulty on the WJ III. A brief description of the process with which the test batteries were equated is presented below.

The calibrating and equating method used to equate the WJ III and the Batería III is described in the Batería III Technical Abstract (Woodcock et al., in press-a), and follows the procedures presented by Woodcock and Muñoz -Sandoval (1993) on their approach to cross-language test equating. The process involves several stages, or steps. First a bank of items for the WJ III was developed, calibrated and normed. An item bank for the Batería III that included adapted and translated items was then developed and calibrated. The two tests were equated through a subset of English items (WJ III) and parallel *translated* English items (Batería III) that

ranged in difficulty (from easy to difficult). The difficulty scale for the Batería III item bank was than rescaled to the difficulty scale of WJ III.

Scoring

The WJ III COG and Batería III COG use ceiling or discontinue rules[7] to limit administration time, as well as minimize frustrations or discouragement of examinees by attempting to answer questions too difficult for them, as is typical with cognitive ability and individually administered achievement tests. When scoring, it is assumed for every examinee that any item above the ceiling would be answered incorrectly. If, hypothetically, items of greater difficulty appear earlier than they should, a ceiling could be established prematurely. For IRT models the assumption is made that:

> a response to an item is a function only of the student's ability and the item's difficulty. If a test is speeded and test directions influence the number of items attempted, then it seems likely that item responses are no longer a simple function of ability and difficulty (Ludlow & O'Leary, 1999, p. 165).

As a result, the scoring scheme for the data used in this study was to consider all items that were not administered to examinees as missing in order that all estimations of ability and analyses are based on actual response patterns from individuals.

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[7] Ceiling rules are used to limit the number of items administered and eliminate those items that are deemed to be too difficult for the subject.

Procedure

The procedure outlined here is a multistage process in which each stage contributes to determining the degree of comparability between the WJ III COG and the Batería III COG. These procedures are based on several works including theoretical, methodological, and professional standards presented earlier. The stages of this study are: (a) examination of factor structures to empirically test similarity of factors (i.e. latent variables) or dimensions across the groups in question, English- and Spanish- speakers; (b) investigation of the respective internal consistency for the two language groups, by looking at the reliability for each language version of each test; (c) completion of Item Response Theory (IRT) based analyses, including DIF to statistically examine items that function differentially for the two language groups; and lastly, (d) the Judgmental Review of test instructions and items that provides a qualitative evaluation of their comparability. The following sections outline the various steps undertaken as part of this study.

Stage 1 – Examination of Factor Structure

Factor analysis was used to examine whether or not the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG are the same. If the structures are the same in the two languages, this supports the hypothesis that both test batteries are measuring the same construct, and you can infer that individuals from either group attach the same meaning to the construct as a whole. Investigating the structure of each of the tests provides one source of validity evidence, as well as the comparison of test structure between the two language versions is one of the methods used to assess the comparability of constructs.

Factor analysis is a family of multivariate techniques that (a) examines the underlying patterns or interrelationships for a large number of variables and (b) determines if these variables

can be condensed into a smaller set of factors (Hair, Anderson, Tatham, & Black, 1998). The goal of this set of analyses was to identify separate underlying dimensions, known as *factors*, to maximize their explanation of the entire variable set and then determine the extent to which each variable is explained by each factor. Further, a major purpose of factor analysis is, by reducing the number of variables to a few common factors, the description of behaviour becomes simplified (Anastasi & Urbina, 1997).

Exploratory Factor Analyses (EFA) is a family of statistical procedures that has been widely used in studying the structure of assessment measures, including investigating the structural equivalence of different language versions of assessments (Hair et al., 1998; Traub, 1983; van de Vijver & Leung, 1997). The primary reason for choosing EFA relates to the overarching research question for this study, "Are the tests from the different language versions comparable?" Thus, the focus of the factor analysis is not to confirm hypotheses about the overall test structure within the two batteries, but instead on examining similarities and differences in the factor structure for the different language versions of each of the specific tests, as well as how the items relate to the factors. That is, the purpose of the factor analysis is to determine the number of factors that are represented by the items within a particular test in both languages. For example, how many factors best represents the items within *Concept Formation*, and is the factor structure the same for the two language versions? For this purpose, separate factor analyses were completed for each language group and the pattern of factor loadings was compared across groups. Evidence of construct equivalence is demonstrated by similar patterns of factor loadings across groups. While there exists an extensive body of research on the factor structure of the WJ III and CHC theory, it can not be assumed that the psychometric properties of a test are the same in a different language. As such, EFA was deemed the most appropriate

method with which to compare the factor structure of the different language versions of the selected tests.

There are, however, limitations associated with using exploratory factor analysis for evaluating construct equivalence. Primarily, because the analyses are conducted on each group separately, evaluating the degree to which there is a similar factor structure is difficult (Sireci, Bastari, & Allalouf, 1998). However, it is possible to compare factor solutions across the English- and Spanish-speaking language groups, when the factor solutions produce the same number of factors. The most common and accepted technique to determine factorial similarly is to calculate a coefficient of congruence (Harman, 1976) between the loadings of the corresponding factors for the two groups (Reynolds, Lowe, & Saenz, 1999). The coefficient of congruence, denoted by Φ_{lm},

$$\Phi_{lm} = \frac{\sum_{j=1}^{P}(a_{1jl})(a_{2jm})}{\sqrt{\sum_{j=1}^{P} a^2{}_{1jl} \sum_{j=1}^{P}(a^2{}_{2jm})}},$$

where (a_{1jl}) is a pattern element for the first sample, jth variable, lth factor, and p is the number of variables (Harman, 1976). While no firm rules or significance testing procedures exist, congruence coefficients range from +1 to -1, with +1 being perfect agreement and –1 being perfect inverse agreement, and .95 might be interpreted to be very comparable, .90 quite comparable, and .70 only somewhat comparable (Harman).

Factor Analysis Models

Two different factor analysis models were used as exploratory approaches to determine the factor structure of the selected tests in the two different language versions, (a) Full-Information Item Factor Analysis (FIFA) and (b) Principal Component Analysis (PCA) (as the method of extraction). The PCA was performed using SPSS (version 10.0) and the FIFA was conducted using TESTFACT (Wilson, Wood, & Gibbons, 1991). For both factor analyses methods, missing data were handled by using pairwise case exclusion, which excludes from analysis cases with missing values for either or both of the pair of variables in computing a specific statistic. Further, once the number of components was determined (criteria for determination of factors is presented below) a PROMAX rotation was performed. PROMAX is an oblique rotation that allows the factors to correlate. The advantage of allowing the factors to correlate is that if the resulting factors prove to be uncorrelated, the model will allow for that and no error would have be made (Kim & Mueller, 1978).

The reason that two different models were employed in this study relates to the data characteristics for some of the selected tests. That is, for a number of tests the data are dichotomous. For dichotomous data, linear factor analysis of Pearson (phi) correlations does not represent the dimensionality of a set of items correctly (J.B. Carroll, 1983). One option then, has been to use tetrachoric correlations instead of the phi correlations, but these coefficients become unstable as they approach extreme values (as is the case with very easy or difficulty items) (Muraki & Engelhard, 1985). To overcome this limitation, nonlinear factor analysis models have been proposed, including FIFA, which is described below.

The FIFA model is based on item response theory, and uses distinct item response vectors instead of computing correlation coefficients. FIFA is regarded as the most sensitive and

informative among various methods of investigating the dimensionality of item sets (Bock, Gibbons, & Muraki, 1988). FIFA analyses were performed using the computer software TESTFACT (Wilson et al., 1991). TESTFACT maximizes the likelihood of the item factor loadings given the observed patterns of correct and incorrect responses. The corresponding likelihood equations are solved by integrating over the latent distribution of factor scores assumed for the population of examinees. This estimation is called marginal maximum likelihood (MML). The implementation of item factor analysis by MML overcomes problems with factor analysis of tetrachoric correlation coefficients (i.e., it avoids the problems of indeterminate tetrachoric coefficients of extremely easy or difficult items) (Bock et al.).

The selection of factor-analytic model then was based on the data characteristics of each test. That is, for tests that used multilevel scoring, PCA was the model of choice. For tests with dichotomous data, FIFA was the chosen model. However, for the timed tests, which were scored dichotomously, the extent of missing data, and the very high proportion of correct responses for many of the items, became problematic for TESTFACT, and the PCA model was used in order to make some comparison between the factor structures of the two language versions of these tests. Given the exploratory nature of this study, and that factor structure comparison was the focus, and that there would be no claims about how many factors, or what these factors represent for these tests definitively, relaxing the assumptions about dichotomous data and linear factor analysis was deemed acceptable.

Determination of Factor Solution

Two criteria were considered initially when determining the number of factors to extract for each test (for each language version). The first criteria, and most commonly used technique, is the latent root (also known as eigenvalue) criterion, which uses a cutoff of one to determine

the number of factors (Hair et al., 1998). That is, the number of factors is equal to the number of eigenvalues greater than one. However, this cutoff is most reliable when the number of variables is between 20 and 50 (Hair et al.), where the number of factors extracted can be too few for the former, or too many for the latter. The second criteria for determining the number of factors extracted was the scree test criterion advocated by Cattell (1966). For this criterion, one examines the graph of eigenvalues for the point at which the eigenvalues begin to level off to form a straight line with an almost horizontal slope. Based on these two criteria, the number of factors was determined. If there was a discrepancy in the number of factors to extract, a third criterion, percentage of variance, was considered. This criterion is typically used to extract factors of practical significance (Hair et al.). That is, factors that account for only a small portion of variance (i.e. less than 5%) are not considered to add practical significance to the factor solution.

For the purposes of this study, factor analyses were completed for each set of items that comprise a test (i.e., all the items from *Spatial Relations* will be included in one set of factor analyses, and all the items from *Concept Formation* will be included in another set of factor analyses, and so forth). Further, analyses for each battery (i.e., WJ III COG and the Batería III COG), were completed separately. Once the number of extracted factors was determined, the similarity of factor solutions as well as factor loadings for the different language tests were compared for similarity. That is, is the number of factors the same or different? If they are the same, how comparable are the factor solutions (i.e., congruence coefficient)? The degree to which the solutions are similar contributes to the determination of the comparability and equivalence of these test batteries.

Stage 2 – Internal Consistency

Another source of information used to determine the comparability of the WJ III COG and the Batería III COG was to examine the internal consistency, or the reliability, with which each test measures what it is intended to measure. Further, reliability evidence is another source that contributes to an evaluation of validity. That is, how reliable are the scores for each measure?

Reliability is an indicator about the reproducibility of test scores; can the same test results be achieved if the same individual(s) were to take the test again under the same circumstances (Crocker & Algina, 1986)? Traditionally, reliability coefficients fell into three broad categories: internal consistency, alternate form and test retest. For many tests, internal consistency coefficients do not different significantly from alternate-form, and may be preferred to the other reliability coefficients (AERA et al., 1999).

For the purposes of this study, it is important to demonstrate the *internal consistency*, or repeatability, of each of the translated tests for each of the respective batteries, as well as compare the measurement accuracy for each of these batteries (and language groups). Are the purported constructs measured with the same accuracy for each of the language groups? This provides another piece of evidence about the comparability of the tests of the WJ III COG and the tests of the Batería III COG.

An internal consistency coefficient is based on the relationships among scores based on individual items within a test (AERA et al., 1999). In order to calculate the internal consistency reliability, the total test must be broken down into two separate scoreable parts. The tests that were included in the present research study utilized different scoring methods. While some tests were scored dichotomously, others employed multiple scoring levels. That is, for some items it

was possible to achieve a score of 0, 1, 2, 3, or 4 points. As such, when the test is split into two parts, you may not have tests that appear to be the same length because of the differences in possible scores. Thus, it is important to make sure that the way in which reliability is calculated is appropriate given the way with which the test of interest is scored. Decisions about the appropriate method to calculate reliability are based on the following. When the test parts may exhibit differences in means and observed score variances, the variances of true scores are heterogeneous and the parts *functional length* is equal, they can be represented by the *essentially tau-equivalent model* (Qualls, 1995). Cronbach alpha is an example of an internal consistency coefficient that conforms to this model, and can be expressed as:

$$\hat{\alpha} = \frac{k}{k-1}\left(1 - \frac{\sum \hat{\sigma}_i^2}{\hat{\sigma}_X^2}\right),$$

where, k is the number of items on the test and the items are scored dichotomously, $\hat{\sigma}_i^2$ is the variance of item i, and $\hat{\sigma}_X^2$ is the total test variance (Crocker & Algina, 1986). However, when the test parts have different *functional lengths*, then a *congeneric model* should be employed (Qualls, 1995). Differences in functional length between two test parts can arise when different item types (i.e., multiple choice, essay, short-answer) and different scoring methods (i.e., dichotomously or polytomous) are employed in the same test. The appropriate reliability estimate to use in this situation is Feldt-Raju, which can be expressed by:

$$F - R\rho XX' = \frac{\sigma_X^2 - \sum \sigma_{Y_j}^2}{(1 - \sum \hat{\lambda}_j^2)\sigma_X^2},$$

where, $\sigma_{Y_j}^2$ equals the observed part-score variances, $\hat{\lambda}_j$ represents the functional length, and σ_X^2 is the total test variance (Qualls, 1995).

As outlined above, the appropriate measure of reliability depends on the nature of the items, and the way with which they are scored. While the item type (*constructed response or multiple-choice*) was the same for most of the items included in this study, the scoring schemes vary for the different tests. The table below presents information about each test, including item type and scoring scheme. For all tests that contain only dichotomously scored items internal consistency was calculated using Cronbach alpha, whereas for tests that utilized multiple point scoring systems internal consistency was calculated using Feldt-Raju.

Results obtained from this stage of analyses, again, contribute to the evidence from which a decision about the comparability of the two different language versions of test will be made.

Table 4

Item Characteristics of the Translated Tests of the WJ III COG and Batería III COG

Test	# of Items	Item Type[8]	Score ranges
Spatial Relations	33	CR	Multiple points possible per item (0 – 3) Number correct (0-81)
Concept Formation	40	CR	Number correct (0-40)
Visual Matching	60	CR	Number correct (0-60)
Picture Recognition	24	MC & CR	Multiple points possible per item (0 – 4) Number correct (0-59)
Analysis-Synthesis	35	CR	Number correct (0-35)
Decision Speed	40	CR	1 point for each correct pair Number correct (0-40)
Rapid Picture Naming	120	CR	Number correct (0-120)

Stage 3 – IRT Based Analyses

Identification of Differential Item Functioning

The main purpose of DIF detection procedures was to determine whether the relative performance of the members of a minority or subgroup and members of the majority group are the same or different. A popular DIF detection method was used to identify items from the selected tests of the WJ III COG and Batería III COG that may be functioning differentially

[8] CR represents "Constructed Response", and MC represents "Multiple Choice".

between English- and Spanish-speaking examinees. DIF items will be identified using an application of the Linn-Harnisch method (LH) (1981), which has been established as a useful approach to identifying item bias due to language and cultural differences and or flawed/problematic test adaptations (Hambleton & Patsula, 1998; Lee & Lam, 1988). This DIF detection procedure is capable of detecting uniform, as well as non-uniform DIF, and is described in greater detail below.

The LH (1981) procedure computes the estimated probability that person *j* would answer item *i* correctly, using:

$$P_{ij} = c_i + \frac{1 - c_i}{1 + \exp[-1.7a_i(\theta_j - b_i)]},$$

where a_i, b_i, c_i, and θ are all estimates. These estimates, or parameters, are based on the data from *all* examinees, and can then be compared to the observed proportion correct for the subgroup, in this case Spanish speakers. The proportion of examinees in the subgroup (g) expected to answer the item (i) correctly is:

$$P_{ig} = 1\frac{1}{n_g}\sum_{j \in g} P_{ij},$$

where n_g is the number of persons in the subgroup, and j is a member in the subgroup. Whereas, the proportion of people in the complete group is:

$$P_i = \frac{\sum_g n_g P_{ig}}{\sum_g n_g}.$$

Then, the observed proportion correct on item *i* for the subgroup *g*, O_{ig}, is the number of people in the subgroup who have responded correctly divided by the number of people in the subgroup. For the complete subgroup it can be calculated from:

$$O_i = \frac{\sum_g n_g O_{ig}}{\sum_g n_g}.$$

The difference then, between the observed proportion correct on item *i* for the complete group and the subgroup, is an index of the degree to which members of the subgroup perform better or worse that the complete group. This, *overall difference*, can be calculated by:

$$D_i = O_i - P_i.$$

This can be further extended to calculate differences for the subgroups at different ranges of the ability scale (i.e., at the low or high end of the ability scale, as well as any other range). This allows one to examine whether or not there are differences between the subgroup and complete group at different points on the ability scale. For example, if there is DIF, is it (a) uniform, and that one group is favored over the other at all points of the ability scale, or (b) non-uniform, and the degree to which one group is favored over the other is different at various points of the ability

scale. The effects of language on performance is expected to vary for different ability levels of students and as such, it is important that the DIF detection procedure used with translations can detect non-uniform, as well as uniform DIF. In addition, the LH procedure can be combined with IRT based analyses to examine psychometric differences of items identified as displaying DIF.

The LH procedure was performed using the computer software program PARDUX, written by George Burket (1998), which applies the procedure developed by Linn and Harnisch (1981) to item-response theory based item characteristic comparisons. This program computes for each item the observed and expected mean response and the difference (p_{diff}) between them (observed minus predicted) by deciles of the specified subgroup, and for the subgroup as a whole. The expected values are computed using the parameter estimates obtained from the entire sample, and the theta estimates (ability estimates) for the members of the specified subgroup. Based on the difference between expected and observed *p*-values, a *Z*-statistic is calculated for each decile and an average *Z*-statistic for the item is computed for identifying degree of DIF. The level of DIF is determined by the set of rules (Ercikan, 2002) presented in Table 5. A negative difference implies bias against the subgroup, whereas a positive difference implies bias in favour of the subgroup. Items that display Level 2 or Level 3 DIF are considered then to indicate that the parameters for those items are not invariant across the two groups (English- and Spanish-speakers).

Table 5

Statistical Rules for Identify Three Levels of DIF

DIF Level	Rule	Implications
Level 1	$\|Z\| < 2.58$	No DIF
Level 2	$\|Z\| \geq 2.58$ and $\|p_{diff}\| < 0.10$	DIF
Level 3	$\|Z\| > 2.58$ and $\|p_{diff}\| \geq 0.10$	Serious DIF

Item Response Theory Models

When performing any statistical procedure it is important that it has been completed and used in an appropriate fashion. Given there a number of IRT models available, there is a choice and flexibility afforded the user. Using the appropriate IRT model to represent items is critical, in that using an inappropriate model can cause inaccurate estimates of item parameters and decrease the utility of IRT techniques (Reynolds et al., 1999). For example, if inaccurate parameters are used in further analyses, for example Differential Item Functioning (DIF) or equating, the degree to which the parameters fail to characterize an item will be introduced as error. Further, accurate parameter estimates are necessary to ensure accurate ability estimates for each examinee (Weitzman, 1996). The implications of inaccurate item parameters include inaccurate ability estimates, which in turn could impact inferences made about an individual's performance or ability level, and quite possibly programming and placement decisions.

The WJ III COG and Batería III COG are based on the Rasch measurement model. Rasch (1960) developed the one parameter logistic model, or Rasch model, to scale dichotomously scored items. As the name suggests, this IRT model utilizes only one parameter, *b*, item difficulty. This model assumes that item difficulty is the only item characteristic that influences

an examinee's performance (Hambleton, Swaminathan, & Rogers, 1991). That is, ability levels can be accurately estimated with a measure of item difficulty (i.e., *b*). Further, this model assumes that all items are equally discriminating, and that examinees will not be able to correctly answer easy items by guessing. Aspects of this model that appeal to users include: it is easier to work with because the model involves fewer parameters than other models (i.e., the Rasch model makes equating easy (Weitzman, 1996); it can be reasonably robust when there are moderate violations of model assumptions; and there are fewer parameter estimation problems than with more general models (Hambleton, 1989). Further, the Rasch model obtains the property of specific objectivity, which means that it can directly compare the difficulty of two items, or the abilities of two persons directly without having to estimate any other parameters or abilities (Divgi, 1986). However, the Rasch model is not without limitations. It can be harder to find items that fit the 1PL model than more general models, and the assumptions of equal item discrimination and no correct guessing among low ability examinees may not be met by multiple choice tests (Divgi; Traub, 1983). Interestingly, proponents of the Rasch model would sooner discard items that do not fit the model, then to investigate using another model to characterize these items (Hambleton).

The LH procedure will be implemented using the three-parameter logistic model (3PL) (Lord, 1980) for the multiple-choice items and the two-parameter partial credit (2PPC) model (Yen, 1993) for the remainder of items, which are open-ended in format (constructed response), to obtain item parameters. A simultaneous calibration of multiple-choice and open-ended items and identification of DIF will be conducted using PARDUX (Burket, 1998).

Three-parameter logistic model.

The item parameters for the multiple-choice items will be obtained using the three-parameter logistic (3PL) (Lord, 1980). In this model, the probability that a person with a score of θ responds correctly to item i is:

$$P_i(\theta) = c_i + \frac{1 - c_i}{1 + \exp[-1.7a_i(\theta - b_i)]},$$

where a_i is the item discrimination, b_i is the item difficulty, and c_i is the probability of a correct response by a very low-scoring student.

Two-parameter partial credit model.

The item parameters for the constructed response items will be obtained using the two-parameter partial credit model (2PPC) (Yen, 1993). The 2PPC model is a special case of Bock's (1972) nominal model and is equivalent to Muraki's (1992) generalized partial credit model. Similar to the generalized partial credit model, in 2PPC, items can vary in their discriminations and each item has location parameters, one less than the number of score levels. The nominal model states that the probability of an examinee with ability θ having a score at the k-th level of the j-th item is:

$$P_{jk}(\theta) = P(X_j = k - 1|\theta) = \frac{\exp Z_{jk}}{\sum_{i=1}^{m_j} \exp Z_{ji}}, \text{ k=1...m}_j,$$

where,

$$Z_{jk} = A_{jk}\theta + C_{jk}\,.$$

For the special case of the 2PPC model used here, the following constraints were used:

$$A_{jk} = \alpha_j(k-1)\,,$$

and

$$C_{jk} = -\sum_{i=0}^{k-1}\gamma_{ji}\,,$$

where $\gamma_{j0} = 0$, and α_j and γ_{ji} are the free parameters to be estimated from the data. The first constraint implies that items can vary in their discriminations and that higher item scores reflect higher ability levels. In the 2PPC model, for each item there are $m_j - 1$ independent γ_{ji} difficulty parameters and one α_j discrimination parameter; a total of m_j independent item parameters are estimated.

Evaluation of the IRT Model Assumptions

IRT models, as with most statistical models, include a set of assumptions about the data to which the model is applied: (a) the ability being measured is *unidimensional*; (b) that an examinee's responses to the items in a test are statistically independent; and (c) that item responses *fit* the IRT model (Hambleton et al., 1991). How these assumptions were evaluated in this study is presented below.

Unidimensionality.

The assumption of unidimensionality can be satisfied if the test data can be represented by a "*dominant* component or factor" (Hambleton, 1989, p. 150). Thus, the results from the EFA were used to evaluate whether this assumption was met for each test.

Item fit.

The Q_1 chi-square statistic developed by Yen (1981) allows one to assess item fit. That is, Q_1 is used to test the null hypothesis that there is no statistical difference between the model in question and the observed responses. The Q_1 statistic sums over all the standardized residuals for all the different ability groups, and is distributed as χ^2 with (number of ability groups – number of parameters in the model) degrees of freedom. The Q_1 statistic can then be standardized in the form of a *Z*-score (Fitzpatrick et al., 1996). Based on extensive evaluations of fit statistics, to indicate *practical* significance, *Z*-values greater than 4.6 should be flagged as having poor fit (Ercikan et al., 1998). The computer program PARDUX (Burket, 1998) was used to estimate item parameters and calculate the Q_1 statistic for each of the tests.

Local item dependence (LID).

The Q_3 statistic developed by Yen (1984) was used to evaluate LID. The Q_3 is the correlation between the performance on two items after taking into account overall test performance. As a correlation, the interpretation is easy. For locally *independent* item pairs the Q_3 statistic is expected to be O. An item pair is flagged as locally *dependent* when $|Q_3| \geq .20$ (Ercikan et al., 1998). The computer program PARDUX (Burket, 1998) was used to estimate item parameters and calculate the Q_3 statistic for each of the tests.

Investigation of Item and Test Characteristics

At the most basic level, IRT was designed to describe the relationship between how an examinee performs on an item and their ability that underlies the performance of the item. This relationship is expressed in mathematical terms by a monotonically increasing function that can be used to describe and predict the performance of an examinee on a test item based on the examinee's ability, or vise versa. This relationship can be represented by an *item characteristic curve* (ICC). The ICC depicts visually how an item is functioning for respondents, illustrating what the associated probability of answering an item correctly is with various levels of ability (θ).

Further, IRT models provide a powerful method of describing items and tests through the use of *item-information functions* and *test-information functions*. Item-information functions display the contribution items make to the ability estimation at any point along the ability scale (Hambleton, 1989). The sum of these item-information functions at a particular ability level (θ) represents the amount of information the test provides at that ability level. The contributions items make to the test largely depend on the discriminating power of the item and the difficulty of an item. These functions expressed mathematically are:

$$I_i(\theta) = \frac{\left[P_i'(\theta)\right]^2}{P_i(\theta)Q_i(\theta)}, \ (i = 1,2,.....,n).$$

$I_i(\theta)$ represents the information provided by item i at θ, $P_i'(\theta)$ is the first derivative of $P_i(\theta)$ with respect to θ, and $P_i(\theta)$ is the item response function, and $Q_i(\theta)=1-P_i(\theta)$ (Hambleton et al., 1991). Summing the item-information functions at an ability level (θ) indicates the

information that a test provides at an ability level (θ). Further, the precision that ability is estimated at an ability level (θ) is inversely related to the amount of information provided by a test at that ability level. This is called the *standard error of measurement* (SEM) and is expressed by:

$$SE(\hat{\theta}) = \frac{1}{\sqrt{I(\theta)}}.$$

For this study, item-information functions, standard error of measurement, as well as correlations between item parameters based on the two separate groups, English- and Spanish-speakers, will be computed and compared for each test. Information functions can be useful to examine parallel tests; tests are said to be parallel when the information functions are equal and they measure the same ability (Samejima, 1977). The results from the investigation of item characteristics will be used as another piece of evidence in the determination of the degree to which the WJ III COG and the Batería III COG are comparable, and parallel.

Stage 4 – Judgmental Review

The DIF procedure is a statistical method used to identify whether or not items are biased against a subgroup population. While it can address "if" there is bias, it cannot answer "why." In order to answer the "why" question, a qualitative examination of the items, and their characteristics, is required (i.e., Allalouf et al., 1999; Ercikan, 1998; Gierl, Rogers, & Klinger, 1999). In previous research related to examining sources of DIF this process is called a *Judgmental Review*. The judgmental review process used in this study combines typical aspects

of this type of approach that have been used in previous research (e.g., Allalouf et al., 1999; Ercikan et al., in press; Gierl & Khaliq, 2001).

Selection and Training of Judgmental Reviewers

Research that examines issues related to translating or adapting tests into other languages offer guidelines about important translator characteristics necessary when using them to translate or adapt tests into other languages. That is, translators need to be: (a) familiar and competent with both the source and target languages and cultures involved (Geisinger, 1994; Hambleton, 2002, in press; Hambleton & Patsula, 1998); (b) generally familiar with the construct being assessed (Geisinger; Hambleton, 2002, in press; Hambleton & Patsula; and (c) familiar with the principles of good test development practices (Hambleton, 2002, in press; Hambleton & Patsula). Further, it is also suggested that the use of more than one translator, to allow for interactions to resolve different points that arise while preparing a test translation or adaptation (Hambleton & Patsula).

Incorporating the guidelines and suggestions presented above, the Judgmental Review for this study used two judgmental reviewers, fluent in English and Spanish (but dominant in Spanish) to examine the equivalence of the English and Spanish test versions. Use of more than one bilingual reviewer also contributed to the reliability of the reviews. The reviewers were graduate students in the Educational and Counselling Psychology, and Special Education department at the University of British Columbia. Both reviewers were native speakers of Spanish, although their country of origin was different (Columbia and Chile), thereby representing two different Spanish-speaking regions. Each reviewer had an educational background that made them generally familiar with the construct being assessed by the WJ III COG and Batería III COG, as well as measurement and research methods.

Training Session

A training session was conducted to explain to the reviewers the process of the judgmental review, and provide examples of translation and adaptation errors identified in previous research. First, the reviewers were briefed about the purpose of the study (examining the comparability of English and Spanish versions of a cognitive battery), including the role of a judgmental review in this study (to examine the items and instructions in each language to detect whether there are differences that may lead to performance differences for the two language groups). Reviewers were informed that the materials they would be reviewing were measures of cognitive ability, and as such, confidentiality about the tests was to be maintained. Reviewers were provided information about the types and examples of translation errors that have been previously documented (See Appendix A). Each reviewer examined these types and examples of sources of translation errors, and were encouraged to ask questions for clarification. This list of sources and examples of translation differences then served as a resource guide for the reviewers when reviewing the materials. Next, the reviewers were introduced to the rating system to be used when evaluating the equivalence of the English and Spanish versions, presented in Table 6. Reviewers were instructed to examine and compare all items and instructions for each language versions simultaneously and identify when there were differences between the two. When a difference was identified, reviewers were instructed to rate this difference, according to the criteria listed in Table 6, paying particular attention to whether the differences would lead to *performance* differences between the two language groups. Reviewers were told to record their ratings and comments on the provided worksheets (See Appendix B). Lastly, the instructions to reviewers summarized that differences could be related to the translation of instructions (e.g., appropriate word use, similarity of meaning, comparable word frequency, etc.), presentation

format or graphic quality of items, or differences with the familiarity of task or graphics used in the tests.

Table 6

Judgmental Review Rating Scale

Rating	Meaning associated with rating
0	No difference between the two versions
1	Minimal differences between the two versions
2	Clear differences between the two versions, but differences may not necessarily lead to differences in performance between two groups
3	Clear differences between the two versions that are expected to lead to differences in performance between two groups

Review Session of Test Instructions and Items

At this stage, there was a comprehensive review by the two reviewers of the instructions and items associated with each test and language version. Reviewers were presented with copies of the English and Spanish versions of instructions and items for each test. This material included the directions to examiners, instructions that examiners orally presented to examinees, as well as the items as they are presented to examinees. Typically, the results of the judgmental review ratings are reported to identify potential reasons for the statistical identification of DIF items. As such, reviewers examine DIF items, as well as some non-DIF items; blind to the status of the items (DIF or non-DIF). For this study, reviewers completed a comprehensive review of all items and instructions for each test. While not typical, or an economical way to examine

potential reasons for DIF, the scope of review was broadened to all items so that every aspect of the different language versions of tests was reviewed for possible differences that may impact the performance differentially for one of the language groups.

The reviewers were responsible to review and identify instructions and items considered to be different between the two language versions, as well as determine whether the differences were expected to lead to performance differences for the two language groups. For example, if a difference was found between the task or test instructions from one language to another, the reviewers were asked to judge whether this difference would provide one group an advantage by positively impacting their performance, or conversely, putting one group at a disadvantage by negatively impacting their performance. Each reviewer had their own set of materials, but worked collaboratively when they encountered instances that might be considered different, which is a typical and advocated approach (Gierl & Khaliq, 2001; e.g., Hambleton & Patsula, 1998). Typically a discussion ensued in Spanish, about the issue at hand, until a consensus about the nature of the difference, rating of the difference, and whether the difference would impact the performance of one group or the other was reached. These differences were then recorded on the worksheet provided. The outcome from this review session was one set of judgmental review ratings that reflects a thorough and thoughtful deliberation of the qualitative equivalence of the English and Spanish versions of the instructions and items with which to compare to the statistical equivalence procedure outcomes.

CHAPTER IV: RESULTS

This chapter provides a detailed description of the results of the present study. It is organized in such a way as to present descriptive statistics related to the tests of cognitive ability that are the focus of this study, followed by results related to each of the four statistical procedure stages outlined in the method section. That is, results related to analyses that examine scale level data (i.e., factor analyses, and internal consistency) will be presented first, followed by Item Response Theory (IRT) results (i.e., DIF, item information, parameter correlations), with the qualitative analyses in the form of a judgmental review being presented last. Further, the presentation of results maps on the purpose of this study in the following manner: (a) the factor analyses results will determine whether the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG are the same; (b) IRT based analyses examines whether there are specific items from the selected tests of the WJ III COG and Batería III COG that function differentially between English- and Spanish-speaking examinees; and lastly (c) the results from the judgmental review provide information about what the sources of differences in constructs being assessed for the two language groups are, should there be any.

The reader is informed that there are instances when the data characteristics for some test items limited the feasibility of including them in particular analyses, and as a result, the number of items for some tests may differ across different sets of analyses. These instances are described in more detail within the pertinent sections.

Data

Data from the norming and calibration samples of the WJ III COG and the Batería III COG, respectively, were used to evaluate the comparability of these two assessment measures.

Group Characteristics

While the previous sections describe the norming and calibration samples, of the WJ III and the Batería III, respectively, this section describes the two groups that are the crux of this study. What follows is a description of general group characteristics for each of the WJ III COG and the Batería III COG, as well as descriptive statistics for both groups for each of the tests examined.

The WJ III sample used in this study consisted of 1,290 participants randomly selected from the norming sample, which represents the data that were released by the publisher. The Batería III sample consisted of 1,413, which represents the calibration sample.

The range of ages included in this study is 9 to 29 years of age. This range was chosen for several reasons. First, for some tests (i.e., *Visual Matching* and *Concept Formation*) there are two sets of stimuli or starting points with accompanying instructions that are contingent on the age of examinee. For *Visual Matching*, the *Visual Matching* 2 stimulus was administered to examinees aged 5 and above. For *Concept Formation*, Introduction 2 is the set of instructions that were administered to examinees that were in Grade 2 and above. Age range was then limited to include only those examinees that could have been exposed to the same set of testing materials. Secondly, sample sizes for the tests for each of the batteries decrease substantially after the age of 29. As a result, the range of age included in this study is 9 to 29 years of age.

The focus of this study was on the comparability of inferences based on scores from tests administered in two languages. The central issue was around the language of administration – English or Spanish. All the tests and items were the same except for the language spoken by the administrator and examinee. Therefore the group membership of any person who was

administered the WJ III COG was English-speaking. Similarly, the group membership of any person who was administered the Batería III COG was Spanish-speaking.

In terms of the number of items included within each test, only the items that were administered to both language groups (i.e. those administered the WJ III COG, and those administered the Batería III COG) were included in the series of analyses in this study. For *Spatial Relations* and *Picture Recognition* the number of "common" items for the WJ III COG and Batería III COG are fewer than either published test. The published version of the WJ III COG was constructed using a "norming scale" (a scale containing only limited items used when collecting normative data), and then additional items from an item pool were linked/equated using Item Response Theory (K.S. McGrew, personal communication, February 3, 2004). As a result, for these selected tests analyses focused on the data for the "common" items.

Descriptive Statistics on the Tests of Cognitive Ability

The sample sizes (see Table 7) and descriptive statistics (see Table 8) for English- and Spanish-speaking students on each of the tests of cognitive ability are presented below. These tables provide information about each sample of subjects for the two test batteries, the WJ III COG and the Batería III COG, which corresponds to the language of administration, English or Spanish, respectively. The WJ III COG sample consisted of 1,290 participants randomly selected from the norming sample and the Batería III COG sample consisted of 1,413, which represents the calibration sample. The age range for both samples included in this study is 9 to 29 years of age.

Overall (across tests), the WJ III COG sample contains slightly more females than males (n=693 and n=646, respectively), with an average age of 16.0 years (SD=5.1). Whereas, for the

Batería III COG, the sample contains slightly more males than females (n=478 and n=424, respectively), with an average age of 15.3 years (SD=4.9).

Table 7

Sample Sizes for Each of the Selected Tests (age 9 to 29)

Test	WJ III COG			Batería III COG		
	Male	Female	Total	Male	Female	Total
Spatial Relations	608	664	1272	397	330	727
Concept Formation	617	673	1290	368	317	685
Visual Matching	616	673	1289	348	300	648
Picture Recognition	609	665	1274	83	81	164
Analysis-Synthesis	617	673	1290	273	245	518
Decision Speed	617	672	1289	346	216	562
Rapid Picture Naming	617	673	1290	207	189	396

In terms of the raw scores, there was no significant difference between the raw scores of each language group for *Analysis-Synthesis*. However, for all the other tests, the English-speaking group's raw scores were significantly higher than the Spanish-speaking group with the exceptions of *Picture Recognition*, where the Spanish-speaking group's raw scores were significantly higher than the English-speaking group's raw scores.

Table 8

Descriptive Statistics for Each of the Selected Tests (age 9 to 29)

Test	# of common items	WJ III COG n	WJ III COG Mean (SD)	Batería III COG n	Batería III COG Mean (SD)	Difference
Spatial Relations	12	1272	24.20 (3.35)	727	21.98 (6.53)	2.22*
Concept Formation	35	1290	25.12 (8.04)	685	21.13 (10.06)	3.99*
Visual Matching	60	1289	47.79 (8.24)	648	40.35 (10.54)	7.44*
Picture Recognition	10	1274	17.01 (4.85)	164	18.89 (3.80)	-1.88*
Analysis-Synthesis	35	1290	25.41 (4.79)	518	25.36 (5.60)	0.05
Decision Speed	40	1289	33.39 (5.70)	562	30.13 (5.05)	3.26*
Rapid Picture Naming	120	1290	111.48 (12.97)	396	93.50 (17.85)	17.98*

† Indicates significant differences at $p<0.05$.
* Indicates significant differences at $p<0.01$.

Stage 1 - Examination of Factor Structures

To examine the factor structure similarity between the tests administered in English and Spanish, exploratory factor analysis (EFA), using Principal Component Analysis (PCA) as the method of extraction with an oblique rotation (PROMAX), and adaptive full-information item factor analysis (FIFA) for selected tests of the cognitive batteries were conducted. The PCA was performed using SPSS (version 10.0) and the FIFA were conducted using TESTFACT (Wilson

et al., 1991). The extraction and rotation of factors were used to identify the factor structures of the scores for each language of administration, for each test.

Factor analyses results are presented for each of the selected tests of cognitive ability separately, and in some cases are grouped according to similarities (i.e., type of FA, or timed tests).

Spatial Relations

For *Spatial Relations*, there were 12 common items for the WJ III COG and Batería III COG, which represents approximately a third of the total number of items published for both language versions of this test (33 items). Of these 12 common items there was very little to no variance in scores for the first 5 items. These five items are targeted to assess early cognitive development and are very easy items, and as a result very few people responded incorrectly to them. This limited amount of variance can be problematic when completing factor analyses, and as such these items were excluded from this set of analyses.

The factor analyses results related to *Spatial Relations* are given in Tables 9 to 11. Table 9 shows the details related to the eigenvalues and the amount of variance accounted for by an unrotated factor solution, as well as the cumulative percent of variance accounted for by each successive factor for each language version of this test. For example, the primary factor for *Spatial Relations* has an eigenvalue of 1.92, which accounts for 27.45% of the variance for the WJ III COG, or English version of the test. The primary factor for the Spanish version of this test has an eigenvalue of 2.05, which accounts for 29.25% of the variance for the Batería III COG. Table 10 summarizes the rotated factor loading values for each factor for each language versions of the test. For example, Item 6 has a factor loading of .53 and .71 for the WJ III COG and Batería III COG, respectively. Lastly, Table 11 contains the inter-factor correlations for each of

the language versions of the *Spatial Relations* test. For example, the correlation between the first and second factor of the WJ III COG and Batería III COG is .23 and .19, respectively. Each subsequent factor analyses results are presented in a similar fashion.

The results of the PCA indicated the data are represented by two factors for both language versions of the test. A 2-factor solution was indicated by both the eigenvalue criterion as well as the scree test criterion (see Figure 1), for both language versions. For the English test version, the first factor accounted for approximately 27% of the variance in the item data, and the second factor accounted for an additional 16% of the variance. For the Spanish data, the first two factors accounted for about 29% and 19% of the variance, respectively. The cumulative variance accounted for by the two factors was 43% and 48% for the English and Spanish data, respectively.

Table 9

PCA Eigenvalues and Variance Explained for Each Factor for Spatial Relations

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	1.92	27.45	27.45	2.05	29.25	29.25
2	1.09	15.54	42.90	1.31	18.75	48.00

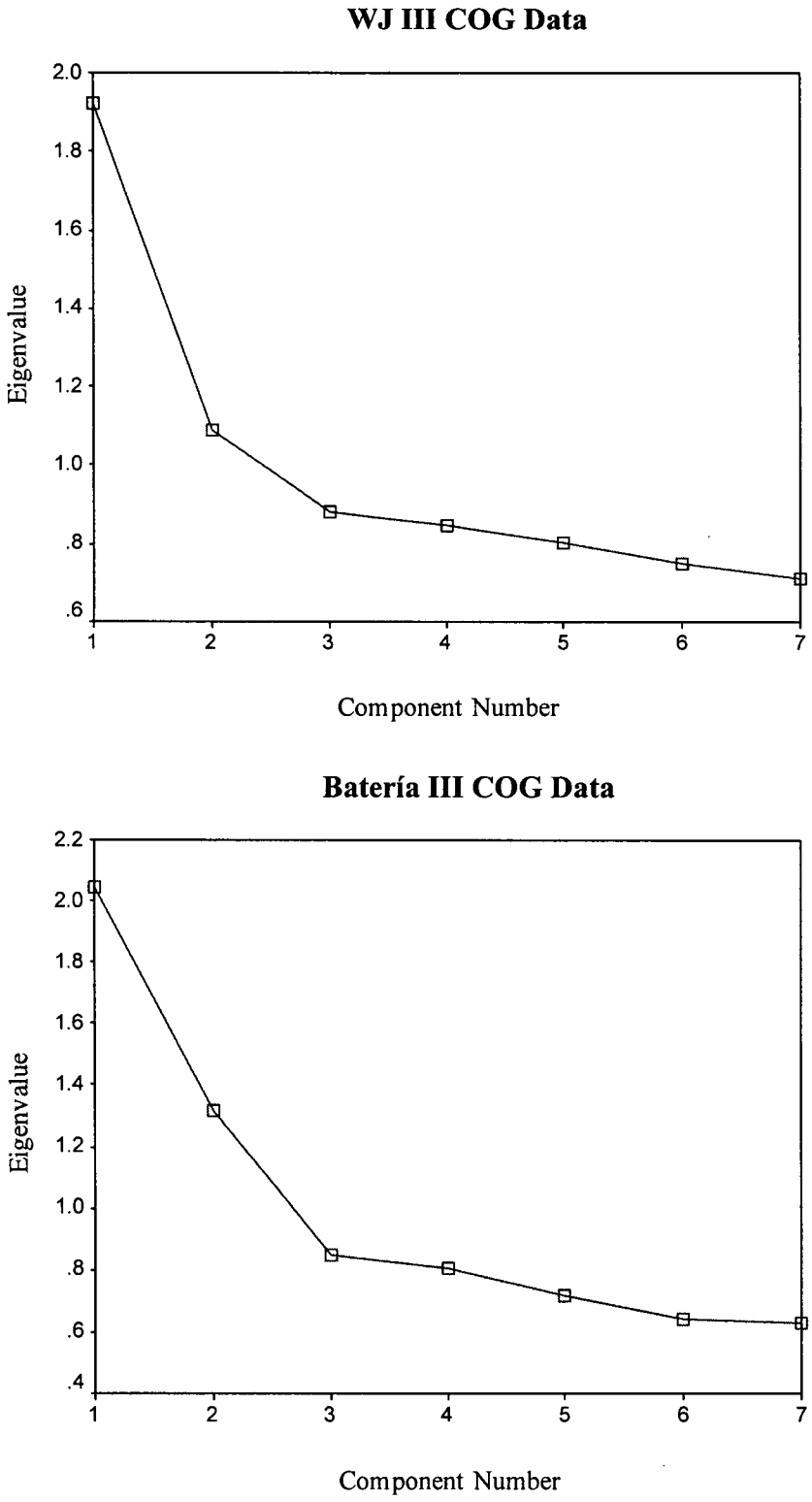


Figure 1. Scree Plots for *Spatial Relations.*

In terms of the factor loadings, summarized in Table 10, for both the English and Spanish data, separate factors corresponded to items that are presented earlier to examinees and items presented later to examinees. For example the first four items are loading on the first factor, while the last 3 items are loading on the second factor. The only difference in the pattern of factor loadings is that while Item 20 loads primarily on the first factor, for the English data, it loads significantly on the second factor as well.

Table 10

PROMAX Rotated Factor Loadings for Spatial Relations

	WJ III COG		Batería III COG	
Item #	1	2	1	2
12	.53		.71	
15	.70		.70	
17	.66		.70	
20	.54	.36	.60	
26		.66		.73
32		.65		.63
33		.68		.75

Notes. Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 11) shows a similar pattern of correlations between the two factors for both language versions of the *Spatial Relations* test, with correlations of .23 and .19 for the English and Spanish versions, respectively.

Table 11

Inter-factor Correlation Matrix for Spatial Relations

	WJ III COG		Batería III COG	
Factor	1	2	1	2
1	1.00	.23	1.00	.19
2	.23	1.00	.19	1.00

Because the factor solutions for both language versions contain the same number of factors, it is possible to calculate congruence coefficients for each factor, which provides an indicator of how comparable the factor solutions are. The resulting congruence coefficients were, .98 for the first factor, and .92 for the second factor. Using Harman's (1976) criteria[9], this means that the first factors of the English and Spanish test versions are very comparable, and the second factors are quite comparable.

The results of the factor-analytic procedures for *Visual Matching*, *Decision Speed* and *Rapid Picture Naming* are presented in succession below. Each of these tests are timed and presented unique challenges for this set of analyses. First of all, there was very little to no variance in scores for a number of items, particularly the first set of items. Further, because these were timed tests, there are a number of items at the end of the test that very few people respond to; they run out of time first. As such, there is a lot of missing data for later items, which results in empty cells in the correlation matrix, and completing the factor analyses is not possible. So then, to evaluate the structure similarity, or dissimilarity, items were included in the factor

[9] .95 very comparable, .90 quite comparable, and .70 only somewhat comparable

analyses for this set of tests if: (a) there was some variance in responses, for both the English and Spanish test versions, and, (b) if the set of items did not generate empty cells in the correlation matrix. As a result, the items at the beginning and very end of these tests were excluded. Therefore, the results reflect data structure based on items that met these criteria.

Visual Matching

For *Visual Matching*, there were 60 common items for the WJ III COG and Batería III COG, which represents all the items associated with the *Visual Matching* 2 stimulus, which is administered to examinees aged 5 and above. Of these 60 common items, a factor analysis was completed with 13 items, Items 40 through 53, for the reasons mentioned above.

The factor analyses results related to *Visual Matching* are given in Tables 12 to 14, with the first table presenting eigenvalues and the variance accounted for by an unrotated factor solution, the second table summarizing the rotated factor loading values, and the last table presenting the inter-factor correlations.

The results of the PCA indicated that the different language versions are represented by a different number of factors. For the English test version, the eigenvalue criterion and scree test criterion (see Figure 2) differed in the number of factors that represents the data, with the former suggesting five factors, and the latter suggesting two factors. After examining the percent of variance accounted for each of the proposed factors, a 5-factor solution was settled on, each of the five factors accounted for more than 5% of the variance. For the Spanish test version, there was also a difference between the eigenvalue criteria (six factors) and scree test criteria (three factors) in terms of the number of factors for the solution. Again, by examining the percent of variance accounted for each of the proposed factors, a 6-factor solution was settled on, with these six factors accounting for more than 5% of the variance. For both the English and Spanish data,

the first factor accounted for about 17% to 18% of the variance with each of the remaining factors accounting for between 8% to 12% of the variance. The cumulative variance accounted for by all of the factors (67%) was considerably more for the 6-factor solution for the Spanish data, than the cumulative variance accounted for (51%) by five factors for the English data.

Table 12

PCA Eigenvalues and Variance Explained for Each Factor for Visual Matching

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	2.20	16.89	16.89	2.34	18.00	18.00
2	1.26	9.73	26.62	1.61	12.35	30.35
3	1.13	8.68	35.29	1.36	10.47	40.81
4	1.07	8.20	43.49	1.20	9.25	50.06
5	1.02	7.85	51.35	1.12	8.62	58.68
6				1.03	7.94	66.62

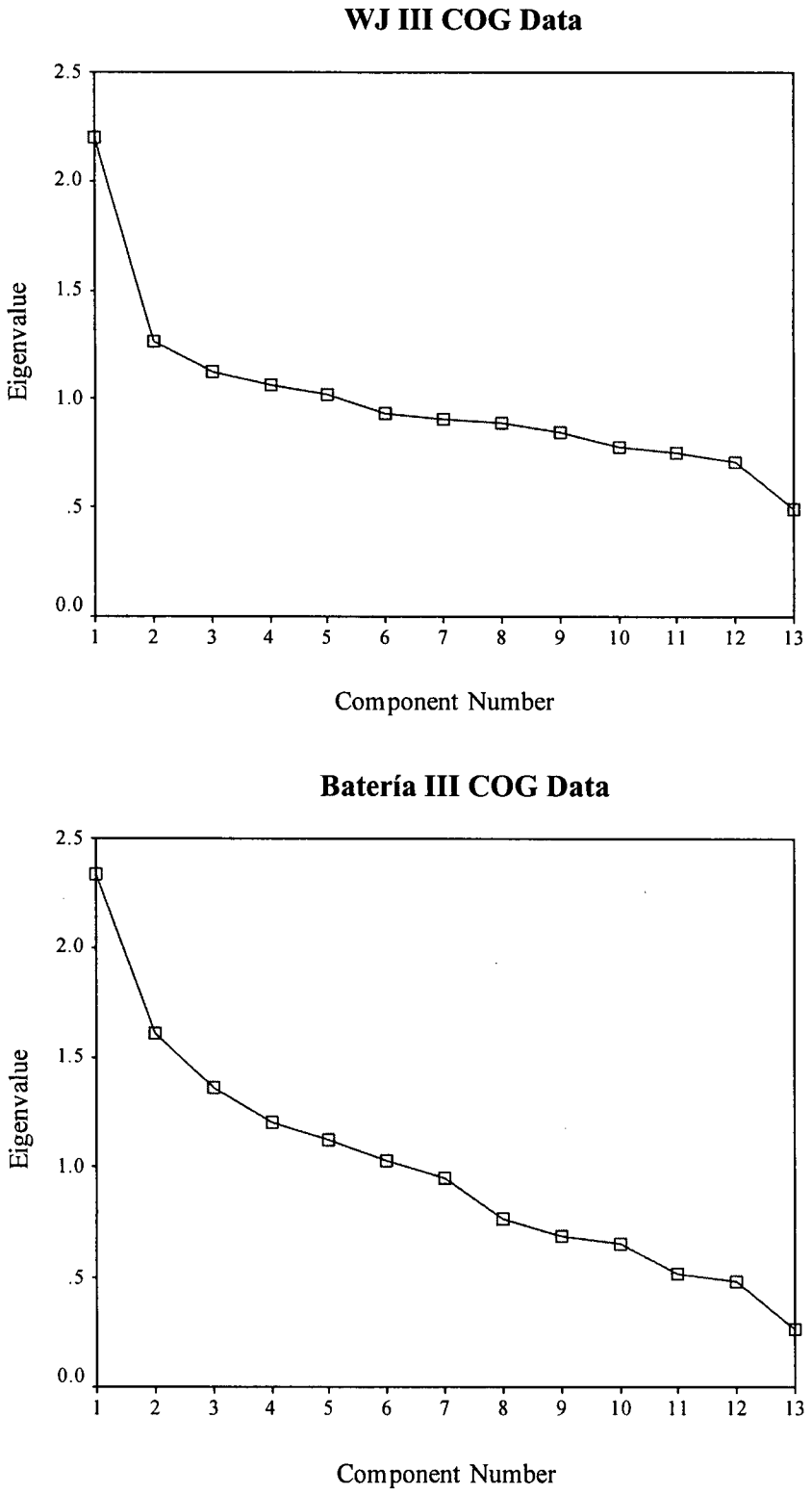


Figure 2. Scree Plots for *Visual Matching.*

In terms of the factor loadings, summarized in Table 13, Factor 4 for the English data and Factor 2 for the Spanish data have 3 items that overlap (Item numbers 41, 50, and 52). Factor 1 of the English data and Factor 5 of the Spanish data have 2 items in common (Items 43 and 45). Otherwise the pattern of loadings is not similar for the two language versions of the test.

Table 13

PROMAX Rotated Factor Loadings for Visual Matching

	WJ III COG					Batería III COG					
Item #	1	2	3	4	5	1	2	3	4	5	6
40			.73			.66					
41			.46	.56			.77				
42								.72			
43	.64			.37						.74	
44		.39	.53					.37		.30	.67
45	.56						.48		-.41	.58	
46		.73				.63					
47		.83				.32	.53	.35	-.42		
48	.63	.35				.65		.61			
49	.34		.55		.56						.82
50				.56			.73				
52				.68		.75	.40			-.39	
53					.83				.81		

Notes. Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 14) shows that for the WJ III COG Factor 1 correlates with the other factors somewhat, but that the correlations amongst the rest of the factors are very low, whereas for the Batería III COG Factor 1 correlates somewhat with Factors 2 and 3 positively, and 5 negatively. Most notable is that for the Batería III COG there are

negative correlations amongst factors, whereas all the correlations for the WJ III COG factors are positive.

Table 14

Inter-factor Correlation Matrix for Visual Matching

	WJ III COG					Batería III COG					
Factor	1	2	3	4	5	1	2	3	4	5	6
1	1.00					1.00					
2	.22	1.00				.20	1.00				
3	.26	.15	1.00			.17	.11	1.00			
4	.12	.01	.01	1.00		.01	-.23	-.04	1.00		
5	.15	.05	.08	.06	1.00	-.12	.19	-.06	-.26	1.00	
6						.03	-.02	.12	-.02	.13	1.00

Decision Speed

For *Decision Speed*, there were 40 common items for the WJ III COG and Batería III COG. Similar to *Visual Matching*, this is a timed test, and the same problems that occurred with *Visual Matching*, were also present with the test. As such, items were eliminated, and a factor analysis was completed with 23 items (Items 17 through 39).

As with the previous sets of analyses, the three tables (Tables 15-17) that relate to eigenvalues and variance accounted for, rotated factor loading values, and the inter-factor correlations for each of the language versions of the *Decision Speed* test are presented below.

The results of the PCA indicated that the different language versions are represented by a different number of factors. For the English test version, the eigenvalue criterion and scree test criterion (see Figure 3) differed in the number of factors that represents the data, with the former suggesting 10 factors, and the latter 5. After examining the percent of variance accounted for

each of the proposed factors, a 5-factor solution was settled on (each of the 5 factors accounts for more than 5% of the variance). For the Spanish test version there was also a difference between the eigenvalue criteria (9 factors) and scree test criteria (5 factors) in terms of number of factors for the solution. After examination of the percent of variance accounted for each of the proposed factors, a 6-factor solution was settled on (each of the 6 factors accounts for more than 5% of the variance). For the English test version, the first of five factors accounted for only 10% of the variance in the item data, and each of the rest of the factors accounted for 5% to 6 % of the variance. For the Spanish data, the first of six factor accounted for about 15%, and each of the remaining factors accounted for between 5% and 9% of the variance. The cumulative variance accounted for by the all of the factors was considerably more for the 6-factor solution for the Spanish data, with 49% of the variance accounted for by the six factors, while the 5-factor solution for the English data only accounted for 32% of the cumulative variance.

Table 15

PCA Eigenvalues and Variance Explained for Each Factor for Decision Speed

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	2.20	9.57	9.57	3.44	14.95	14.95
2	1.46	6.34	15.91	1.97	8.55	23.50
3	1.36	5.90	21.80	1.66	7.22	30.72
4	1.23	5.36	27.16	1.49	6.49	37.21
5	1.22	5.30	32.46	1.47	6.39	43.60
6	1.15	5.01	37.48	1.21	5.28	48.88
7	1.15	4.99	42.47	1.10	4.80	53.68
8	1.12	4.88	47.35	1.04	4.53	58.21
9	1.07	4.66	52.01	1.01	4.41	62.62
10	1.02	4.44	56.45			

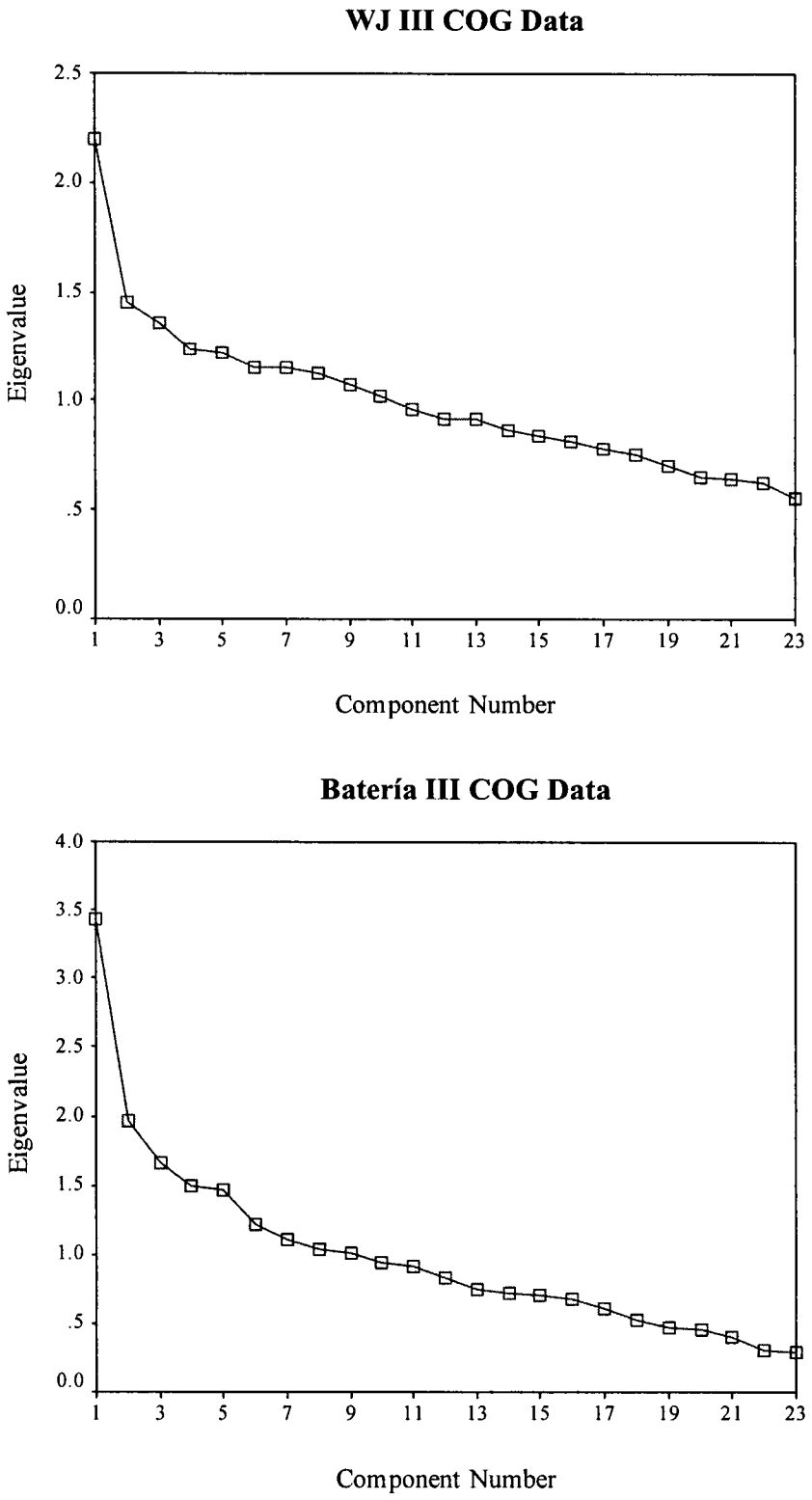


Figure 3. Scree Plots for *Decision Speed.*

In terms of the factor loadings, summarized in Table 16, Factor 1 for the Spanish data seems to have the last items load on it, it appears that these last items are represented by two factors (Factors 1 and 3) for the English data.

Table 16

PROMAX Rotated Factor Loadings for Decision Speed

	WJ III COG					Batería III COG					
Item #	1	2	3	4	5	1	2	3	4	5	6
17		.50					.67				
18		.39	.32								.59
19		.51						.61			
20		.52						.70			
21	.31	.30						.63			.36
22		.44					.68				
23	.54						.53				
24	.56			.37							.71
25			.56				.32		.33	.49	
26				.63					.30	-.43	
27					-.39			.35	.31		.44
28	.30	.46							.55		
29				.52					.71		
30				.42			.37			-.35	
31					.51				.42		
32					.37	.45					
33					.59	.65					
34	.39		.32			.60			.33	-.36	
35	.49					.64					
36			.50			.61					.30
37	.58					.56	-.36	.46	.46		
38			.61			.48		.33			
39	.41									.77	

Notes. Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 17) shows that for both the WJ III COG and Batería III COG factors are minimally to only somewhat correlated with one another.

Table 17

Inter-factor Correlation Matrix for Decision Speed

	WJ III COG					Batería III COG					
Factor	1	2	3	4	5	1	2	3	4	5	6
1	1.00					1.00					
2	.17	1.00				.06	1.00				
3	.11	.04	1.00			.23	.07	1.00			
4	.13	.18	.01	1.00		.16	.03	.10	1.00		
5	.06	.05	.08	-.06	1.00	-.17	.05	.00	-.22	1.00	
6						.13	.18	.06	.15	.06	1.00

Rapid Picture Naming

For *Rapid Picture Naming*, there were 120 common items for the WJ III COG and Batería III COG. This is also a timed test, and the problems that have been described previously related to these tests also apply to *Rapid Picture Naming*. As a result, a factor analysis was completed with 46 common items, which range between Item 39 and 89. The eigenvalues and variance accounted for, rotated factor loading values, and the inter-factor correlations for each of the language versions of the *Rapid Picture Naming* test are presented in Tables 18 to 20.

The results of the PCA indicated that the different language versions are represented by a different number of factors. For the English test version, the eigenvalue criterion and scree test criterion differed in the number of factors that represents the data, with the former suggesting 20 factors, and the latter 4. Examining the percent of variance accounted for each of the proposed factors indicated that only the first factor accounted for more than 5% of the variance, however,

because the scree plot (see Figure 4) indicates that there is still a sharp drop for successive factors, until after the fourth, a 4-factor solution was settled on. For the Spanish test version there was also a difference between the eigenvalue criteria (21 factors) and scree test criteria (1 factor) in terms of number of factors for the solution. After examining the percent of variance accounted for each of the proposed factors, a 1-factor solution was settled on because this was the only factor that accounted for more than 5% of the variance.

For the English test version, all four factors individually accounted for less than 10% of the variance in the item data. For the Spanish data, the one factor accounted for only 7% of the variance. The cumulative variance accounted for by all of the factors for the English data were 21%.

Table 18

PCA Eigenvalues and Variance Explained for Each Factor for Rapid Picture Naming

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	3.65	7.94	7.94	3.01	6.54	6.50
2	2.49	5.42	13.36	1.82	3.96	10.50
3	1.80	3.91	17.28	1.77	3.85	14.35
4	1.54	3.35	20.63	1.73	3.76	18.11
5	1.44	3.12	23.75	1.68	3.65	21.77
6	1.40	3.05	26.80	1.63	3.55	25.32
7	1.39	3.03	29.82	1.58	3.43	28.75
8	1.31	2.84	32.66	1.51	3.29	32.03
9	1.25	2.72	35.38	1.46	3.17	35.21
10	1.18	2.57	37.95	1.43	3.11	38.32
11	1.18	2.55	40.51	1.42	3.10	41.41
12	1.15	2.51	43.01	1.29	2.80	44.21
13	1.10	2.40	45.41	1.23	2.67	46.89
14	1.06	2.30	47.71	1.18	2.56	49.44
15	1.03	2.24	49.94	1.15	2.51	51.95
16	1.02	2.22	52.17	1.13	2.45	54.40
17	1.00	2.18	54.35	1.09	2.37	56.77
18	1.00	2.18	56.52	1.06	2.31	59.07
19	1.00	2.18	58.70	1.06	2.30	61.37
20	1.00	2.18	60.88	1.03	2.23	63.59
21				1.02	2.21	65.80
22				1.00	2.18	67.98

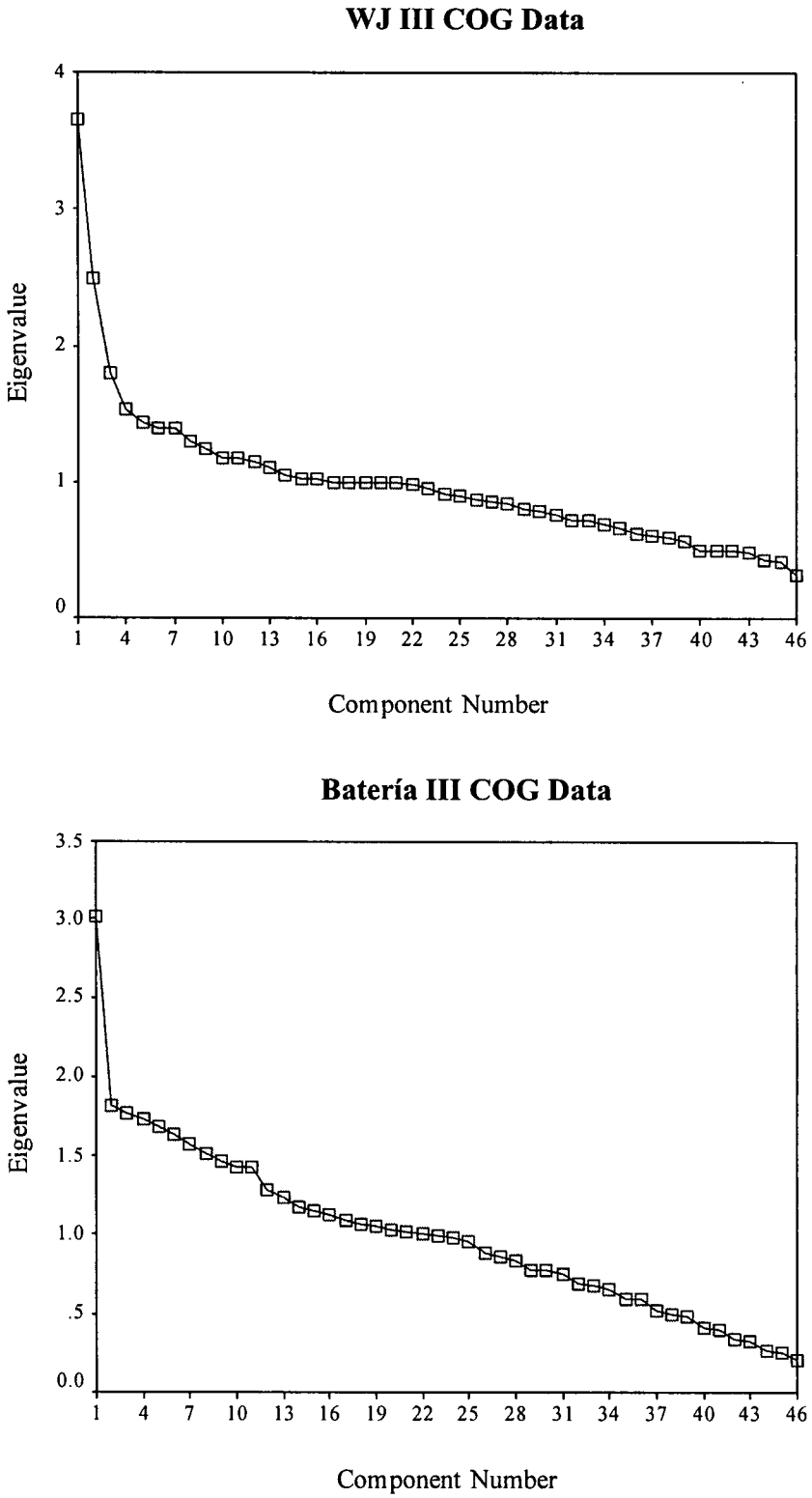


Figure 4. Scree Plots for *Rapid Picture Naming.*

In terms of the factor loadings (see Table 19), there were some similarities, where two items (Items 37 and 38) of the Spanish factor overlap with Factor 3 of the English data structure, and another three items (Items 43, 49, and 65) overlap with the second component of the English factor solution.

Table 19

PROMAX Rotated Factor Loadings for Rapid Picture Naming

	WJ III COG				Batería III COG
Item #	1	2	3	4	1
30					.63
31				.69	
33					
34					.44
35					
36					
37			.74		.42
38			.76		.53
39					
40				.49	
41		.56	.59		
43		.62			.60
44					
47		.73			
48					.56
49		.49			
51				.59	
53					
55					
58					
59					.43
63					.51
64					
65		.32			.30
66		.73			
67					
68		.37		.50	
69					.55
71		.30			
72					
73					
74	.40				
75					
76	.31				
77	.43				
78					
79					
80	.33				
81	.59				
82	.67				
83	.58				
85	.48		.47		
86	.64				
87	.62				
88					
89	.75				

Notes. Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 20) indicated that the factors for the English data are not correlated with one another.

Table 20

Inter-factor Correlation Matrix for Rapid Picture Naming

	WJ III COG				Batería III COG
Factor	1	2	3	4	1
1	1.00			1.00	1.00
2	.06	1.00			
3	.05	.10	1.00		
4	.05	.07	-.10	1.00	

Picture Recognition

For *Picture Recognition*, there were 10 common items for the WJ III COG and Batería III COG, which represents approximately half of the total number of items published for both language versions of this test (24 items). Of these 10 common items, there was very little to no variance in scores for the first 4 items. These four items represent very early and very easy items, and as a result very few people responded incorrectly to them.

Three tables (Tables 21 to 23) are related to *Picture Recognition*, and contain information on the eigenvalues and amount of variance accounted for by an unrotated factor solution, a summary of the rotated factor loadings, and the inter-factor correlations, for each of the language versions.

The results of the PCA indicated the data are represented by two and three factors for the WJ III COG and Batería III COG, respectively. For the English test version, the eigenvalue criterion and scree test criterion (see Figure 5) were in agreement for a 2-factor solution;

however, they were not in agreement for the Spanish test version data. For the Spanish test version the eigenvalue criteria suggested three factors, while the scree test criteria indicated one factor. By examining the percent of variance accounted for each of the proposed factors, a 3-factor solution was settled on because each of the three factors accounted for more than 15% of the variance. The first factor for both language versions accounted for similar amounts of variance, 26% and 27%, for the English and Spanish data, respectively.

Table 21

PCA Eigenvalues and Variance Explained for Each Factor for Picture Recognition

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	1.53	25.51	25.51	1.64	27.41	27.41
2	1.08	19.91	43.43	1.17	19.54	46.95
3				1.04	17.27	64.22

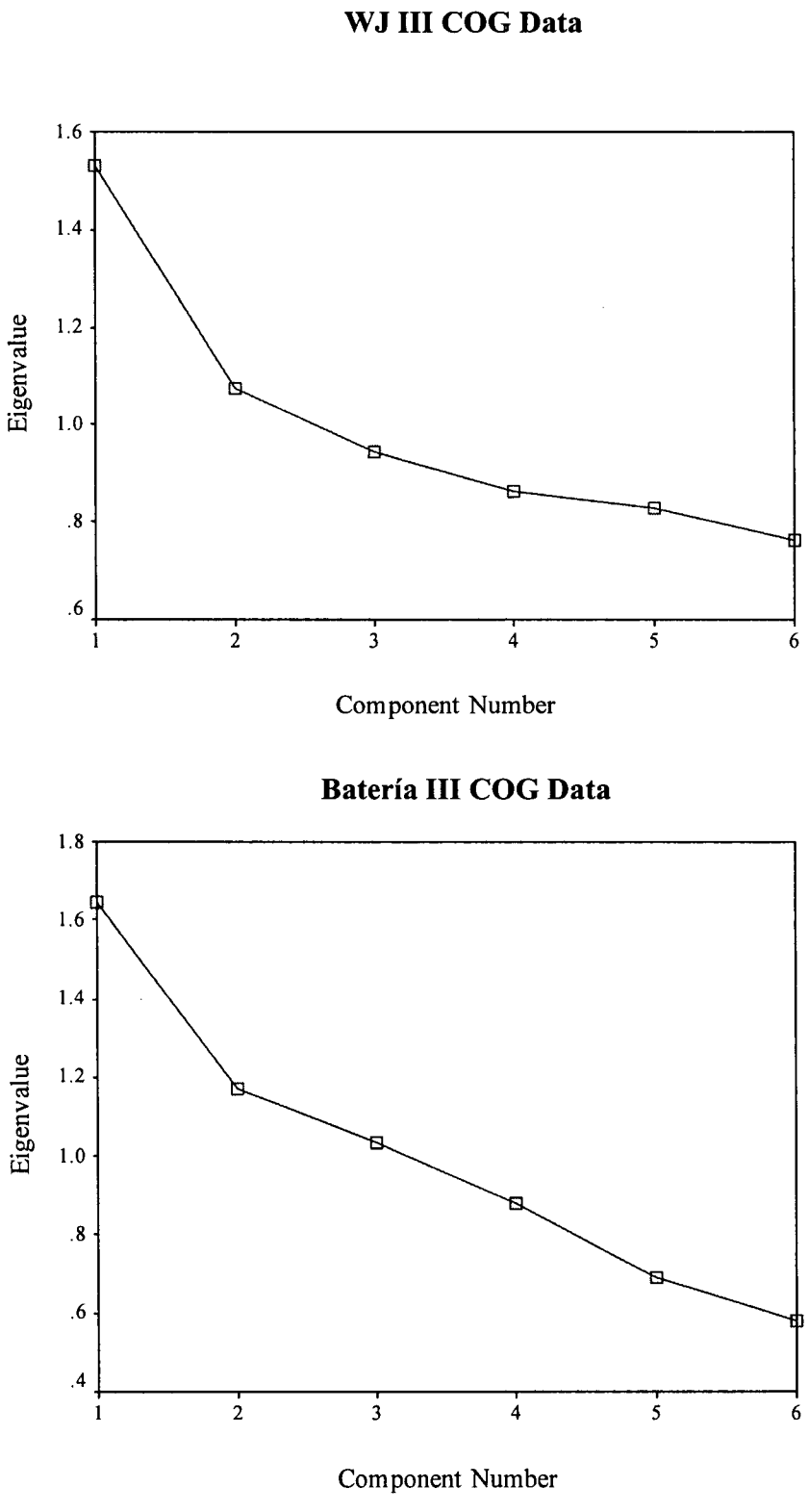


Figure 5. Scree Plots for *Picture Recognition.*

The factors that represent the English data corresponded to items that are presented earlier to examinees and items presented later to examinees, however this pattern is not quite as clear for the Spanish data. In both cases Item 23 (the last item) is associated with items that were presented earlier to examinees (i.e., Factor 1 for the English data and Factor 2 for the Spanish data).

Table 22

PROMAX Rotated Factor Loadings for Picture Recognition

	WJ III COG		Batería III COG		
Item #	1	2	1	2	3
11	.62	-.52			.78
16	.64			.78	
17	.50		.48	.59	-.54
22		.66	.76		.30
23		.63	.83		
24	.49	.34		.59	

Notes. Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 23) suggests that Factors 1 and 2, for the English data are not correlated. However, there is somewhat of a correlation between the first and second factors for the Spanish data, but Factor 3 is minimally correlated with the other factors.

Table 23

PCA Inter-factor Correlation Matrix for Picture Recognition

	WJ III COG		Batería III COG		
Factor	1	2	1	2	3
1	1.00		1.00		
2	-.01	1.00	.27	1.00	
3			-.09	-.15	1.00

For the following two tests, *Concept Formation* and *Analysis-Synthesis*, factor analyses were completed using TESTFACT (Wilson et al., 1991).

Concept Formation

For *Concept Formation*, there were 35 common items for the WJ III COG and Batería III COG, which represents all the items associated with the use of Introduction 2, which is typically used for participants who are in Grade 2 and above. The factor analyses results related to *Concept Formation* are given in Tables 24 to 26.

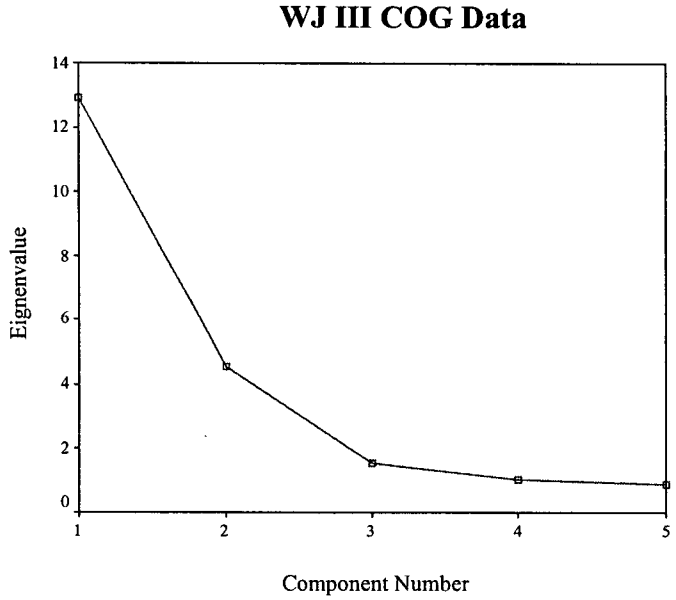
The results of the FIFA indicated the data are best represented by a 2-factor solution, for both different language versions of this test. For the English test version, the eigenvalue criterion and scree test criterion (see Figure 6) differed in the number of factors that represents the data, with the former suggesting four factors, and the latter suggesting two factors. Similarly, for the Spanish test version, the eigenvalue criterion and scree test criterion also differed in the number of factors that represents the data, with the former suggesting five factors, and the latter suggesting two factors. After examining the percent of variance accounted for each of the proposed factors, a 2-factor solution was settled on for both test versions, because each of these factors accounted for more than 5% of the variance. For the English test version, the first of the two factors accounted for 44% of the variance in the item data, and the second factor accounted

for an additional 6% of the variance. For the Spanish data, the two factors accounted for 49% and 9% of the variance, respectively. The cumulative variance accounted for by the all of the factors was 50% and 59% for the English and Spanish data, respectively.

Table 24

FIFA Eigenvalues and Variance Explained for Each Factor for Concept Formation

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	12.82	43.93	43.93	12.18	49.42	49.42
2	4.46	5.68	49.61	5.09	9.34	58.76
3	1.51	4.19	53.80	1.69	4.08	62.84
4	1.00	2.26	56.06	1.47	3.87	66.71
5				1.18	3.09	69.80



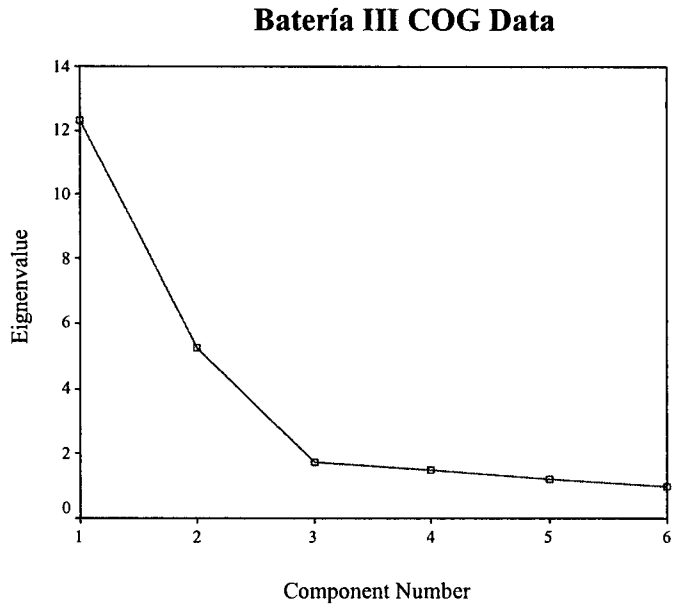


Figure 6. Scree Plots for *Concept Formation.*

In terms of the factor loadings, summarized in Table 25, for both the English and Spanish data the separate factors corresponded to items early and late items, however they are represented somewhat differently. For example, for the WJ III COG, more difficult items load primarily on Factor 1, however there are several of the difficult items that load on Factor 2, which represents the first half of the test. For the Batería III COG, all of the items that represent the second half of the test primarily load on the first factor. Interestingly, for Items 32, 36, and 38, which load on the second factor for the English data, also have factor loadings greater than .3 on the second factor for the Spanish data (although they have higher loading on the first factor).

Table 25

PROMAX Rotated Factor Loadings for Concept Formation

	WJ III COG		Batería III COG	
Item #	1	2	1	2
6		0.34		0.76
7				0.81
8		0.67		0.74
9		0.58		0.77
10	-0.42	0.84		0.60
11		0.90		0.90
12		0.89		0.68
13		0.64		0.75
14		0.69		0.66
15		0.63		0.73
16		0.73		0.86
17		0.52	0.30	0.58
18		0.54		0.57
19		0.40		0.70
20		0.59	0.30	0.55
21		0.51	0.57	
22		0.65	0.44	0.30
23		0.50	0.49	
24	0.61		0.80	
25	0.76		0.77	
26	0.68		0.68	
27	0.86		0.78	
28	0.84		0.77	
29	0.81		0.76	
30	0.45		0.89	-0.64
31	0.38		0.84	-0.35
32		0.55	0.45	0.34
33	0.73		0.82	
34		0.41	0.74	
35	0.90		0.74	
36		0.49	0.40	0.34
37	0.95		0.80	
38	0.31	0.43	0.50	0.30
39	0.63		0.73	
40	1.01		0.65	

Notes: Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 26) shows that the two factors are strongly correlated for both the English and Spanish data.

Table 26

Inter-factor Correlation Matrix for Concept Formation

	WJ III COG		Batería III COG	
Factor	1	2	1	2
1	1.00		1.00	
2	.75	1.00	0.61	1.00

Because the factor solutions for both language versions contain the same number of factors, it is possible to calculate congruence coefficients for each factor, providing an indicator of how comparable the factor solutions are. The resulting congruence coefficients were, .90 for the first factors, and .85 for the second factors, indicating that both factors are quite comparable between the two language versions.

Analysis-Synthesis

For *Analysis-Synthesis*, there were 35 common items for the WJ III COG and Batería III COG, which represents all the items. The factor analyses results related to *Analysis-Synthesis* are given in Tables 27 to 29.

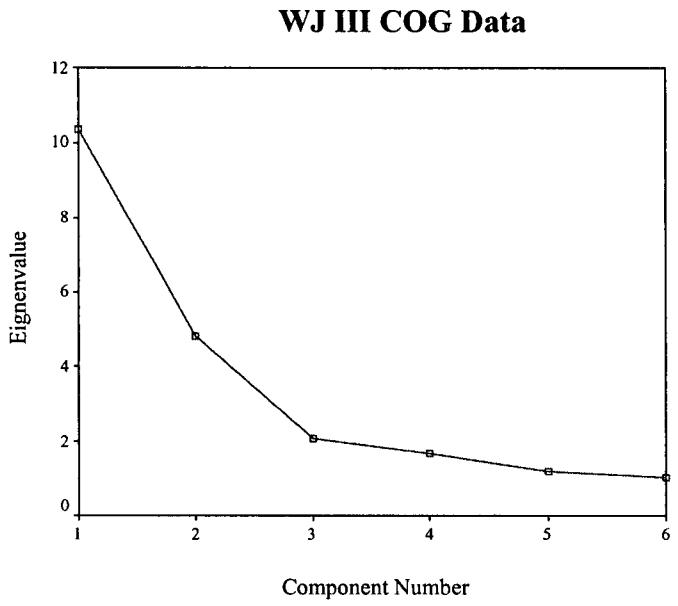
The results of the FIFA indicated the number of factors that represent that data are different for the two language versions of this test. For the English test version, the eigenvalue criterion and scree test criterion (see Figure 7) differed in the number of factors that represents the data, with the former suggesting six factors, and the latter suggesting two factors. After examining the percent of variance accounted for each of the proposed factors, a 3-factor solution

was settled on because each of the factors accounted for more than 5% of the variance. Similarly, for the Spanish test version, the eigenvalue criterion and scree test criterion also differed in the number of factors that represents the data, with the former suggesting seven factors, and the latter suggesting three factors. After examining the percent of variance accounted for each of the proposed factors, a 3-factor solution was settled on for both test versions because each of the factors accounted for more than 5% of the variance. For both language versions of this test, there is a similar pattern for how much variance is accounted for by each of the factors. With the first factor for both test versions accounting for 36% of the variance, the second factor accounting for 11 to 13% of the variance (the English and Spanish test, respectively), and the third factor accounting for approximately another 5% of the variance. The cumulative variance accounted for by the all of the factors was 53% and 55% for the English and Spanish data, respectively.

Table 27

FIFA Eigenvalues and Variance Explained for Each Factor for Analysis-Synthesis

	WJ III COG			Batería III COG		
Factors	Eigenvalue	% of Variance accounted for	Cumulative %	Eigenvalue	% of Variance accounted for	Cumulative %
1	10.21	36.47	36.47	9.60	35.79	35.79
2	4.70	11.02	47.49	4.56	12.90	48.69
3	1.90	5.42	52.91	3.05	5.95	54.64
4	1.65	4.02	56.93	1.77	4.70	59.34
5	1.12	3.47	60.40	1.49	4.21	63.55
				1.16	4.21	67.76
				1.03	2.22	69.98



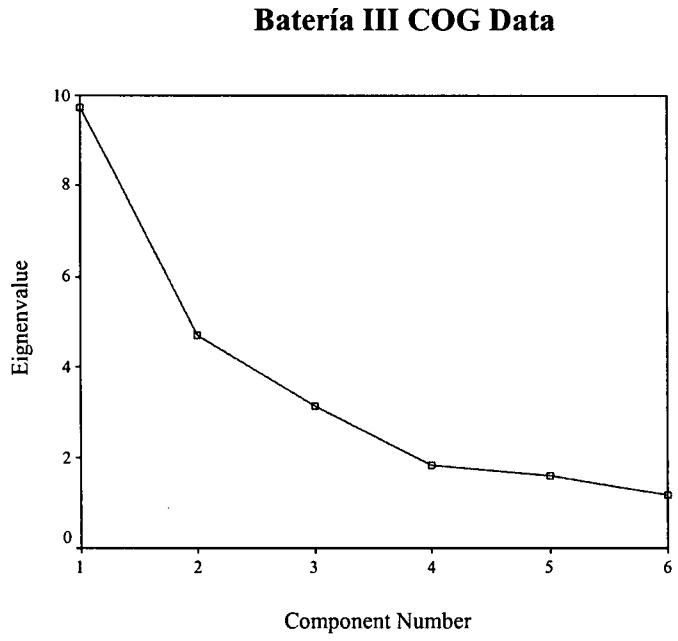


Figure 7. Scree Plots for *Analysis-Synthesis.*

In terms of the factor loadings, summarized in Table 28, for both the English and Spanish data, separate factors primarily correspond to item order, items located at the beginning of the test on one factor, items located at the middle of the test on another factor, and items located at the end of the test on a third factor. However, there are some inconsistencies with this pattern for some items. For instance, while the first 19 items all primarily load on to Factor 1 for the English data, the first five items for the Spanish data load on to Factor 2 or 3, and only Items 6 to 19 load primarily on to Factor 1 in the same way as the English data. Conversely, while all the later items (Items 27 to 35) load primarily on one factor (Factor 2) for the Spanish data, these items are dispersed amongst the three factors for the English data.

Table 28

PROMAX Rotated Factor Loadings for Analysis-Synthesis

	WJ III COG			Batería III COG		
Item #	1	2	3	1	2	3
1	0.40					0.87
2	0.68	0.31				0.56
3	0.85	0.42	-0.47		-0.32	1.01
4	0.36				0.31	
5	0.71		-0.30			0.34
6	0.64			0.50		
7	0.81			0.77		
8	0.73			0.72		-0.31
9	0.75			0.76		
10	0.60	-0.30		0.48		0.41
11	0.45			0.58		
12	0.65	-0.46		0.73	-0.36	
13	0.38			0.35		
14	0.65			0.78		
15	0.96			0.99		
16	0.71			0.91	-0.37	
17	0.59			0.73		
18	0.44			0.64		
19	0.79			0.94		
20			0.88			0.67
21			0.57	0.42		0.37
22			0.75			0.75
23			1.02			0.81
24			0.94		0.30	0.62
25			0.79			0.77
26			0.63		0.39	0.40
27				0.31	0.32	
28		0.70			0.74	
29		0.84			0.69	
30	-0.40	0.56			0.73	
31	-0.40		0.33		0.50	
32		0.38	0.39		0.68	
33		0.72			0.83	
34	0.35		0.42	0.37	0.47	
35	0.39		0.37		0.49	0.31

Notes. Factor loadings less than .30 are omitted.

The inter-factor correlation matrix (Table 29) showed that for both the WJ III COG and Batería III COG Factors 1 and 3 are strongly correlated with each other. To get an indication of

how comparable the factor solutions are between the language versions congruence coefficients were calculated for each factor. The resulting congruence coefficients were, .83, .80, and .60, for Factors 1, 2, and 3, respectively. This indicates that the first two factors are quite comparable between the two language versions, but that the third factor is not.

Table 29

Inter-factor Correlation Matrix for Analysis-Synthesis

	WJ III COG			Batería III COG		
Factor	1	2	3	1	2	3
1	1.00			1.00		
2	0.16	1.00		.036	1.00	
3	0.61	0.35	1.00	0.57	0.47	1.00

Summary

In this section, results related to the examination of the factor structure similarity between the tests administered in English and Spanish were presented. A summary of the factor solutions for each test and language version is presented in Table 30. The information provided in the table includes for each test, the type of factor analysis (PCA or FIFA), the number of factors in the factor solution for each language, and the evaluation of the congruence coefficients (i.e., the degree to which the factors are congruent) for tests with the same number of factors.

Three (*Spatial Relations*, *Concept Formation*, and *Analysis-Synthesis*) of the seven tests had the same number of factors represent both language versions. The remaining four tests had different numbered factor solutions between the two language versions. For the tests with the same number of factors representing both language versions data, the congruence coefficients ranged from .60 to .98 and, except in the case of the .60, indicated the factors were somewhat to

very comparable. In terms of the tests for which the data were best represented by a different number of factors for the two language versions the following were observed. The percent of variance accounted for by the first factor for all of these tests, for both languages, were lower (7% to 18%) than for the tests with the same number of factors in the factor solution (27% to 49%), as well, the factor solutions typically involved more factors than the tests with the same number of factors representing both language versions.

Table 30

Summary of Number of Factors for the WJ III COG and Batería III COG

Test	Type of Factor Analysis	Number of Factors		Congruence Coefficients Evaluation
		WJ III COG	Batería III COG	
Spatial Relations	PCA	2	2	Very Comparable to Quiet Comparable
Picture Recognition	PCA	2	3	—
Visual Matching	PCA	5	6	—
Decision Speed	PCA	5	6	—
Rapid Picture Naming	PCA	4	1	—
Concept Formation	FIFA	2	2	Quiet Comparable
Analysis-Synthesis	FIFA	3	3	Quiet Comparable to Not Comparable

Stage 2 - Internal Consistency

This section presents the results of analyses related to the *internal consistency*, or the degree to which individuals' scores would remain relatively consistent over repeated administrations of the same test or alternate test forms (Crocker & Algina, 1986), of each of the translated tests for each of the respective batteries. This set of analyses can be used to compare

the measurement accuracy for each of these batteries (and language groups); are the purported constructs measured with the same accuracy for each of the language groups? This provides another piece of evidence about the comparability of the tests of the WJ III COG and the tests of the Batería III COG.

The calculated reliability estimates for each of the selected tests are shown in Table 31. Included in the table is information about which method, Cronbach alpha or Feldt-Raju, was used to calculate the internal consistency estimate. As indicated earlier, the method depended on the different scoring schemes for the different tests, that is, for all tests that contained only dichotomously scored items internal consistency was calculated using Cronbach alpha, whereas for tests that utilize multiple point scoring systems internal consistency was calculated using Feldt-Raju. These estimates, calculated separately for each population, are compared in an effort to identify differences in the internal consistency of the scores for the English and Spanish versions of these tests.

Table 31

Reliabilities for the Selected Tests of the WJ III COG and Batería III COG

Test	# of Common Items	Reliability Method	WJ III COG	Batería III COG	|Difference|
Spatial Relations	12	Feldt-Raju	0.77	0.92	0.15
Concept Formation	35	Cronbach alpha	0.94	0.96	0.02
Visual Matching	60	Cronbach alpha	0.94	0.96	0.02
Picture Recognition	10	Feldt-Raju	0.90	0.85	0.05
Analysis-Synthesis	35	Cronbach alpha	0.87	0.89	0.03
Decision Speed	40	Cronbach alpha	0.91	0.91	0.00
Rapid Picture Naming	120	Cronbach alpha	0.97	0.97	0.00

The reliability estimates tended to be very similar for the two groups and ranged between .77 to .97 for the English test version and .85 to .97 for the Spanish test version. The last column in the table presents the absolute difference between the internal consistency estimates for the English and Spanish administrations, separately for each test. The difference between internal consistency estimates between the two language administrations ranged from no difference to .15. The only difference between internal consistency estimates for the different language administrations that seems noteworthy, is that of *Picture Recognition*, where the difference is .15. A difference of this magnitude suggests that there exists a meaningful difference between the estimates of internal consistency for the selected common items for this test. In other words, it appears that for this test, the set of common items are more internally consistent for the Spanish test version (r=.92) than for the English test version (r=.77).

Stage 3 - Item Response Theory Based Analyses

IRT based analyses were limited to 3 of the 7 selected tests. For a number of items, and for some tests overall, there was limited variability in the response patterns. Response sets for items need to include correct as well as incorrect responses in order to have stable and reliable parameter estimates. In the case where there are large numbers of items with high p-values (proportion correct), where very few people are providing incorrect responses, parameter estimates can be unreliable. As a result, IRT related analyses, including DIF, Item and Test Information, and Correlation of Item Parameters, could not be completed on the timed tests (*Visual Matching*, *Decision Speed*, and *Rapid Picture Naming*). For these tests items are very similar from beginning to end, with only minor changes to increase the difficulty of an item, and it is the speed with which one gets through the task that separates people on an ability scale. Consequently, there is very little variability in item responses for all the items contained on these

tests. That is, typically if a person reached an item, it was likely they were to get it correct. For most of the items for these tests the p-values (difficulty) were greater than .95. The implication for the other tests was that items with p-values greater than .95 were removed from the IRT based analyses in order that the estimating procedure for the rest of the items was more stable and reliable. Lastly, the Spanish sample that completed *Picture Recognition* was too small to provide reliable and stable parameter estimates, and was therefore also excluded from this set of analyses.

There were two other instances in which items were not included for some or all of the IRT based analyses. One situation was when, after the iteration process when estimating parameters, the calibration procedure did not converge, and parameters could *not* be estimated. The other situation was specific to the DIF detection procedure. The DIF detection procedure for any item divides the two samples into deciles, based on their total score in order to match people with similar scores (or ability), to detect differences in response patterns between the two groups. As a result, there are instances when the case counts in a particular decile(s) is too low, or even empty, for one language group, and a DIF statistic can not be calculated. A summary of items eliminated and the accompanying reason is presented in Table 32.

Table 32

Summary of Eliminated Items and Reasons for Elimination for IRT Related Analyses

Test	Eliminated Item(s)	Reason for Elimination
Spatial Relations	1 to 2, 4 to 5, and 9	p-value[†]>.95
Concept Formation	6 to 7, and 11 21 to 40*	p-value>.95 Empty cells
Picture Recognition	All	Sample size for Batería III COG too small for stable parameter estimates
Analysis-Synthesis	1-5, 7-10, 12, 15-17 23, 24	p-value>.95 Could not be estimated
Visual Matching	All	Little to no variance in item scores
Decision Speed	All	Little to no variance in item scores
Rapid Picture Naming	All	Little to no variance in item scores

[†] Indicates difficulty level of the item
* Impacts only the DIF analyses

PARDUX (Burket, 1998) and its companion software FLUX (Burket, 1993) were used to perform the Item Response Theory based analyses, including DIF detection, investigation of item and test information, and the correlation of parameter estimates.

Evaluation of the IRT Model Assumptions

There are three assumptions related to the use of IRT models: (a) the ability being measured is *unidemsional*, (b) an examinee's responses to the items in a test have local independence, and (c) the item responses *fit* the IRT model (Hambleton et al., 1991). The evaluations of each of these are presented below and summarized in Table 33.

Table 33

Evaluation of IRT Assumptions

Test	# of Common Items	Unidimensional	# of Items with Poor Fit (Q_1)[1]	# of Item-Pairs with Local Dependency (Q_3)[2]
Spatial Relations	7	Yes	4	0
Concept Formation	32	Yes	10	1
Analysis-Synthesis	21	Yes	8	3

[1] Poor fit is defined as $z>4.60$.
[2] Local dependence is defined as $Q_3 \geq 0.200$.

Unidimensionality.

The assumption of unidimensionality can be satisfied if the test data can be represented by a "*dominant* component or factor" (Hambleton, 1989, p. 150). Using this criteria for each test included in the IRT based analyses the factor analytic results indicated that these tests were essentially unidimensional, as represented by a dominant factor for all the solutions (see Tables 9, 24, and 27). Essential unidimensionality requires the existence of a dominant factor and is considered sufficient to satisfy the unidimensionality assumption in IRT applications.

Item fit.

The chi-square-based Q_I goodness of fit statistic (Yen, 1981) was examined for the LH DIF analyses to examine whether there was model misfit by the estimating procedures. Tables 34 through 36 present information on model fit for each item, for *Spatial Relations*, *Concept Formation* and *Analysis-Synthesis*, respectively. Items that display model misfit as identified by the Q_I statistic are in bold italic typeface. For the *Spatial Relations* test four out of the seven items were identified as misfitting, for the *Concept Formation* 10 out of 32 items were identified

as misfitting, and lastly, the 8 out of 21 items were identified as having poor fit for the *Analysis-Synthesis* test.

Examination of the differences between Observed and Predicted for the worst item in each test (Item 33 for *Spatial Relations*, Item 16 for *Concept Formation*, and Item 35 for *Analysis-Synthesis*) reveal that in each case this difference is nearly zero. The fact the that total difference between the observed and predicted values is nearly zero for the poorest fitting items suggests that there is indeed a good fit between the item data and the model, and that the size of the sample may be inflating the chi-square statistic.

Table 34

Q_1 Goodness of Fit Results for Spatial Relations

Item #	Total N	χ^2	*df*	*Z*-value	Observed	Predicted	Observed-Predicted
12	1883	35.62	17	3.19	0.943	0.925	0.019
15	1877	34.50	26	1.18	0.902	0.893	0.009
17	1875	43.44	17	4.53	0.805	0.798	0.007
20	***1868***	***99.94***	***17***	***14.22***	***0.700***	***0.702***	***-0.002***
26	***1701***	***67.21***	***26***	***5.71***	***0.708***	***0.721***	***-0.013***
32	***1689***	***114.11***	***26***	***12.22***	***0.656***	***0.672***	***-0.016***
33	***1684***	***170.13***	***26***	***19.99***	***0.593***	***0.616***	***-0.024***

Notes. Items that display model misfit as identified by the Q_1 statistic are in bold italic typeface.

Table 35

Q_l Goodness of Fit Results for Concept Formation

Item #	Total N	χ^2	*df*	*Z*-value	Observed	Predicted	Observed-Predicted
8	***1844***	***25.68***	***8***	***4.42***	***0.937***	***0.919***	***0.018***
9	***1844***	***27.52***	***8***	***4.88***	***0.894***	***0.878***	***0.016***
10	1844	22.75	8	3.69	0.952	0.935	0.017
12	***1829***	***24.80***	***8***	***4.20***	***0.921***	***0.912***	***0.010***
13	***1829***	***25.93***	***8***	***4.48***	***0.858***	***0.851***	***0.008***
14	1829	17.86	8	2.47	0.861	0.852	0.008
15	***1829***	***29.85***	***8***	***5.46***	***0.873***	***0.865***	***0.009***
16	***1829***	***43.45***	***8***	***8.86***	***0.899***	***0.890***	***0.009***
17	1828	16.05	8	2.01	0.874	0.865	0.009
18	1829	21.34	8	3.34	0.800	0.793	0.007
19	***1829***	***24.53***	***8***	***4.13***	***0.856***	***0.847***	***0.008***
20	1828	23.87	8	3.97	0.882	0.873	0.009
21	1684	12.00	8	1.00	0.775	0.775	0.001
22	***1684***	***27.13***	***8***	***4.78***	***0.567***	***0.572***	***-0.005***
23	1684	12.31	8	1.08	0.618	0.621	-0.003
24	1679	10.45	8	0.61	0.536	0.539	-0.003
25	1679	12.57	8	1.14	0.469	0.474	-0.005
26	1677	10.33	8	0.58	0.516	0.519	-0.004
27	1673	17.22	8	2.31	0.497	0.501	-0.004
28	1673	18.12	8	2.53	0.488	0.493	-0.004
29	1668	11.21	8	0.80	0.444	0.450	-0.006
30	1474	20.09	8	3.02	0.873	0.877	-0.004
31	1475	15.56	8	1.89	0.834	0.839	-0.005
32	***1475***	***37.14***	***8***	***7.28***	***0.713***	***0.720***	***-0.008***
33	1475	18.31	8	2.58	0.585	0.593	-0.008
34	1475	13.48	8	1.37	0.730	0.737	-0.006
35	1472	8.29	8	0.07	0.361	0.373	-0.012
36	1474	13.74	8	1.43	0.647	0.656	-0.009
37	***1474***	***24.03***	***8***	***4.01***	***0.409***	***0.420***	***-0.011***
38	1474	6.50	8	-0.37	0.765	0.771	-0.006
39	1473	20.51	8	3.13	0.631	0.639	-0.007
40	1468	11.98	8	1.00	0.435	0.445	-0.010

Notes. Items that display model misfit as identified by the Q_l statistic are in bold italic typeface.

Table 36

Q_1 Goodness of Fit Results for Analysis-Synthesis

Item #	Total N	χ^2	*df*	*Z*-value	Observed	Predicted	Observed-Predicted
6	1788	12.53	8	1.13	0.904	0.893	0.011
11	1788	8.14	8	0.03	0.951	0.944	0.007
13	1787	13.40	8	1.35	0.802	0.798	0.004
14	1788	10.46	8	0.62	0.912	0.905	0.008
18	1788	9.62	8	0.41	0.859	0.854	0.005
19	1788	15.53	8	1.88	0.939	0.928	0.011
20	1763	13.58	8	1.39	0.841	0.832	0.009
21	1763	10.10	8	0.52	0.880	0.875	0.006
22	1763	14.07	8	1.52	0.751	0.744	0.007
23	1762	9.87	8	0.47	0.780	0.772	0.009
25	***1759***	***26.65***	***8***	***4.66***	***0.723***	***0.717***	***0.006***
26	***1695***	***39.09***	***8***	***7.77***	***0.589***	***0.592***	***-0.003***
27	***1695***	***38.64***	***8***	***7.66***	***0.422***	***0.432***	***-0.010***
28	***1693***	***34.58***	***8***	***6.65***	***0.233***	***0.247***	***-0.014***
29	***1690***	***34.19***	***8***	***6.55***	***0.218***	***0.234***	***-0.016***
30	1689	18.77	8	2.69	0.131	0.144	-0.013
31	1688	5.70	8	-0.58	0.145	0.155	-0.010
32	***1399***	***38.69***	***8***	***7.67***	***0.288***	***0.310***	***-0.022***
33	1399	23.15	8	3.79	0.142	0.167	-0.025
34	***1395***	***31.72***	***8***	***5.93***	***0.485***	***0.501***	***-0.015***
35	***1398***	***43.20***	***8***	***8.80***	***0.544***	***0.556***	***-0.012***

Notes. Items that display model misfit as identified by the Q_1 statistic are in bold italic typeface.

Local item dependence (LID).

The Q_3 statistic developed by Yen (1984) was used to evaluate that examinees' responses to the items in a test are statistically independent, one of the three assumptions related to the use of IRT models. The Q_3 statistic is the correlation between the performance on two items after taking into account overall test performance. An item pair was flagged as locally *dependent* if $|Q_3| \geq .20$ (Ercikan et al., 1998).

Overall, there were only four item pairs flagged as LID (See Table 33) across all three tests included in the IRT-based analysis. The Q_3 values for these four item pairs ranged from .2 to .3 (see Table 37). In three out of the four instances of item pairs identified as LID, the pair of

items are presented one after the other to examinees. While there were three item pairs identified as LID for *Analysis-Synthesis*, this represents a very small portion of the total possible number of item pairs. That is, there were only three item pairs flagged as LID out of 210 item pairs. While a large amount of LID results in inaccurate estimates of item parameters and test information (Yen, 1993), this small amount of LID is expected to have minimal effects on item parameters.

Table 37

Item Pairs with Local Item Dependency (LID)

Test	Item Pair	$\|Q_3\|$ Value
Concept Formation	30 and 31	.30
Analysis-Synthesis	14 and 19	.20
	28 and 29	.28
	30 and 31	.21

Identification of Differential Item Functioning

The LH (Linn & Harnisch, 1981) DIF detection procedure was used to detect DIF items for the selected tests of cognitive ability. The main purpose of DIF detection procedures is to determine whether the relative performance of the members of a minority or subgroup and members of the majority group is the same or different. The results of the DIF detection procedures are summarized in Table 38. Table 38 presents the number of items for which DIF procedures were performed, whether or not the item favoured the English (Pro-English) or the Spanish (Pro-Spanish) language groups, and their degree of DIF (Level 2 or Level 3) for each test. For example, for the *Concept Formation* test, 12 items went through the DIF detection

procedure, of which there were two items identified as DIF. These two items were Level 2 DIF and favoured the participants who were administered the English language test version.

Overall, out of 40 items, 9 items were identified as DIF in the English and Spanish versions of the Tests of Cognitive Ability. Of these DIF items, 67% (six items) functioned in favour of the English test version. In terms of the specific tests, the *Spatial Relations* test had the greatest number of DIF items (six out of seven items), which were evenly split between the language versions in terms of which population the items favoured. The *Concept Formation* and *Analysis-Synthesis* tests had only three DIF items between them, all of which favoured the participants administered the English test version.

Table 38

Number of DIF Items for Each Test of Cognitive Ability

		Pro-English		Pro-Spanish	
Test	# of Common Items	Level 2	Level 3	Level 2	Level 3
Spatial Relations	7	1	2	1	2
Concept Formation	12	2	0	0	0
Analysis-Synthesis	21	1	0	0	0

Investigation of Item Characteristics

This section examines information about how well the items are measuring the various abilities assessed by the two tests for which these analyses could be completed, *Concept*

Formation and *Analysis-Synthesis*[10]. That is, based on item parameter estimates, we can obtain item-information functions which are a powerful method of describing and *comparing* items and tests. Item information function values were computed based on the item parameter estimates using FLUX (Burket, 1993).

Item information functions indicate the degree of measurement accuracy provided by test items for different ability levels. The area under the item information function (*Area*), the values of the location of maximum information (*Location of Maximum Information*), and the height of the item information function at the location of maximum information (*Maximum Information*), for each item were calculated for each population. In order to obtain comparable parameter estimates for which a mathematical difference between the populations would be meaningful, the Stocking and Lord (1983) equating procedure was conducted. This method solves for the linear transformation that minimizes the squared differences between the test characteristic curves from two separate calibrations for a given ability level. This equating method does not affect the relative value of the item parameters to one another and, therefore, does not affect the definition of the scale or trait being estimated. Values for *Area, Location of Maximum Information,* and *Maximum Information* based on the transformed (and therefore comparable) parameters are shown in Tables 39 and 40. Each table presents information on each item that was comparable for the two language versions. That is, item parameters were estimated for each item for each sample. If an item could not be calibrated with one of the samples, then it was dropped from the other sample as well.

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[10] Spatial Relations was not included in this set of analysis because there were not enough items from which to draw anchor items in order to equate parameter estimates for the two language versions.

For *Concept Formation*, items in the middle of this test have larger amounts of information, in terms of Area, as well as Maximum Information (the height of information at maximum utility) than at the beginning or end, for both language versions. In all cases, the location of maximum information is greater for the Spanish version of items, indicating that these items provide more information for the Spanish examinees at greater ability levels. There are some notable differences between the English and Spanish values for *Concept Formation*. Overall, the items for the Spanish version of *Concept Formation* provide 15% more information than the English version (Total Area). One item in particular, Item 34, provides twice as much information for the Spanish than the English version of this item. Further, for Item 34 there is a striking difference between the height of the item information function at the location of maximum information for the Spanish and English versions, with the height of the Spanish version more than five times that of the English version.

Table 39

Item Information for Concept Formation

	Area			Location of Maximum Information		Maximum Information	
Item #	WJ III COG	Batería III COG	Difference	WJ III COG	Batería III COG	WJ III COG	Batería III COG
8	0.019	0.016	0.003	90	167	0.11	0.09
9	0.011	0.015	-0.004	95	183	0.05	0.08
10	0.008	0.014	-0.007	17	140	0.05	0.08
12	0.027	0.034	-0.007	143	187	0.19	0.29
13	0.018	0.021	-0.004	150	214	0.09	0.12
14	0.016	0.028	-0.011	136	231	0.08	0.19
15	0.022	0.027	-0.005	154	219	0.13	0.19
16	0.025	0.023	0.002	130	213	0.17	0.14
17	0.018	0.028	-0.009	136	225	0.10	0.20
18	0.023	0.020	0.003	185	250	0.14	0.11
19	0.022	0.024	-0.002	155	233	0.13	0.15
20	0.019	0.029	-0.010	142	215	0.10	0.22
21	0.024	0.022	0.002	213	278	0.14	0.12
22	0.017	0.020	-0.003	270	326	0.08	0.10
23	0.019	0.022	-0.003	264	304	0.10	0.13
24	0.028	0.037	-0.009	288	327	0.20	0.35
25	0.036	0.036	0.000	307	334	0.32	0.32
26	0.035	0.034	0.001	295	330	0.31	0.30
27	0.039	0.035	0.004	302	331	0.38	0.31
28	0.037	0.039	-0.002	301	336	0.34	0.38
29	0.030	0.034	-0.004	316	333	0.23	0.29
30	0.018	0.023	-0.005	179	250	0.09	0.13
31	0.017	0.025	-0.007	195	269	0.08	0.15
32	0.015	0.021	-0.007	240	290	0.06	0.12
33	0.029	0.033	-0.004	291	329	0.21	0.27
34	0.018	0.041	-0.024	240	304	0.08	0.43
35	0.031	0.030	0.001	336	369	0.25	0.24
36	0.015	0.017	-0.002	260	308	0.06	0.08
37	0.031	0.030	0.001	328	359	0.24	0.22
38	0.020	0.024	-0.004	230	290	0.10	0.14
39	0.030	0.030	0.000	280	324	0.23	0.23
40	0.037	0.033	0.004	320	358	0.35	0.28
Total Area	0.753	0.864	-0.111				

For *Analysis-Synthesis*, as was the case with *Concept Formation*, items in the middle of the test have larger amounts of information, in terms of Area, as well as Information (the height of information at maximum utility) than at the beginning or end, for both language versions, with the exception of the very last item. In all cases, the location of maximum information is greater for the Spanish version of items, indicating that these items provide more information for the Spanish examinees at greater ability levels compared to the English examinees. There are some notable differences between the English and Spanish values for *Analysis-Synthesis* as well. In this case, overall, the items for the Spanish version of *Analysis-Synthesis* provide 16% less information than the English version (Total Area). Two items in particular, Items 22 and 25, provide approximately twice as much information for the English than the Spanish version of this item. Further, for these items, there is a striking difference between the height of the item information function at the location of maximum information for the two language versions, with the height of the English version more than three times that of the English versions.

Table 40

Item Information for Analysis-Synthesis

	Area			Location of Maximum Information		Maximum Information	
Item #	WJ III COG	Batería III COG	Difference	WJ III COG	Batería III COG	WJ III COG	Batería III COG
6	0.013	0.013	0.000	124	179	0.06	0.06
11	0.007	0.012	-0.004	32	141	0.04	0.06
13	0.006	0.007	-0.001	116	210	0.02	0.02
14	0.012	0.008	0.004	104	159	0.05	0.03
18	0.005	0.009	-0.003	65	203	0.02	0.03
19	0.026	0.015	0.011	131	197	0.18	0.07
20	0.033	0.025	0.008	209	273	0.27	0.16
21	0.024	0.022	0.002	180	243	0.14	0.12
22	0.045	0.021	0.024	243	308	0.50	0.11
25	0.038	0.023	0.015	247	324	0.36	0.13
26	0.023	0.017	0.006	286	354	0.13	0.07
27	0.014	0.015	-0.001	333	421	0.05	0.06
28	0.011	0.010	0.002	429	514	0.03	0.03
29	0.014	0.011	0.003	428	495	0.05	0.03
30	0.009	0.006	0.002	531	614	0.02	0.02
31	0.004	0.006	-0.002	610	626	0.01	0.02
32	0.021	0.013	0.008	383	493	0.11	0.04
33	0.016	0.022	-0.005	462	517	0.07	0.12
34	0.023	0.026	-0.003	329	414	0.13	0.16
35	0.028	0.034	-0.006	313	406	0.20	0.28
Total Area	0.371	0.311	0.060				

Standard Error of Measurement

A test information function is obtained by summing the information of the items that contributed to the test score. The standard error of measurement (SEM) of a given ability level is the reciprocal of the square root of the test information at that ability level (Hambleton et al., 1991). In an effort to examine the similarity or difference of the accuracy of the different language versions of tests, SEM as a function of scores is presented in Figures 8 and 9. As with

the previous section that examined item information functions, this set of analysis could only completed for two tests, *Concept Formation* and *Analysis-Synthesis*[11].

For both *Concept Formation* (Figure 8) and *Analysis-Synthesis* (Figure 9) the SEM functions revealed that the accuracy of the test was similar for both language versions, but for higher scores the test was more accurate for the Spanish-speaking population, while for lower scores the test was more accurate for the English-speaking population.

[11] Spatial Relations was not included in this set of analysis because there were not enough items from which to draw anchor items in order to equate parameter estimates for the two language versions.

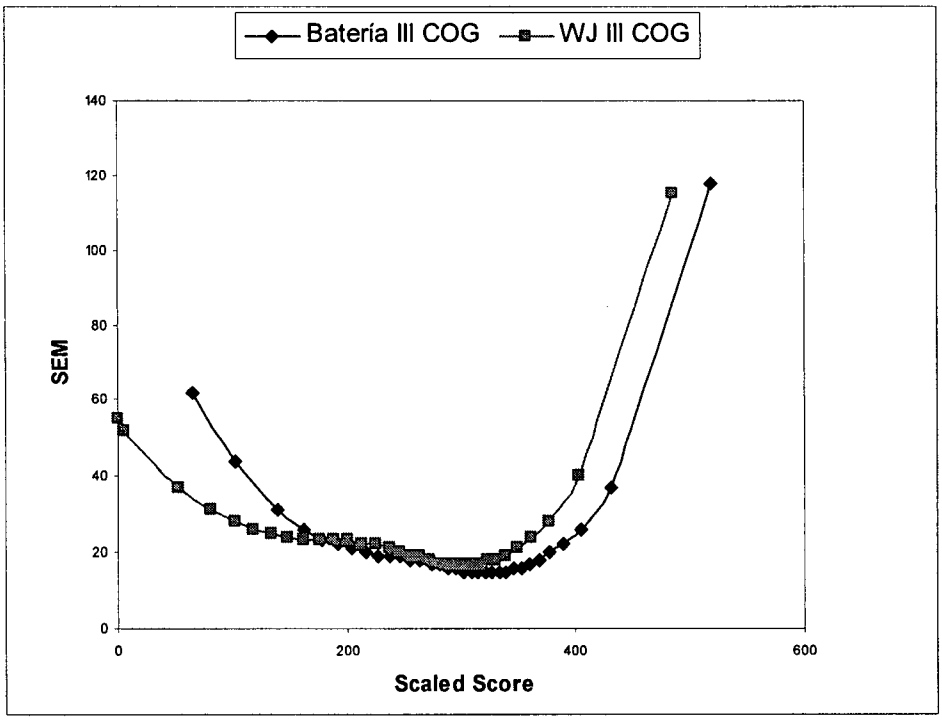

Figure 8. Standard Error of Measurement for *Concept Formation.*

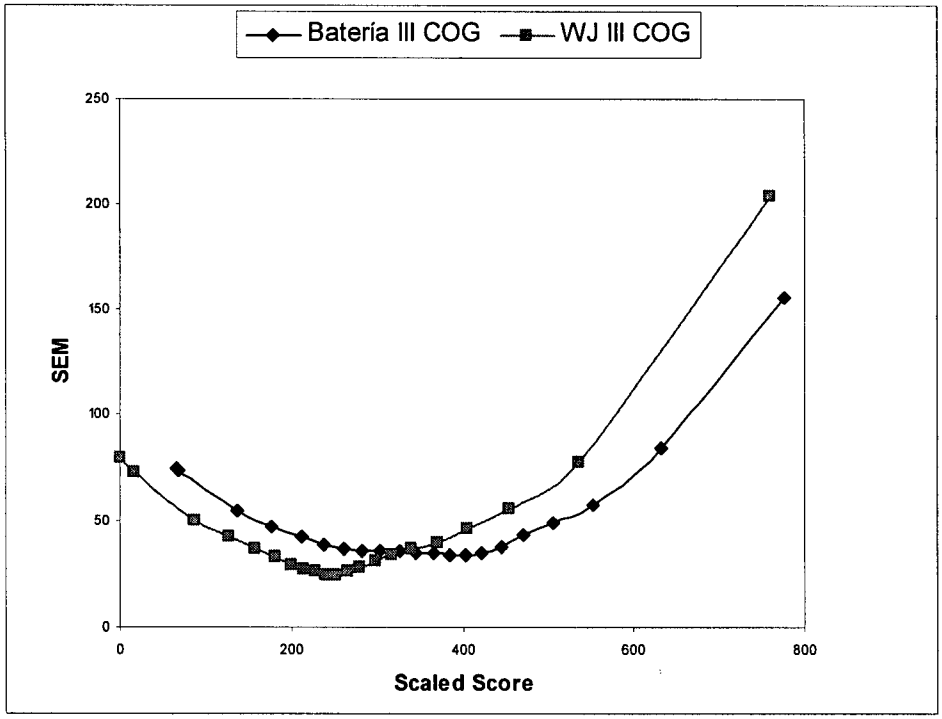

Figure 9. Standard Error of Measurement for *Analysis-Synthesis.*

Correlation of Item Parameters

Table 41 presents correlations of item parameters, α and β, based on the calibrations of items separately for each language group, as well as separately for each test. The correlations between the item parameters indicate that the correlations of the difficulty parameters β_1-β_3, (the difficulty parameters for each of the levels of the multiple scoring) ranged from .70 to .97. The correlations were lower for *Spatial Relations*, particularly for the Level 2 and Level 3 scoring (β_2 and β_3). These correlations indicate that the ordering of item difficulties tended to be similar for these tests. The discrimination parameter (α) correlations were noticeably lower, ranging between 0.52 and .81. The lower α parameter correlations indicate that the relationship between what the items are assessing with the overall construct assessed by the whole test varied for some of the items between the two language versions. The lower the correlations are, the larger the number of items where differences in the ordering of the discrimination parameters were observed.

Table 41

Correlation between IRT Item Parameters

Test	# of Common Items	Correlations				
		a	β_1	β_2	β_3	p
Spatial Relations	7	.52	.83	.68	.70	1.00
Concept Formation	35	.71	.97			.993
Analysis-Synthesis	21	.81	.97			.999

Scatter plots (Figures 10 to 12) for the correlations of each parameter for each test provide visual representation of the relative order of items for the two populations. For *Concept*

Formation and *Analysis-Synthesis* specific items were flagged as being particularly different in terms of the discrimination (α) parameter between the two language groups. For *Concept Formation*, it was Item 34, and for *Analysis-Synthesis* it was Item 22. In terms of the difficulty parameters, two *Concept Formation* items (Items 8 and 16) as well as two *Analysis-Synthesis* items (Items 19 and 22) were flagged as being particularly different between the two language groups.

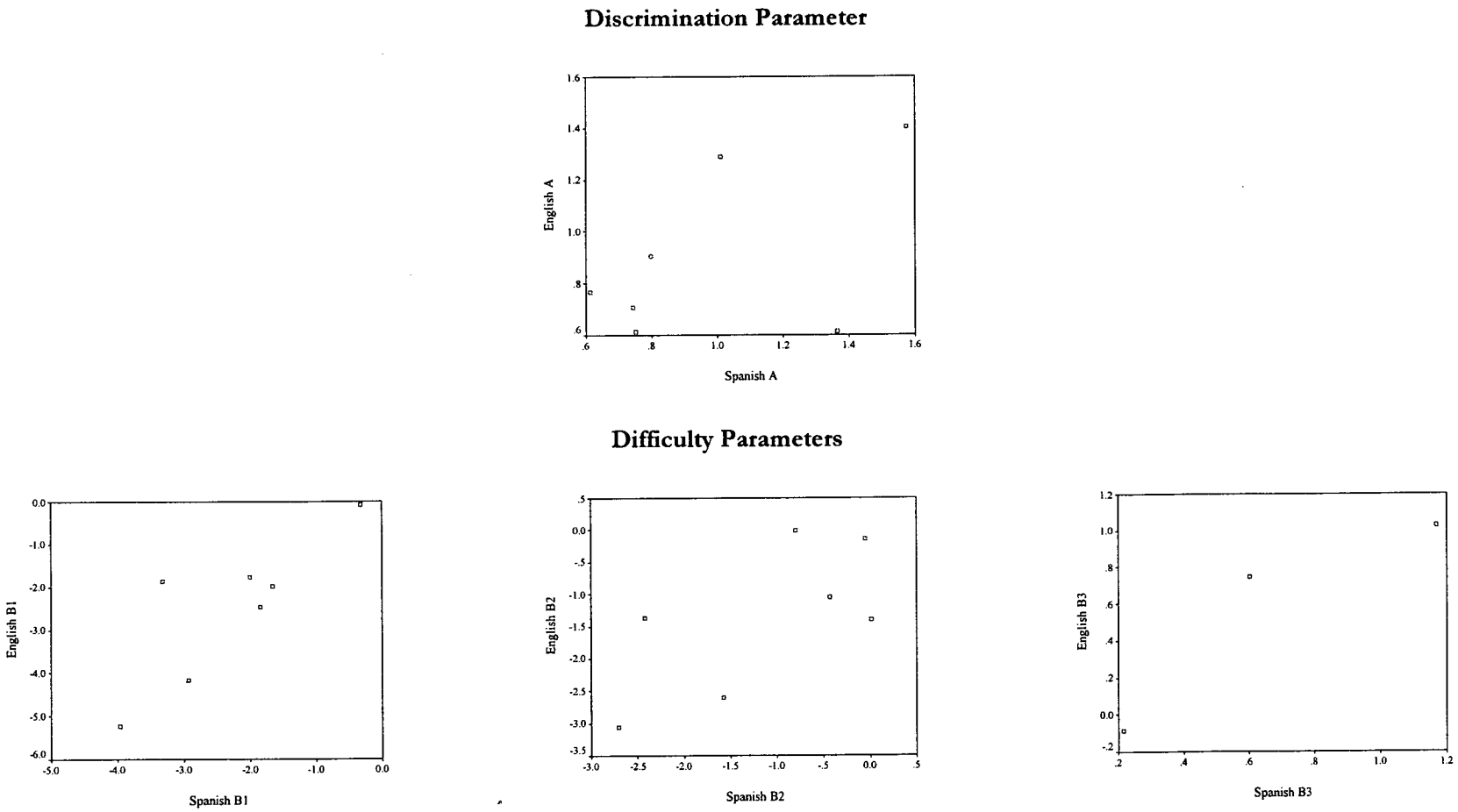

Figure 10. Scatter Plots for the Discrimination and Difficulty Parameters for *Spatial Relations*.

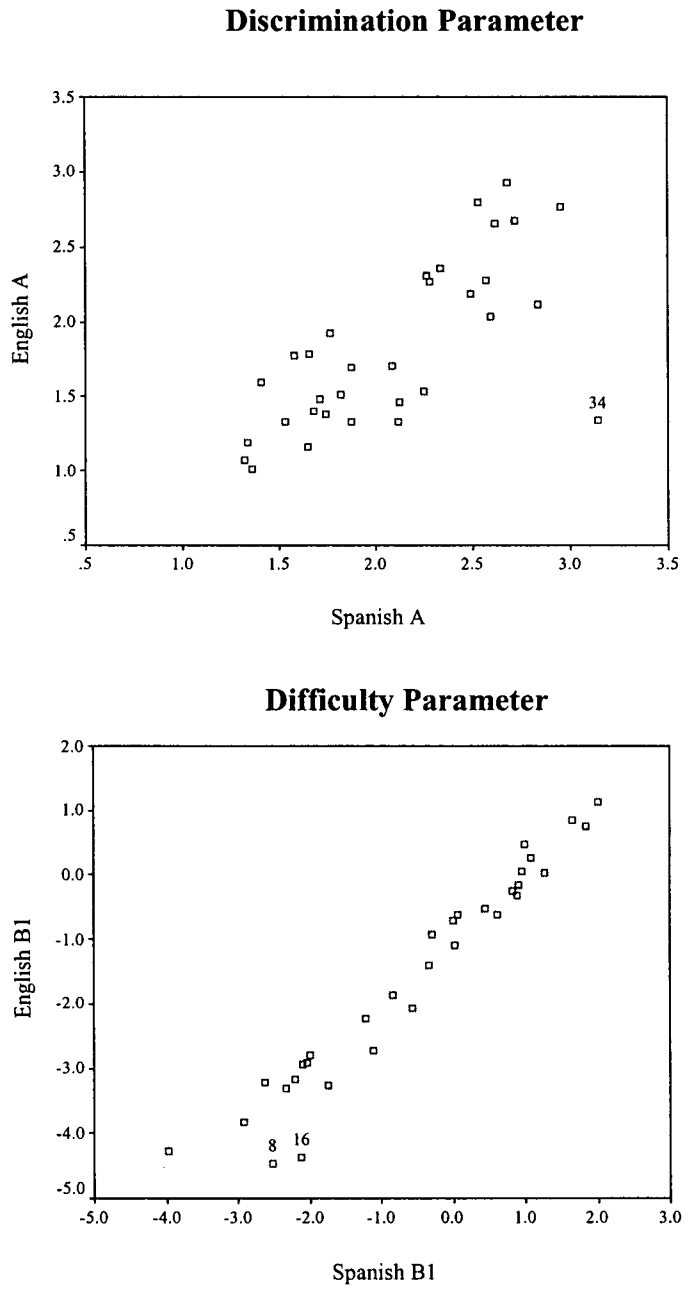

Figure 11. Scatter Plots for the Discrimination and Difficulty Parameters for *Concept Formation.*

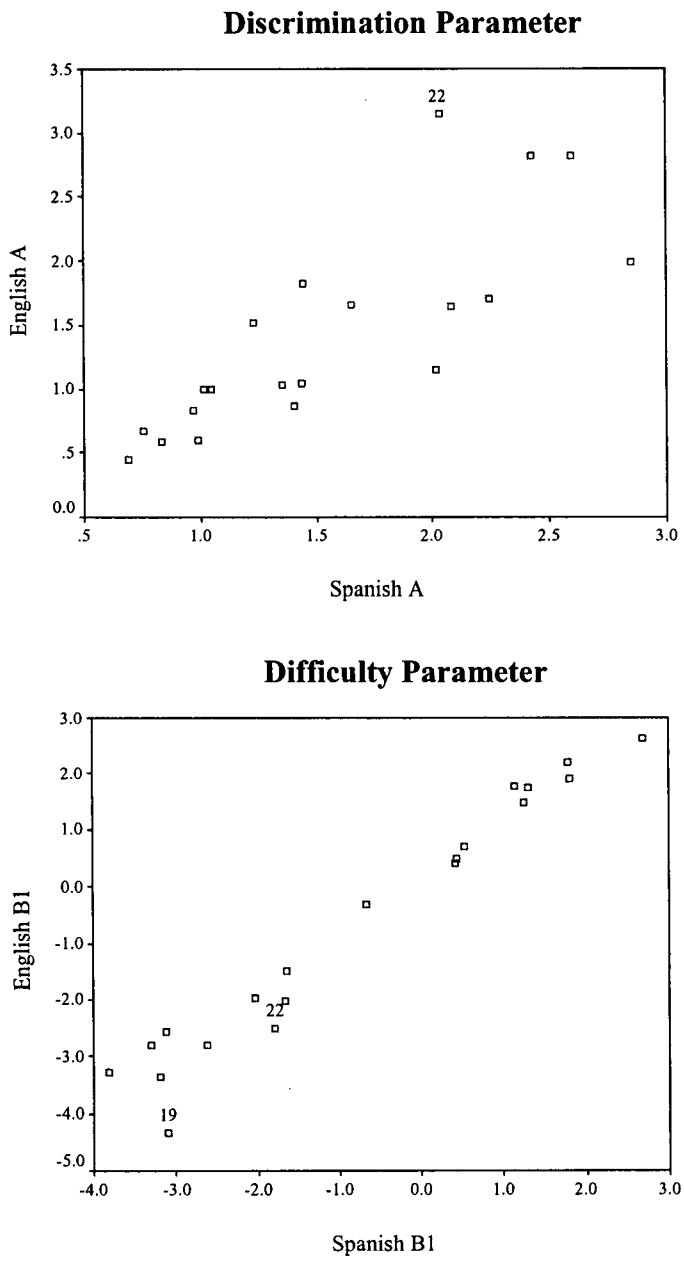

Figure 12. Scatter Plots for the Discrimination and Difficulty Parameters for *Analysis-Synthesis.*

Stage 4 - Judgmental Review

A qualitative examination of the English and Spanish versions of the test items and their instructions to examinees by the two bilingual reviewers to evaluate the equivalence of the two language versions was completed. Typically, the results of the judgmental review ratings are reported to identify potential reasons for the statistical identification of DIF items. Of the tests included in the DIF analyses (*Spatial Relations*, *Concept Formation*, and *Analysis-Synthesis*) very few items (nine items in total) were identified as DIF (See Table 38). As such, the results related to the Judgmental Review are organized by the type of differences they identified, and are not limited to a review of only the DIF items. Differences that were considered "somewhat different" or "very different" are described below.[12]

Differences in Items

The judgmental review process did not identify any differences in the items between the two language versions of the tests. At the outset of the review process, the reviewers were instructed to look for differences between the presentation or graphic representation of the items, but also to examine pictures or objects for differences in familiarity (i.e., a picture of a phone that would be unfamiliar to someone from a Spanish speaking country). This research study examined only *translated* tests, in which the items remained exactly the same, and only the directions were translated from English to Spanish. As such, it is not surprising that the

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[12] Recall that reviewers were asked to rate differences between language versions. A rating of 0-1 indicated no or negligible differences between the two versions; a rating of 2 indicated that there were clear differences between the translations that may not necessarily lead to performance differences; a rating of 3 indicated that there were clear differences between the two versions that were expected to lead to performance differences.

reviewers did not find any differences between the items for the two language versions of these tests, nor did they find any differences related to objects or pictures being more familiar or common to one language than the other.

Differences in Instructions to Examiner

The reviewers identified several differences in the instructions that are presented to the examiner, and provide directions related to the administration and scoring of the various tests. In this case, the impact on the performance of examinees would be indirect, and result if there are differences in how the test was administered based on these instructions. Examples are presented below.

For three tests, the administration overview provided to the reviewers identified two inconsistencies. The English test version reads "Very young subjects or individuals who function at very low levels may be confused by more than one line per page." In the Spanish version, instead of "very young subjects" the phrase "Sujetos menores o inmaduros" which means "immature subjects" was used. The reviewers indicated that "Personas jóvenes" would be a better translation. Another difference identified by reviewers for this statement to administrators, was that the Spanish test translation was more specific when referring to individuals functioning at low levels on *this* test ("otros que tengan dificultad con la prueba"), whereas the English does not include this sentiment explicitly. The Spanish statement makes specific reference to performances related to the test in question, whereas it could be interpreted that the English is speaking about "low functioning individuals" with respect to this test, as well as others, or overall low functioning. Neither reviewer felt that this would impact how well a person performed on this test, but it could impact how the test is administered for certain individuals. Examples of this difference occurred in *Spatial Relations*, and *Concept Formation*. A similar

difference, related to the first identified difference (young versus immature) was identified for the *Visual Matching* instructions to administrators, although in this case the English refers to "older," while the wording in Spanish was "mature" ("maduros").

In another example of differences in the instructions to examiners, the overview for *Visual Matching* in English reads, "If you administer *Visual Matching* 2 first, and *the subject has difficulty with* the Practice Exercise, administer *Visual Matching* 1 and use that score instead." Whereas, instead of using the phrase "difficulty with" the Spanish version refers to if a student obtains a low score ("obtiene una calificación muy baja"). The reviewers rated this difference as "somewhat different" (a rating of 2), but that they were not expected to lead to differences in performance between the two groups.

There was one instance when the reviewers indicated that there were clear differences in the instructions to examiners between the two versions, and expected them to lead to difference in performance between the two groups (a rating of 3). This occurred with *Rapid Picture Naming*, where the examiners are instructed to turn the page (of the workbook examinees work through) immediately if the time limit has not elapsed. Whereas, in the Spanish version examiners are told to inform subjects to turn the page if there is still time remaining. Given this is a timed test, the reviewers believed that the extra verbal instructions to Spanish examinees could slow down the speed with which examinees proceed through this test, thereby negatively impacting their total raw score for this test.

Differences in Instructions to Examinees

For these sets of differences, reviewers identified dissimilarities with the instructions to the examinee. In these cases, the impact on the performance of examinees would be direct. Examples are presented below.

Reviewers identified differences in one of the statements made to examinees during the introduction and sample items for the *Spatial Relations*. Specifically, once an examinee has responded correctly to Sample C, the examiner is to say "That is correct, pieces X and C. You had to turn piece X to make it fit." The reviewers thought that the same statement in Spanish was more specific in relation to turning the piece to make it fit. The Spanish version reads "Tienes que parar la parte X," which indicates that you had to "stand up" part X. The reviewers thought the translation should be "Tienes que girar la parte X," which indicates that a "turn" is required. The reviewers rated this difference as "somewhat different" (a rating of 2), but that they were not expected to lead to differences in performance between the two groups.

When introducing the sample items for the *Visual Matching* 2, the English examiner reads the following statement "I want to find out how fast you can find *two things* that look alike." In Spanish, the phrase is more specific "Haz un circulo alrededor de los dos números que son equales en cada hilera," indicating to the subject that they are required to find *two numbers* that are alike (the task involves finding the two numbers in a set of six that are the same). While different, the reviewers rated it as "somewhat different" and they did not expect it to lead to differences in performance between the two groups.

During the instructions for *Analysis-Synthesis* examinees are presented a key (or legend) and instructed in the English version "Use the key to help work the puzzles." The reviewers indicated that the Spanish version is less specific ("ayude con los rompecabezas), which they translated to mean "help *with* the puzzles." They thought that a more equivalent translation would have been "ayude a resolver los rompecabezas." Again, while the reviewers indicated that the translations were "somewhat different," they did not expect it to lead to difference performances for the two groups.

There was one instance when the reviewers indicated that there were clear difference in the meaning of the instructions to examinees between the two versions, and expected them to lead to difference in performance between the two groups (a rating of 3). This occurred with *Decision Speed*, where the examiner is describing the task and indicates "If you have trouble finding the two things that go together, skip that row and move on to the next one." In the Spanish version, examinees, when they have trouble with an item are instructed to leave it out ("déjalo sin hacer"). The reviewers felt that the English directions were more specific and could favour the English group.

Summaries of the differences identified by the reviewers between the English and Spanish versions of the test instructions are presented in Tables 42 and 43. These tables indicate for which tests a difference was identified, the difference rating, which language group would be favoured by the difference (if applicable), and a description of the difference detected. Table 42 presents this information for the identified differences in the instructions to the examiner, and Table 43 presents this information for the identified differences in the instructions to the examinee.

Table 42

Summary of Judgmental Review Ratings and Noted Differences in the Instructions to Examiners

Test	Rating*	Instructions Favour	Noted Differences
Spatial Relations	2		The English version uses the term "very young subjects." The Spanish version uses the term "immature."
Concept Formation	2		The English version uses the term "very young subjects." The Spanish version uses the term "immature."
Visual Matching	2		The English version uses the term "older subjects." The Spanish version uses the term "mature."
	2		The English version uses the phrase "a subject has difficulty with." The Spanish version uses the phrase "a subject who obtains a low score."
Rapid Picture Naming	3	English	The English version instructs examiners to turn the page for examinees. The Spanish version instructs examiners to tell the examinee to turn the page.

* A rating of 2 indicated that there were clear differences between the translations that may not necessarily lead to performance differences; a rating of 3 indicated that there were clear differences between the two versions that were expected to lead to performance differences.

Table 43

Summary of Judgmental Review Ratings and Noted Differences in the Instructions to Examinees

Test	Rating*	Instructions Favour	Noted Differences
Spatial Relations	2		The English version uses the phrase "turn the piece." The Spanish version uses the phrase "stand up the piece." Reviewers thought that the Spanish translation was more specific than the English version.
Visual Matching 2	2		The English version uses the phrase "find two things that look alike." The Spanish version uses the phrase "find two numbers that look alike." Reviewers thought that the Spanish translation was more specific than the English version.
Analysis-Synthesis	2		The English version uses the phrase "use the key to help work to puzzle." The Spanish version uses the phrase "use the key to help with the puzzle." Reviewers thought that the English version was more specific than the Spanish translation.
Decision Speed	3	English	For the English version examinees are instructed "If you have trouble finding the two things that go together, skip that row and move on to the next one." For the Spanish version examinees are instructed "If you have trouble finding the two things that go together, leave it out." Reviewers thought that the English version was more specific than the Spanish translation.

* A rating of 2 indicated that there were clear differences between the translations that may not necessarily lead to performance differences; a rating of 3 indicated that there were clear differences between the two versions that were expected to lead to performance differences.

CHAPTER V: DISCUSSION

Summary

This research study concerned the investigation of the construct comparability of the WJ III COG and the Batería III COG, which are the English and Spanish versions of the same battery, respectively. These are measures of cognitive functioning that purport to be direct counterparts of one another. The study examined the degree of comparability and sources of incomparability of seven tests of cognitive ability that were translated from English to Spanish. These tests were: *Spatial Relations*, *Concept Formation*, *Visual Matching*, *Picture Recognition*, *Analysis-Synthesis*, *Decision Speed*, and *Rapid Picture Naming*. The purpose of the study was to address the following questions:

1. Are the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG the same? Are tests within the two batteries measuring the same constructs?
2. Are there specific items from the selected tests of the WJ III COG and Batería III COG that function differentially for English- and Spanish-speaking examinees? Are there items that are easier or more difficult for examinees from a particular language group (when matched on ability)? Which items are they?
3. What are the sources of differences in constructs being assessed for the two language groups? Are there item characteristics that might be associated with the differential functioning of the items? Are there problems associated with translation of the items?

Answers to these questions contributed to evidence for determining the degree of comparability of the inference based on the test scores from the two different language versions. Between the two language versions of the tests, at the scale as well as the item level, the results

indicated that there were different levels of psychometric similarities and differences for some of the seven tests. The summary of evidence related to each question is discussed below.

Research Question One

In order to assess whether there were differences in the dimensionality and structure of each of the selected tests of the WJ III COG and Batería III COG, exploratory factor analysis was applied. Overall, the factor structures for each of the seven tests for both language versions suggested that they were "essentially uni-dimensional"(Stout, 1990). That is, there is a primary factor that accounts for a large proportion of the explained variance in every case. In terms of the similarity of factor solutions between the two language versions, three out of the seven tests (*Spatial Relations*, *Concept Formation*, and *Analysis-Synthesis*) had the same number of factors for both languages. Further, for these three tests the congruence coefficients calculated indicated that the factors were quite comparable (six out of seven factor comparisons were quite to very comparable). This means that the constructs are represented and measured in a similar way for the different language versions of each of these tests. For the remaining tests, while the number of factors was different between the language versions, there similarities in the factor solutions. For instance, the amount of variance accounted for by the primary factor for each test was similar in both languages.

Two more general observations were made about the pattern of factor solutions. First, the tests with the least amount of variance explained by the factor solutions were timed tests. For each of the timed tests, items at the beginning and end had to be eliminated in order to complete factor analysis. As a result, factor solutions are based on only a portion of test items. The fact that there remains a large portion of variance unexplained by the factor solutions could indicate that the critical information that is the crux of what these tasks were designed to measure has not

been captured. This finding was not surprising given the nature of these tasks, where the speed with which one moves through the items is in large part what these tests measure, or at least what separates those who do well from those who do poorly. Hence, by removing items from the end of these tests critical information about an individual's performance is excluded in the analysis. Were these items to be included in the factor analysis, the amount of variance accounted for and the similarity of factor solutions for the different language versions would likely increase.

Second, the factor solutions appeared to be detecting test structure (for example, item difficulty, ceiling or discontinue rules[13], and a shift in task demands). That is, factors seemed to differentiate between items at the beginning and end of the tests, with items at the beginning of test being represented by one factor, and items at the end of the test being represented by another factor. In some cases, the differentiation between early and late items coincided with a ceiling or a discontinue rule. Thus, it may not be the difficulty of items related to test structure that the factor solutions are detecting, but the point on the test where some examinees of certain ability or with a particular score continue with more items, versus those for whom the test is terminated. Further, some test items beyond the discontinue rule represent a cognitive shift in the task. For instance, with *Concept Formation*, as the examinee moves through the test, he or she is required to incorporate new information and change the cognitive method he or she has used to solve problems in order to continue to respond correctly. This "cognitive shift" could also be what the different factors are detecting. From these analyses, it cannot be determined whether it is item difficulty, position in test, discontinue rules, or changes in the tasks, or something else entirely, that is being represented by the factor solutions.

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[13] Ceiling rules are used to limit the number of items administered and eliminate those items that are deemed to be too difficult for the subject.

Research Question Two

A series of IRT related analyses were completed to determine whether there were specific items from the selected tests of the WJ III COG and Batería III COG that functioned differentially for the English- and Spanish-speaking examinees. These analyses included DIF, examination of differences between item information functions, and an examination of the correlations between item parameters for the different language versions of the selected tests. The IRT analyses were limited to three tests: *Spatial Relations*, *Concept Formation*, and *Analysis-Synthesis*. Data characteristics, such as item difficulty, variance in response patterns for items, and missing data were all considered in the selection and exclusion of tests for this set of analyses. That is, items that were very easy (more than 95% of examinees responded correctly) did not have enough variance in responses to accurately estimate parameters. Items that were difficult were typically administered to only a small portion of the examinees, those with higher ability levels, which meant that for the rest of the sample response information was considered missing (this study used only legitimate, intentional responses in the item estimation process).

The *Spatial Relations* test had the greatest number of DIF items (six out of seven items), which were evenly split between the language versions in terms of which population the items favoured. This means that there were three items that were easier for the English-speaking examinees than the Spanish-speaking examinees and three items for which the opposite was true. While the data characteristics limited the analysis to 7 of the 12 items that were common between the two language versions of this test, this is a large number of DIF items (58%) to be identified for one test. *Concept Formation* had two DIF items and *Analysis-Synthesis* had 1 DIF item, all of which favoured the English language group. These DIF items represented a smaller

proportion of the number of items than in the case of *Spatial Relations*, 16% and 5% for *Concept Formation* and *Analysis-Synthesis*, respectively.

The examination of item information functions provided more evidence about the comparability of items between the two language versions. This examination indicated the degree of measurement accuracy provided by the test items for different ability levels. For the two tests for which this set of analysis was completed, *Concept Formation* and *Analysis-Synthesis*, the results suggested that for both language versions the items in the middle of the test have larger amounts of information than those at the beginning or end. In other words, both language versions of these tests measured examinees more accurately by items placed near the middle of these two tests, which also corresponded to items of medium difficulty. For both tests there were specific instances where items displayed very different degrees of measurement accuracy for the two language versions. For *Concept Formation*, these items showed a higher degree of measurement accuracy for the Spanish version, and for *Analysis-Synthesis* the opposite was true; items had a higher degree of measurement accuracy for the English version. This means that there are some differences in how well some items are measuring the construct between the two language versions. These item level differences will impact how well the construct is being measured overall. Large differences in how well the construct is measured, will lead to differences in the degree to which the inferences based on scores from the different language versions are comparable.

The IRT parameter comparisons indicated some discrepancies between constructs for the two language versions. If the correlations between the discrimination parameters are low, then there is a large difference between how items are ordered by discrimination between the two language versions. Consistent with the pattern of results from the DIF analyses, the most notable

differences were with the *Spatial Relations* test; it had the lowest correlation between the discrimination parameters. The correlations between the discrimination parameters for *Concept Formation* and *Analysis-Synthesis* were higher, and indicated similarity between the constructs measured by the two language versions of these tests.

Together, this set of item level analyses demonstrated that there exists a difference between the two language versions at the item level for *Spatial Relations* test, whereas, *Concept Formation* and *Analysis-Synthesis* demonstrated a better degree of comparability.

Research Question Three

A qualitative examination of the English and Spanish versions of the test items and their instructions to examinees was completed to identify the sources of differences in constructs being assessed by the two language versions of the test. Typically, the results of a judgmental review are intended to identify potential reasons for DIF items. For this study the review was expanded to include all test instructions and items as another piece of evidence about the degree of comparability of the translated tests of the WJ III COG and Batería III COG.

The judgmental review found that there were no differences in the items between the two language versions of the tests. At the outset of the review process, the reviewers were instructed to look for differences between the presentation or graphic representation of the items, but also to examine pictures or objects for differences in familiarity (e.g., a picture of a phone that would be unfamiliar to someone from a Spanish speaking country). This research study examined only *translated* tests, in which the items remained exactly the same, and only the directions were translated from English to Spanish. As such, it is not surprising that the reviewers did not find any differences between the items for the two language versions of these tests, nor did they find

any differences related to objects or pictures being more familiar or common to one language than the other.

With respect to the instructions between the two language versions of tests, the judgmental review found very few differences in relation to the amount of material that was reviewed (i.e., all the material associated with the seven tests). Of the differences identified, there were only two instances in which reviewers thought that these differences would lead to differences in performance between the two groups. In each instance, the differences identified related to the instructions provided to the examinee. For example, with *Rapid Picture Naming* the Batería III COG examiners are instructed to tell the examinee to turn the page when they reach the end, whereas the WJ III COG examiners are instructed to just turn the page for the examinee. For *Decision Speed*, the reviewers felt that the instructions relating to what to do if you have trouble answering an item were more specific in the English test version. In both cases the reviewers thought that the differences favoured the English-speaking examinees. The differences that reviewers highlighted related to the timely completion of the tests, important factors given that both these tests are timed. Anything that may slow down the progress of examinees through items has the potential to impact their obtained score. None of the differences that were identified by the judgmental reviewers provided a sound explanation of the causes of the previously identified DIF items.

Degree of Comparability

The purpose of this study was to examine selected tests of the WJ III COG and Batería III COG in order to provide information about the degree of equivalence and comparability of scores. This project was based on Messick's (1989a; 1989b; 1995) unitary notion of validity in

which one must make an overall evaluative judgment of the degree to which evidence supports the adequacy and appropriateness of score inferences.

Table 44 is a summary of the evidence that was gathered for this study. As is apparent from the empty cells, there are only a few pieces of evidence with which to draw conclusions about the degree of comparability for some tests. This limitation made drawing conclusions about the degree of comparability for some tests difficult. However, rather than focus on what cannot be determined, I will focus on what can be said from the results of this study.

Table 44

Summary of Completed Analyses by Test

			IRT Based Analyses			
Test	EFA	r	DIF	Correlation of Item Parameters	Item Information	Judgmental Review
Spatial Relations	*	*	*	*		*
Concept Formation	*	*	*	*	*	*
Analysis-Synthesis	*	*	*	*	*	*
Picture Recognition	*	*				*
Visual Matching	*	*				*
Decision Speed	*	*				*
Rapid Picture Naming	*	*				*

The evidence gathered for *Concept Formation* and *Analysis-Synthesis* suggests that the different language versions are somewhat comparable. The structural equivalence, internal consistency, minimal DIF, correlated item parameters, and a qualitative review of the tests all speak to the high degree of comparability for the different language versions. However, there was some evidence that the accuracy with which some items measured examinee ability is different between the two language versions. This means that, overall, each language version is

measuring the same construct, with similar accuracy, and that there is a good translation of the instructions. Together, the gathered evidence suggested that there is a high degree of comparability between the English and Spanish version of *Concept Formation* and *Analysis-Synthesis*, indicating that inferences based on scores from these two versions are comparable.

The evidence related to *Spatial Relations* was interesting. There were differences between the scale and item level results and how they support the degree of comparability of the inferences based on the scores from the different language versions of this test. That is, the factor analytic results indicated structural equivalence between the two language versions, suggesting that the construct is represented and measured the same way by both language versions of this test. This result is not surprising when you consider that this test is designed to measure a narrow ability, and that each item contributes to the assessment of that ability. However, structural equivalence is necessary, but not sufficient when demonstrating the degree of comparability for two tests. Analysis of the item level data revealed a relatively high number of DIF items and relatively low item parameter correlations, indicating that there are differences between how examinees and the items interact for the two language versions. These item level results put the degree of comparability for the English and Spanish version of this test into question, and evidence from this study suggested that the inferences based on scores from these two versions are not comparable.

Conclusions about the degree of comparability of the two language versions for the other tests (i.e., *Picture Recognition*, *Visual Matching*, *Decision Speed*, and *Rapid Picture Naming*) remain in question because the limited scope of analyses. While a Judgmental Review is typically used to discover the source of DIF, for these four tests, they became one of the only pieces of evidence of comparability across the language versions. The judgmental review

process revealed only minimal differences in the item instructions for the two language versions, and in fact, both reviewers felt that all the tests were translated well. This was not surprising given the long history of the WJ III (and its predecessors) and the diligent translation process that was undertaken for the development of the Batería III. However, a judgmental review is not sufficient to determine comparability. To supplement a judgmental review process, statistical techniques that are able to identify non-equivalent test items than may not be readily detected when using judgmental review are necessary to determine the degree of comparability (Hambleton, in press).

Integration of Findings

Contrary to other researchers in the area of test translation and adaptation who have found relatively large number of DIF items (e.g., Allalouf et al., 1999; Ercikan, 1999; Ercikan & McCreith, 2002; Gierl, Rogers, & Klinger, 1999; Gierl & Khaliq, 2001), overall there were relatively few DIF items found for the comparisons made in this study. There are several factors that could have contributed to the low number of DIF items. First, the translation and history of these batteries makes them unique. The test authors' commitment to developing and establishing a quality instrument was apparent. The validation process was driven by the same theoretical underpinnings and industry standards that drove the present study (i.e., the work of Messick (1989a; 1989b; 1995), and the criteria outlined by the *Standards* (AERA et al., 1999). Second, this study moved beyond group administered achievement type tests, and examined tests of cognitive ability and focused on tests that were translated and *not* adapted. The implications of these characteristics are that the onus of understanding an item has been somewhat removed for examinees. That is, the nature of cognitive ability tests are that they are more oral and pictoral than typical achievement tests, and that instructions are presented to the examinee by an

examiner, rather than the examinee having to read each particular question. Compared to group administered achievement tests, the amount of text presented to an examinee and the amount of text that needs translated or adapted is limited, particularly for the cognitive tests included in this study. It is possible that the results may appear different for the tests not examined in the present study. For those tests, the English version was *adapted* into Spanish, rather than *translated*, and adjustments to content were made because of cultural and language considerations (i.e., for a vocabulary test, word frequency may be different between the two languages). Because of this, more differences for the different versions of those tests may have manifested because there have been more alterations made to the item and test content. As a result the impact on psychometric similarities between the two language versions of those tests may be greater than for the tests that were the focus of this study.

Implications

The results of this study have several implications related to decisions about and the methods used to establish the degree of comparability of the WJ III and Batería III, most of which centre around the results related to *Spatial Relations*.

As stated above, the results for *Spatial Relations* indicated that six out of seven items were identified as DIF. For these items the pattern of responses is different for English- and Spanish-speaking examinees, and means that the language of administration impacts the performance of individuals. Together with the other pieces of evidence, it was determined that the degree of comparability of the inferences based on the different language versions of this test is low. As such, the use of these non-equivalent tests will lead to interpretation errors and faulty conclusions. For instance, if the consequences based on the respective scores are the same,

whether that is a decision about an appropriate intervention or educational classification, and the scores are incomparable, the decision for one group is going to be inappropriate.

The results for *Spatial Relations* also bring to light methodological issues related to equating and DIF detection procedures. With respect to equating, it is critical that items selected to link the Batería III to the WJ III meet some basic criteria. That is, the items that are used in the linking have similar measurement accuracy for both language versions and are DIF free. The DIF results for *Spatial Relations* indicated that a large number of the items that were used to equate the language versions of this test displayed DIF. Further, *Spatial Relations* was the only test in which there was a large difference between the internal consistency of scores for the two language versions. A test form that produces a score with a low reliability estimates will not be adequately equated (Embretson, 1999). Hence, the use of DIF items, and items which produce a score with low reliability, are problematic for the equating process, and as a result, the US English-speaking norms for the Spanish-speaking examinees for this test should not be used.

A large number of DIF items within a test also presents a problem for DIF detection procedures. Specifically, the LH DIF procedure used an internal matching criterion as a measure of ability, on which the two language groups are then matched and item response patterns are compared. The internal matching criterion is based on sum of the number of correct items within the test. In the case when there are a large number of DIF items present, the total score calculated on the basis of these DIF items and the other non-DIF items within the test is likely going to be distorted. This is referred to as *contamination* of the criterion (Camilli, 1993). A strategy that has been proposed to address this issue is the use of an iterative DIF procedure. The first stage of an iterative DIF detection identifies potential DIF items, which are then removed from the computation of the criterion. This new criterion is then used to detect DIF items. Using a two-

stage DIF detection methods has been shown to flag different items as DIF, and that differences are related to the amount of DIF found in the first stage (Zenisky, Hambleton, & Robin, 2003). As such, further investigation of *Spatial Relations*, as well as other test in which there is a large number of DIF items should use a two-stage DIF detection method.

The results from *Concept Formation* and *Analysis-Synthesis* with respect to the measurement accuracy of items have implications for equating and test construction. The examination of the amount of information that items measured by the different language versions of these tests revealed that there are items that vary in their precision for measuring ability for the two language versions. The more information measured by an item, the more accurate the estimate of ability. If items have different degrees of measurement accuracy for the different language versions and are used in the equating process, the transformation of ability estimates will not be accurate. That is, even if the difficulty of the items for the two versions have been equated, the amount of information at different score levels may be different and may be associated with measurement error.

With respect to test construction, and specifically ceiling rules, it is imperative that items located around the ceiling(s) of the test are informative for both language versions of the test so that the decision to discontinue the presentation of items is based on an accurate estimate of ability. Bias may enter if, for one language version, there is more information, and therefore more accurate ability estimates. It is possible that for some examinees, a poor estimate of their ability around a ceiling could lead to premature discontinuation of a test, and therefore underestimate their ability.

Implications for Practitioners

The Batería III was developed so that test users would be able to measure cognitive ability of Spanish individuals in their first language. The intention was that the inferences based on the scores from this test would be more appropriate than to assess these abilities in English, their second language. However, if the comparability of the inferences based on the scores of the Batería and WJ III is not demonstrated, then the problems that a Spanish test version was intended to resolve remain. That is, the consequences based on the respective scores may not be the same for the two language groups. For example, educational programming or intervention designs that are contingent on the pattern of results from these tests may be applied inappropriately. The *Standards* (AERA et al., 1999) clearly articulate that it is the test developers responsibility to provide "empirical and logical evidence for score reliability and the validity of the translated test's score inferences for the intended uses" (p. 99), as well as report evidence that "the different language versions measure equivalent or similar constructs, and that the score reliability and the validity of inferences from scores form the two versions are comparable" (p. 99). The results from this study suggest that inferences based on scores from *Concept Formation* and *Analysis-Synthesis* are somewhat comparable, and practitioners can treat, interpret, and compare scores for these test as such. However, with respect to *Spatial Relations*, at this time there is not enough evidence to suggest that inferences based on the scores from the WJ III COG and Batería-III COG are comparable, and practitioners should not treat them as such. The use of this non-equivalent test will lead to interpretation errors and faulty conclusions about these two groups. For instance, practitioners use scores to make decisions about an individual's strengths and weaknesses, appropriate interventions, and special education placements. Presumably, these decisions are going to be the same for scores from the WJ III

COG and Batería III COG. So, if these scores are assumed to be comparable when they are not, then decisions for one group are going to be inappropriate. In terms of the remaining tests, until research has demonstrated the comparability of the two language versions, practitioners should be cautioned not to treat them as comparable.

Limitations

There were several limitations to this study, a number of which are related to the data characteristics associated with the tests used. Salient features of the data that were problematic included large amounts of missing data, a lack of variability for a number of easy items, and the use of different scoring schemes (binary and multiple level scoring) for both language versions. These test characteristics limited the scope of analyses as well as creating methodological problems, each of which is described in more detail below.

The amount of missing data was a major hurdle in this study. The extent of missing data impacted the scope of analyses, as well as the methods and associated software applications. The missing data in this study can be characterized as questions that were not administered, or items that were not reached by individuals. A number of the tests used in this study used ceiling or discontinue rules to limit administration time, as well as minimize frustrations or discouragement of the examines by attempting to answer questions too difficult for them, as is typical with cognitive ability and individually administered achievement tests. Specifically, because of the amount of missing data, a large set of items were excluded from the factor analysis and DIF analysis, thereby limiting the conclusions with respect to these items or the tests they are associated with. Furthermore, the missing data in these data sets eliminated potential software packages that could have been used as a second DIF detection method (so as to verify items flagged as DIF). While the strategy employed in this study was to use only

legitimate, intentional responses in the item estimation process (Ludlow & O'Leary, 1999), the extent to which there was missing data for the more difficult items on some tests may have impacted the accuracy with which items at the end of some tests were calibrated because these items are were only administered to higher-ability examinees and therefore are based on fewer responses.

Similar to the missing data issue, the lack of variability for a number of easy items impacted the scope of analyses for this study. That is, the lack of variability for easy items often led to their exclusion from analyses again restricting the scope of analyses and the items included in these analyses. Hence, the conclusions and information about the various tests in this study is only based on a portion of the data. Further, because the items have been excluded there is no information about the degree of comparability of these items between the two language versions available.

The polytomous data for the various items and tests limited the statistical software with which I could appropriately actualize the analyses. For example, some software packages claimed to handle polytomous data, but by that they meant a key could be used to then impose dichotomous scoring, thereby losing all the information contained for the multiple levels of scores. To illustrate, by scoring an item where the possible score ranges from 0 to 4 into right and wrong (0 or 1), the variability in scores when an item is partially correct (obtaining a 1, 2, or 3) is lost. This, in addition to the extent of missing data, made the use of another DIF detection procedure (and the accompanying software) to verify DIF items problematic. That is, if the necessary modifications to the data were made in order to complete a secondary set of DIF analyses, the data would have arbitrary characteristics, thereby making it a different data set that the one the initial analyses were completed on. As a result, a second method would not be a

verification of the first set of analyses because the data would be different between the sets of analyses.

Lastly, while there are a number of pieces of evidence gathered in order to make a summative judgment about the comparability of the inferences based on these test scores, the results from this study did not address all the important issues related to validity. Demonstrating the predicative nature of these scores, or how comparable the other tests of cognitive ability on these batteries are, or to what extent these tests are comparable for other sub-groups, whether that be different age groups, or different countries of origin (recall that the calibration sample for the Batería III represents a large number of Spanish-speaking countries) are important aspects of validity that need further investigation. These types of investigations are also important for the construct comparability research area as a whole.

Contributions of Findings to Literature

There exist a number of guidelines that speak to the need to look at the comparability of translated tests (e.g., the *Standards* (AERA et al., 1999), *Principles for Fair Student Assessment Practices for Education in Canada* (1993), and the Guidelines for Adapting Educational and Psychological Tests (summarized by van de Vijver & Hambleton, 1996). This study is an example of the type of research that is supported and requested by these documents in order to demonstrate the validity and comparability, or lack of it, for translated tests. In this way this study contributed to the body of work on construct comparability, which is in the early stages of development, as well as moves it forward by investigating a cognitive rather than achievement type of assessment tool. Further, this study began the necessary research required to support or oppose the validity of the score inferences made from the WJ III and Batería III. It is important that test developers establish that the constructs measured by these instruments exist in all sub-

groups of the populations of interest, that they are measured in the same manner in all groups, and that items that are thought to be equivalent across languages are linguistically and statistically equivalent (Sireci & Allalouf, 2003).

The methodological issues encountered in this study relate mainly to the limitations based on the data characteristics of these cognitive ability tests. The problematic features of the data (including, large amounts of missing data, a lack of variability for easy items, and the use of different scoring schemes) are in large part related to the nature of these tests. That is, cognitive ability tests are designed to measure ability over a large age range, items are ordered from very easy to very difficult, and in some cases processing speed is the targeted ability (i.e., timed tests). The tests that presented the most methodological challenges were the timed tests. Perhaps, the methodologies used in this study, and other construct comparability research is not suited for these types of tests. In the same way that new methodologies have been developed to examine sets of items that are locally dependent (i.e., violate the assumption of local item dependence (LID) through the use of testlets (e.g., Yen, 1993), perhaps innovative approaches to investigate the comparability of timed tests should be pursued.

Future Directions

There are a number of different areas of research related to construct comparability research and the measures that were the focus of this study that deserve further study. First, while this study marks the beginning of the investigation required in order to determine the comparability of tests from the WJ III COG and the Batería-III COG, the investigation must continue. Determining the degree of comparability for other tests is still an important empirical question that should be investigated and answered. In order to overcome some of the limitations, listed previously, of this study, continuing the investigation of the degree of comparability of the

WJ III COG and Batería-III COG there are two possible approaches; (a) continuing with the existing data, or (b) collect new data. For the first approach, in order to overcome some of the limitations of this study, specifically the limited variability of item scores and large amounts of missing data for items at the end of some tests, two strategies could be employed. The first strategy would be to look at narrower age ranges. By narrowing the age range, the amount of variability in item scores should increase. For instance, by examining only the data for those aged 9 to 14 years of age, the proportion of individuals to respond correctly to items at the beginning of the test would likely decrease, thereby increasing the variability in item scores, and hence make it possible for them to be included in analyses. A codicil to this type of investigation may be the discovery that the degree of comparability fluctuates depending on age group. This approach may, however, come with its own set of limitations. By using smaller age ranges sample sizes are going to decrease, which will jeopardize parameter estimation, as well as decrease power (the probability of correctly rejecting the null hypothesis).

The second approach for continuing this research is really a hypothetical one. If, as researcher I could have designed the data collection for use with this study what would I have been done differently? First and foremost, data collection would sample a broad ability distribution, that is a more rectangular shape instead of a bell shaped distribution. Having a broader ability range would increase the number of people administered items at the beginning of tests who responded incorrectly, increasing the variability in scores for these items. Further, it would increase the number of people administered items at the at the end of tests, decreasing the proportion of missing data for these items. Further, I would have all items published in both language versions administered to the different language samples. This would overcome the problem associated with *Spatial Relations* for which there were only 12 common items because

for the English sample, only these 12 were administered during standardization. In this way, analyses could speak to the comparability of *all* items, as well as provide the test developers information with which they could use to select the best items for linking the tests.

This study examined the differences between the item response patterns for individuals administered the two different language versions of selected tests of the WJ III COG and the Batería III COG. Another important program of research to be investigated with these measures is the degree of comparability and validity of inferences of scores based on the use of US norms for individuals administered the Batería III COG. Specifically, derived scores (i.e., scaled scores, age-equivalents, etc.) for individuals administered the Batería III COG are calculated using the US norms of the WJ III COG, which are based on a *US* nationally representative standardization sample. This is accomplished by using a calibration sample to determine the empirical difficulty of the Batería III COG items and then rescaling them to the empirical difficulty of the English counterparts of the WJ III COG. Given the diligence that was paid to making the items and instructions of the Batería III appropriate for the Spanish-speaking world (Woodcock et al., in press-a), it seems reasonable to presume that this test will be administered to individuals outside of the US. As such, is it appropriate to derive norm-referenced scores for these individuals based on a US standardization sample? Would having a standardization sample based on a representative sample of Spanish-speakers from countries outside the US that will use this assessment make a difference? Even the *WJ III Technical Manual* states "the validity of a test's norms depends on the degree to which the norming sample represents the population that the subject's test results will be compared to" (McGrew & Woodcock, 2001, p. 17). The purpose of a calibration sample is to *calibrate* item parameters, and may not meet the standards of representativeness that is the aim of a standardization sample. Hence, the degree of

comparability between an English-speaking standardization sample and a Spanish-speaking calibration sample, versus the degree of comparability between an English-speaking standardization sample and a Spanish-speaking standardization sample may be different, and is an empirical question.

Another potential area for further research would be to investigate the differences that were detected in this study for *Spatial Relations* further. What happens to the pattern of DIF when an iterative DIF detection procedure is used? If DIF is still evident, a more thorough investigation into the causes of this DIF is warranted. While the reviewers used in this study did not indicate they thought there were differences between the two language versions of this test, perhaps a larger, more experienced panel with test translation would. Further, the use of think-aloud protocols may provide information about how the different language groups process items for this tests. Reviews such as these may discover causes of DIF. Then, with the sources of DIF identified, it may be possible to revise these items (or instructions), thereby making them viable to use. The identification and revision of DIF items can be more economical than rebuilding the test with new items, and has been done successfully by other researchers (e.g., Allalouf, 2003).

Other interesting avenues for investigation are related to item information. This study used the 2PPC model to estimate parameters. This model includes parameter estimates that describe an items difficulty as well as how well it discriminates between examinees at different ability levels. The Rasch model uses only a difficulty parameter, and as such it has been demonstrated that there is a loss of item information (Sykes & Yen, 2000). It would be interesting to pursue whether there is indeed a loss of item information when the Rasch model is used to estimate parameters, and whether there are more or less instances of differences in the degree of measurement accuracy between the two languages.

Results from cognitive ability tests continue to play an important role, as a singular source of information, for making life altering decisions about children's schooling and education. Therefore, it is important to expect these tests to meet the highest ethical and psychometric requirements. This study moved us one step closer to addressing and investigating these requirements with the hopes that more steps are made in the future.

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Appendix A

Codes for the Sources of Translation Differences

1. Differences in cultural relevance.

   When the relevance of item content to each culture differs.

   Example: The content of a reading comprehension passage is more relevant to one of the groups.

2. Changes in format.

   Differences in punctuation, capitalization, item structure, typeface, and other formatting usages that are likely to affect the performance for one group of examinees.

   Example: A word that appeared only in the stem of the English form was presented in all four options of the French form thus representing a difference in item structure.

   Example: A letter was located above the X-axis for all distractors in the French form whereas two of the distractors in the English form had the letter below the X-axis. The variation in the position of the letter might have led the English-speaking examinees to think that it was relevant. In fact, the location of the letter was not relevant in answering the item correctly.

3. Changes in content.

   The meaning of the item changed in the translation.

Example: A word that has a single meaning was translated into a word that has more than one meaning.

Example: An item dealing with computing number of kilograms of apples in each of two boxes was stated simply and very clearly in the English form. In the French form, the item instructed examinees to compute kilograms of apples in each one of the two boxes. The word "boxes" in French is plural which might have caused some confusion about whether they were supposed to add the amounts for each box.

4. Omissions or additions that affect meaning.

Omissions or additions of words, phrases, or expressions that affect meaning and are likely to affect the performance for one group of examinees.

Example: The English form of an item contained the expression "*this number written in standard form*" while the French form had the phrase "*ce nombre est*" ("*this number is*"); the idea of "standard form" is excluded from the French translation.

Example: The English form of an item contained the word "*different*" in the phrase "*five different Celsius thermometers*" while the French form omitted the word "*different*" ("*cinq thermomètres*").

5. Differences in verb tense.

Example: The word "*reads*" in the English item was translated into "*a lues*" in the French item.

6. Differential frequency, difficulty or commonness of vocabulary.

The translation was accurate but some words became easier or more difficult.

Example: The word "*pace*" was used in the English item and was translated into "*pas*" (step) in the French item. In this case, a very difficult word in the stem was translated into a very simple word.

Example: The English item used the word "*burns*" while the French translation used the word "*combustion*". The word "*combustion*" in French is not as common as the word "*burns*" in English, and could have made the French version of the item more difficult.

7. Exclusion or inappropriate translation of key words.

Key words are important vocabulary that provides information, or guides thinking processes of examinees. Exclusion or inappropriate translation of these words can lead to confusion or make the item easier or more difficult.

Example: The stem in the English form stated "whenever scientists carefully measure any quantity many times, they expect that …". The answer is "most of the measurements will be close but not exactly the same". In the French form, the stem was translated as "when scientist measure the same quantity many times, they expect that…". The word "same" in the French form could lead to the examinees to think that this quantity was known and the answer should be that the scientists should get the same amount every time.

8. Differences in information that guides the examinees' thinking processes.

Additional information can guide examinees' thinking processes.

Example: The English item asks "At what point will the reflection of the candle appear to be?" In the French form, the item asks "En quell point l'image de la bougie apparaĭtra-t-elle?" ("At which point will the image of the candle seem to appear to be?") The French version provides more information by telling the examinees that the reflection in the mirror may seem different than the actual objects. This additional information could have made the item in the French version easier.

9. Differential length or complexity of sentences.

   The translation was accurate but the sentences became easier or more difficult.

10. Differences in words, expressions, or sentence structure inherent to language and/or culture.

    Differences in words, expressions, or sentence structure of items that are inherent to the language and/or culture and are likely to affect the performance for one group of examinees.

    Example: The English sentence "Most rollerbladers do not favour a helmet bylaw" was translated into "La plupart des personnes qui ne font pas de patin à roulettes sont pour un règlement municipal en faveur du port du casque protecteur" The expression for "rollerbladers" ("personnes qui font patin à roulettes") and "helmet bylaw" ("un règlement municipal du casque protecteur") differ dramatically between English and French forms because "rollerblader" and "helmet bylaw" have no expression that is directly parallel in French.

Example: An English item used a 12-hour clock using AM and PM while the French translation uses a 24-hour clock. The 12- vs. the 24-hour clock represents an English-French cultural difference.

11. Differences in words, expressions, or sentence structure not inherent to language and/or culture.

    Differences in words, expressions, or sentence structure of items that are not inherent to the language and/or culture and are likely to affect the performance for one group of examinees.

    Example: The English phrase "*basic needs met*" versus the French phrase "*les services offerts*" focuses on "needs" in English and "services" in French.

    Example: The English phrase "*traditional way of life*" versus the French phrase "*les traditions*" present two distinct concepts surrounding "*a way of life*" and "*traditions*" in the English and French forms, respectively.

    Example: The English phrase "*animal power*" versus the French phrase "*à l'aide des animaux*" present distinct concepts related to "*the power of animals*" and "*the help of or aid by animal*" in the English and French forms, respectively.

    In all three examples, alternative phrases would produce items that were closer in meaning across the two languages. Hence, these differences are not inherent to the languages unlike the examples in source #10.

12. Free feel to add other possible sources of difference:

Reviewer's name: Date: Test 1

INSTRUCTIONS:

1: Work on the following items to determine what you think is:

(0)	**No difference**	No difference in meaning between the two versions
(1)	**Negligible difference**	Minimal differences in meaning between the two versions
(2)	**Somewhat different**	There are clear differences in meaning between the two versions but they are not expected to lead to differences in performance between the two groups of examinees
(3)	**Very different**	There are clear differences in meaning between the two versions that are expected to lead to differences in performance between the two groups of examinees

2: Please determine how confident you are when giving your rating to an item.
(0) Not confident (1) Somewhat confident (2) Confident (3) Very confident

3: If there is a difference, please determine the language group (Spanish or English) the item would favor.

4: Please indicate the code for the source(s) of difference. Refer to the 'Codes for the Sources of Translation Difference' sheet.

5: Please describe the translation problems.

EXAMPLE:

Item #	Rating[1]	Confidence rating[2]	Favors (E or F)	Code(s)[3]	If the Rating of an item is 2 or 3, please provide the following information: Description of Translation Problems: English Version	French Translation	Problem	Translation Should be
E8	2	3	F	7	A son	Un enfant	English version more specific	fils

[1] 0 – No Difference 1 – Negligible Difference 2 – Somewhat Different 3 – Very Different
[2] 0 - Not Confident 1 - Somewhat Confident 2 - Confident - Very Confident
[3] See 'Codes for the Sources of Translation Difference' sheet

Reviewer's name: Date: Test 2

Item #	Rating[1]	Confidence Rating[2]	Factors (e.g., EE)	Codes[3]	If the Rating of an item is 2 or 3, please provide the following information: Description of Translation Problems: English Version	Spanish Translation	Problem	Translation Should be
Instructions								
1								

[1] 0 – No Difference 1 – Negligible Difference 2 – Somewhat Different 3 – Very Different
[2] 0 - Not Confident 1 - Somewhat Confident 2 - Confident 3 - Very Confident
[3] See 'Codes for the Sources of Translation Difference' sheet