Structural invariance of multiple intelligences, based on the level of execution

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The independence of multiple intelligences (MI) of Gardner's theory has been debated since its conception. This article examines whether the one- factor structure of the MI theory tested in previous studies is invariant for low and high ability students. Two hundred ninety-four children (aged 5 to 7) participated in this study. A set of Gardner's Multiple Intelligence assessment tasks based on the Spectrum Project was used. To analyze the invariance of a general dimension of intelligence, the different models of behaviours were studied in samples of participants with different performance on the Spectrum Project tasks with Multi-Group Confirmatory Factor Analysis (MGCFA). Results suggest an absence of structural invariance in Gardner's tasks. Exploratory analyses suggest a three-factor structure for individuals with higher performance levels and a two-factor structure for individuals with lower performance levels.

Invarianza estructural de las inteligencias múltiples en función del nivel de ejecución. La independencia de las inteligencias múltiples (IM) de la teoría de Gardner ha sido objeto de controversia desde su concepción. Este artículo analiza si la estructura unifactorial de la teoría de las IM manifestada en estudios anteriores es invariante para alumnos de baja y alta habilidad. En el estudio participaron doscientos noventa y cuatro alumnos, con edades comprendidas entre los cinco y los siete años, que completaron un conjunto de tareas de rendimiento para la evaluación de la teoría de las IM recogidas en el Proyecto Spectrum. Para analizar la invarianza de la estructura unifactorial se estudiaron los diferentes modelos de comportamiento en muestras de sujetos con diferentes niveles de rendimiento en las tareas para la evaluación de las IM a través de un análisis factorial confirmatorio multigrupo. Los resultados sugieren la ausencia de una invarianza estructural de las tareas de Gardner. Análisis exploratorios sugieren la existencia de una estructura con tres factores para los sujetos de mayor rendimiento y dos factores para la muestra de alumnos con rendimiento más bajo.

More than a century of controversy on intelligence concerning its structure has lead to two opposite approaches: one defending a general (*g*) factor as the best and the sufficient construct to represent intelligence (Spearman, 1904, 1927); the other one, proposing a multifactor perspective and taking intelligence formed by several independent aptitudes (Thurstone, 1938). Progressively, hierarchical models are proposed to solve this controversy combining general or higher order factors with primary aptitudes (Cattell, 1963; Horn & Cattell, 1966; Vernon, 1965). A more recent proposal of higher and lower factor level combination is present in the three-stratum theory of cognitive abilities, usually known as the CHC (Cattell-Horn-Carroll) theory. This theory implies that, after the correlations among 80 primary aptitudes, a dozen of second-order factors is proposed, as well as a third level of factor analyses with a general factor quite similar to Spearman's *g* factor (Carroll, 1993, 1996, 2003; Horn & Noll, 1997).

Spearman's *g* factor has a long tradition in psychology. Defined as comprehension, relations and correlates apprehension (Spearman, 1927), *g* factor seems be present in all daily activities and namely in intelligence tests. In general, studies have shown positive and statistically significant correlations between different intelligence test scores, even when using multifactor batteries which assess differentiated aptitudes more clearly (Jensen, 1998; Larson & Saccuzzo, 1989; Messick, 1992; Scarr, 1985; Watkins & Canivez, 2004; Watkins, Wilson, Kotz, Carbone, & Babula, 2006).

Thus the concept of «general intelligence», also known as the *g* factor, is well established in practice and research psychology (Jensen, 1998; Lubinski, 2004). The authors have highlighted the role of the *g* factor in cognitive performance as being related to understanding situations and establishing relationships, making inferences and connections, the acquisition of concepts, the retention and evocation of information, learning and academic performance, abstract reasoning and problem solving. The *g* factor is involved in the multiple cognitive functions found in intelligence tests (Lubinski, 2004), sometimes assumed in different ways, for example as «neurological efficiency» (Eysenck, 1988), «mental speed» (Jensen, 1987), «working memory» (Kyllonen & Christal, 1990) or «information processing components» (Sternberg, 1985).

Contradicting this definition of a *g* factor in terms of neurological and psychological significance, some critics suggest that the *g* no longer refers to the intercorrelations between different tests (Gardner, 1983, 1999). For example, Gardner has understood the *g* factor as a statistical artefact, rather than being related to common situational demands in intellectual testing, which is associated to answer speed and flexibility or motivation towards success among other variables (Gardner, 2006). Complementarily, other authors question the true *g* practical interest, since its measure is less reliable when using highly abstract items or tasks that are more distant from sociocultural context and everyday situations (Ackerman, 1994). Accordingly, Gardner (1983) proposes a different conception of intelligence, breaks away from the psychometric importance given to a *g* factor and suggests a more contextual assessment as an alternative to traditional tests or psychometric tradition. Indeed, along his proposal of multiple intelligences (MI), this author proposes suitable contextualized situations to assess intelligence for diverse life or daily learning and performance realities.

According to Gardner (1983), intelligence is the subject's capacity to solve problems that are of value to a specific culture. Intelligence has a biopsychological origin and is influenced by the subject's environment, experience and motivation. Since then, this theory has received a favourable opinion from educators and teachers, but also has collected criticisms from some researchers. The MI theory's empirical support is, at least, incipient. The idea that all children can be intelligent in any of the proposed intelligences and thus develop their potential is quite optimistic for parents and teachers, although it has not been empirically demonstrated. On the other hand, his position regarding the irrelevance of an IQ test as a predictor of academic performance, has been more refuted than confirmed, despite the limits that everyone can identify in intelligence tests or a g factor (Gottfredson, 1997, 2003; Neisser et al., 1996).

Also, he claims the independence of the different intelligences while some authors anticipated the emergence of common factors. Some studies have used the techniques of exploratory (EFA) and confirmatory analysis (CFA) in order to study the independence of multiple intelligences assessed by performance-based tasks. Of them, some have provided evidence of the multifactorial structure of the MI theory, for example, Plucker, Callahan and Tomchin (1996) and Ferrándiz, Prieto, Ballester, and Bermejo (2004) analyzed the psychometric properties of a set of assessment tasks of the Spectrum Project through an EFA with varimax rotation, showing partial evidence of the independence of the multiple intelligences. A second group of studies have proven some convergence between the Gardner's multiple intelligences. For example, Visser, Asthon, and Vernon (2006) provided evidence of a large *g* factor having substantial loadings for tests assessing purely cognitive abilities (i.e., Linguistic, Logical-Mathematical, Spatial, Naturalistic), but lower loadings for tests measuring non-cognitive abilities (i.e., Bodily-Kinesthetic, Music) through an EFA. Indeed, Gridley (2002) and Castejón, Pérez, and Gilar (2010) have found that Gardner's multiple intelligences are not completely independent of each other but they cannot be grouped into a general factor of intelligence using a CFA. Finally a third group of authors support the idea that the tasks proposed by Gardner in the Spectrum Project may not differ substantially from classical tests, anticipating that the MI test scores present a regular convergence into a single factor using both EFA (Pyryt, 2000) and CFA (Almeida et al., 2010).

An important critique to the Multiple Intelligences theory is that all tasks were initially developed with students with poor performance and at-risk children (Messick, 1992). This may explain why it is so difficult in his case to find the psychometric regularities and the independence of tasks when analyzing students with different levels of performance. For example, authors suggest that the *g* factor has a higher impact on the explanation of cognitive differences, namely in groups of participants with lower capabilities. This is known as the Spearman's law of diminishing returns (Reynolds & Keith, 2007; Reynolds, Keith, & Beretvas, 2010; Spearman, 1927), which will be considered in the analysis of our data too. As a response to these controversies, our study seeks to replicate the one-factor MI structure (structural invariance) when studying students' groups with different performance levels (including high and low ability).

Method

Participants

The study was conducted in the Region of Murcia (Spain). The sample was composed of 294 pupils (47.95% boys, 52.05% girls). They were selected incidentally from a number of private and public schools located in Murcia (Spain) to represent the school population. Roughly, equal samples were taken from each of three grades: kindergarten (aged 5, *n*= 100), first year of elementary school (aged 6, *n*= 96), and second year of elementary school (aged 7, *n*= 98). The sample varied in terms of ethnic and social background, in line with the Spanish population. The population of the studied sample was representative of the national general population (51.31% boys; 48.69% girls; 33.04% kindergarten, 33.60% first grade, 33.33% second grade). The differences in percentage between the sample and the population were not statistically significant for both gender [X^2 (1)= 1.334, *p*= .228] and grade [X^2 (2)= 0.027, *p*= .987].

Instruments

Nine performance-based tasks were used to assess MI. These tasks were proposed by Gardner, Feldman and Krechevsky in the Spectrum Project (1998a, 1998b, 1998c), and have been adapted to the Spanish population by Ferrándiz and cols. (Ferrándiz, 2004; Ferrándiz et al., 2004; Ferrándiz, Prieto, Bermejo, & Ferrando, 2006). Each task assesses the skills involved in a specific intelligence, according to the author's theory. Figure 1 shows a brief description of the activities and the skills assessed in relation to each of the intelligences. A group of trained psychologists assessed each of the intelligences on the basis of a specific checklist, which listed the tasks, the skills involved, and the evaluation criteria. Every skill was evaluated with specific criteria in a likert-type scale ranging from 1 (never expresses) to 4 (always expresses). Based on the observed ratings, the internal consistency of the MI scores ranged from α= .63 for Bodily-Kinesthetic intelligence, to α= .87 for Visual-Spatial intelligence.

Procedure

The school director, teachers and parents authorized the study. Accordingly, we informed students of the aims of the study and its confidentiality. The tests were administrated during school time.

Due to the nature of the MI activities, the assessment was carried out in small groups and with five researchers per classroom. We administered the tests according to the guides provided by the Spectrum Project (Gardner et al., 1998c).

Research design and data analysis

As a first step, preliminary statistical analyses were conducted to examine the distribution and relationship of the MI task scores. These included descriptive (*Mean and Standard Deviation*),

internal consistency (*Cronbach's alpha*), and correlation analyses (*Pearson's product-moment correlation coefficient*). Secondly, a non-hierarchical cluster analysis (K-means) was carried out to group high and low performance students in MI tasks. Thirdly, a multiple-group confirmatory factor analysis (MGCFA) was used to test the invariance of a general factor for MI tasks for the high and low performance student groups obtained in the cluster analysis. The MGCFA is a well-established technique, which investigates group differences in means and covariance within the common factor model. The fit of each model to the data was

Intelligence (α)	Tasks and Description	Assessed Skills
Naturalist (.79)	*Discovery*: Students are requested to seek differences-similarities between some objects (feather, stone, etc.) and describe them in retail. *Float and sink*: Teachers ask whether each object would float or sink in a tank of water and why	*Accurate observation*: pay attention to details *Identification of relationships*: establish cause-effect relationships, similarities-differences *Formulation and verification of hypotheses*: identify-fix shortcomings using logical reasoning *Experimentation*: manipulate objects, see different uses and possibilities of working with them *Interest*: value given to the level of knowledge and motivation in relation to the natural world
Visual-Spt. (.87)	*Create a sculpture*: Students are asked to create a figure with clay. *Draw …*: Students are asked to draw an animal they know, a person and an imaginary animal	*Representation*: create recognizable objetct symbols, spatially coordinate elements into whole *Exploration*: designs, use of materials of artistic expression, flexibility, creativity and invention *Artistic talent*: use various pieces of art to express emotions, produce effects, beautify drawings
Body-Kines. (.63)	*Creative movement:* Students are asked to do some simple physical exercises, such as to follow the rhythm of clapping while rowing, and also to represent ideas by using their body	*Sensitivity to rhythm*: control various movements, which vary according to the pace *Expressiveness*: express different states of mind and emotions by using the body *Body control*: maintain a balance by using different elements (ropes on the ground, benches) *Production of ideas through movement*: invent and propose on how to move the body in space
Linguistic (.70)	*Story-telling*: Students play with a model that has a scenery and several characters. They are asked to make up a story and tell it *Reporter*: After watching a short voiceless videos, students are asked to tell what happened	*Functions of language*: narration, interaction, research, description and categorization *Narration*: narrative structure, thematic consistency, use of narrative voice, use of dialogue, etc. *Information*: level of organization, accuracy of content, structure of the plot, vocabulary, etc.
Log-Math. (.76)	*Game of the dinosaur*: Table game in which students advance positions depending on a score acquired with two dices. One dice marks the number of positions, the other marks the direction to follow with a minus (backward) and a plus (advance) sing	*Numerical reasoning*: view, organize and solve problems, using operations and calculations *Logical reasoning*: articulate the data in the best way possible in order to win the game *Spatial reasoning*: view the data of the game and understand the necessary movements
Musical (.65)	*Singing*: Students are asked to sing different songs (easier and more complicated)	*Sensitivity to pitch*: distinguish between short and long notes of a song or melody *Rhythm*: express correct number of musical notes, distinguish between short-long notes, etc. *Musical ability*: sing a song with correct melody and rhythm, including expressiveness

Note: All the skills were assessed by an expert observer in a likert-point scale (1 = never expresses; 4 = always expresses)

Figure 1. IM Tasks and Assessed Skills (Gardner, Feldman, & Krechevsky, 1998a, 1998b, 1998c; adapted by Ferrándiz, 2004; Ferrándiz, Prieto, Bermejo, & Ferrando, 2006)

compared sequentially to that of the next model, progressing from the least to most restricted level. Given non-significant findings that indicated good fit, the next level of constraint was tested. The method of *estimation of the maximum likelihood* was used in all of the models tested. The measurements of evaluation of the adjustments used to verify the adequacy of the model to the data were the following: *chi-square statistics (χ^2), comparative fit index (CFI;* Bentler, 1990*), and root mean square error of approximation (RMSEA;* Steiger, 1990*)*. Finally, two EFA were carried out to analyze the structural variance for the MI tasks in both high and low performance groups.

We used the programs SPSS 18.0 and the AMOS 17.0 (Arbuckle, 2005) for the statistical treatment of the data.

Results

The following section includes a descriptive analysis of the tasks which integrate the MI of the Spectrum Project. In Table 1, we present the mean, the standard deviation and the correlations found in all six tasks.

The children who participated in the study present higher mean values in the Logical-Mathematical intelligence (*M*= 3.53; *SD*= 0.55), and worse mean values in the Linguistic intelligence (*M*= 2.06; *SD*= 0.56). The correlation coefficients obtained, besides being statistically significant in most of the cases, show low values and inferior correlations to .40 for all of the intelligences. The higher coefficients emerge in the correlation between the Naturalistic intelligence and the Corporal, Linguistic and Logic-Mathematical intelligences (values of .35 and .34, *p*<.01, respectively). The lowest correlations emerge between the Musical intelligence and the Visual-Spatial and Logic-Mathematical intelligence (*r*= .12, *p*<.05).

Considering these MI scores as proposed by Gardner (Naturalistic, Linguistic, Corporal, Visual-Spatial, Musical and Logic-Mathematical), our objective is to verify whether a general intelligence factor for Multiple Intelligence tasks (e.g., Almeida et al., 2010) is invariant for high and low performance students. We pursued one MGCFA solution according to different performance groups to test for measurement equivalence of the Gardner MI. Mardia's coefficient was 8.473. According to Bollen (1989), if Mardia's coefficient is lower than P(P+2), where P is the number of observed variables, then there is multivariate normality. As in this study, we used six observed variables, therefore, we can affirm that there was a multivariate normal distribution of the data, which allowed us to use the Maximum Likelihood estimation method in the MGCFA.

We assessed the initial fit of the models using the chi-square statistics, as well as other practical model fit indices, including the RMSEA and CFI. Given the sensivity of the chi-square, we used the following criteria recommended by Bollen (1989) to determine if there was a relatively good fit between the hypothesized models and observed data: a cutoff above .95 for the CFI and a cutoff value bellow .06 for the RMSEA (Hu & Bentler, 1999).

Although we analyzed a general intelligence dimension, we also studied the behaviour of the different models we studied from the samples of subjects with distinct outcomes in the *Project Spectrum* tasks. We analyzed the invariance of the general intelligence structure in relation to the realities and profiles with different performance. In order to do so, we used a cluster analysis (K-Mean) and considered two clusters that would create centroids with better and worse performance in the multiple intelligence assessment tasks. The data in Table 2 shows two clusters with 104 individuals with better performance and 101 with worse values in the multiple intelligence tests (89 missings).

We then specified MGCFA to test the structural invariance of the two groups (high and low abilities) with different performance scores in Gardner's tests. The MGCFA allows us to assess the measurement invariance by using the same factorial structure tested previously by Almeida et al. (2010), which suggests a general factor for MI tasks. Accordingly, we adopted a method, which consisted of comparing the fit of more constrained models successively. As researcher proceeds from one step to another, we tested the change in model fit associated with the greater constraints. Following the recommendations of Cheung & Rensvold (1999), we used a change in the CFI smaller than or equal to .01 between successive levels of invariance as a cutoff within which invariance was not rejected.

The results of the tests of measurement invariance can be found in Table 3. Model 1 was the initial model, in which no constraint was imposed across the two levels of student performances. What is more, the model revealed good fit indices. To test the metric invariance in Model 2, the factor loadings were constrained to be equal across the two cluster groups. The χ^2 did not increase significantly (*p*= .375) and the RMSEA was good. Nonetheless, ΔCFI was outside the cutoff .01. Following the recommendations of Cheung and Rensvold (1999), we classified Gardner's tasks as possessing loading variance between groups (Δχ^2= 7.609, Δ*df*= 4, ΔCFI= .229). We considered the structural variance for lower and

Table 1
Descriptive analysis and intercorrelations of Gardner's Assessment Tasks

	M	SD	1	2	3	4	5
1. Naturalistic	2.43	.49					
2. Linguistic	2.06	.56	.34**				
3. Corporal	2.73	.48	.35**	.26**			
4. Visual-Spatial	2.56	.59	.22**	.29**	.25**		
5. Musical	2.53	.49	.13*	.18**	.20**	.12*	
6. Logic-Math.	3.53	.55	.34**	.25**	.19**	.28**	.12*

Note: M= Mean; SD= Standard Deviation; * p<.05; ** p<.01

Table 2
Mean and standard deviation of the clusters indicating high and lower ability subjects

Clusters of Gardner's tests				
	Low ability (*n*= 101)		High ability (*n*= 104)	
	Mean	Standard deviation	Mean	Standard deviation
Naturalistic	2.18	.36	2.71	.46
Linguistic	1.76	.41	2.38	.50
Corporal	2.48	.43	2.98	.42
Visual-Spatial	2.26	.47	2.87	.50
Musical	2.46	.50	2.61	.44
Logic-Math.	3.27	.67	3.79	.27

higher performance groups because we found metric invariance for Model 2. Furthermore, we did not test more restricted models because we did not find invariance when factor loadings were constrained to be equal.

In order to understand the structural variance of the MI tasks, we conducted EFA using subtest Z scores. To enable a more informed decision on the proper number of factors to retain, multiple factor retention criteria were applied: Kaiser's, Velicer's MAP test, and Horn Parallel analyses. Horn Parallel and Velicer MAP tests are statistical procedures that include comparisons of the sample size of randomly generated eigenvalues to the size of sample data correlation matrix when increasing number of components derived from data. Both methods have been shown to be superior to conventional factor criteria such as Cattell's Scree test or Kaiser criteria (O'Connor, 2000). According to the different retention criteria, three factors were obtained for the higher performance students (with 57.86% explained variance) and two factors for the lower performance students (with 41.14% explained variance). Concerning the first situation, we found three tasks related to the first factor (Naturalistic, Bodily-Kinesthetic, Logic-Mathematical), two tasks for the second factor (Visual-Spatial and Linguistic), and two tasks for the third factor (Bodily-Kinesthetic, Musical, and negatively for Logic-Mathematical). As shown in Table 4, factor one and two were strongly associated to the more traditional intelligences with more emphasis on cognitive processes. On the other hand, the third factor was more associated to the artistic intelligences. The EFA for lower performance students revealed that the cognitive intelligences were more associated to the first factor, whereas the artistic intelligences were more associated to the second factor. In sum, our results showed more independence associated with MI for high ability than for low ability students.

Table 3
Fit measures for Gardner general factor multi-groups of high and lower ability subjects

Models	χ^2	df	sig.	χ^2/ df	$\Delta\chi^2$	Δdf	CFI	ΔCFI	RMSEA
Model 1	16.919	19	.595	.890	_	_	1.000	_	.000
Model 2	24.528	23	.375	1.066	7.609	4	.771	.229	.015

Table 4
Multiples intelligences rotated component matrix for high and low performance students

	High performers (*n*= 168)			Low performers (*n*= 126)	
	1	2	3	1	2
Naturalistic	.85			.51	
Bodily-Kinaesthetic	.56		.59		.67
Visual-Spatial		.75		.50	
Logic-Mathematic	.42		-.43	.61	
Linguistic		.52		.59	
Musical			.68		.67
Eigenvalues	1.23	1.17	1.07	1.37	1.10
% of variance	20.55	19.52	17.79	22.79	18.34

Note: Values bellow .32 were deleted

Discussion

If we analyze individuals' behaviour in daily tasks and evaluate Gardner's MI, we verify that the confirmatory model tested emphasizes a convergence of the results in the six tests for a general dimension of intelligence. In this sense, these results aren't far from the results obtained in the classic intelligence or psychometric tests (Jensen, 1998; Watkins & Canivez, 2004). Equally, other studies make reference to the difficulty in assuming the tasks that evaluate MI and even, Gardner's MI as independent from each other. Contrarily to Gardner's pretensions, the multiple intelligence tasks used in the *Spectrum Project* converge into a single factor (Almeida et al., 2010). This fact supports in empirical terms, a general dimension of intelligence, as Sternberg verified (1994), with his Multiple Intelligence theory «*smells a bit like g*». Accordingly, Visser et al., (2006) highlight evidence of a single *g factor* which is represented in numerous tasks (not only in an academic setting) and emphasize their predictor capacity when considering different criteria variables. Furthermore, Bernard & Olivarez (2007) also found a general common factor when considering results only in the Linguistic and Logic-Mathematical intelligences. Nonetheless, both of these intelligences are highly attached to academic learning and achievement.

Intelligence can then be understood as a complex aptitude which approaches important aspects related with problem-solving as well as the capacity to infer, to think in an abstract manner and to understand surrounding environments (Neisser et al., 1966; Rindermann, 2007). According to Gardner, intelligence is relatively autonomous and correlations among different intelligences will not be high. Considering this, we tried to understand if this does not only apply to the specific case where the multiple intelligence tasks were developed (i.e., students with low abilities). In this sense, we tried to observe the invariance of the results' explicative models in the six intelligences tested by testing the convergence into *g*, considering the structural models of higher and lower ability groups of children. Results show no evidence for structural invariance between children with different scores in the Multiple Intelligence Tests. To understand this absence of structural invariance, we developed two EFA, which revealed different factorial structures for higher and lower performance students.

Data also showed a more differentiated structure for higher ability students with three distinct factors (*versus* two factors for lower ability students). Considering the initial structure set by Gardner (1999), namely Traditional Intelligence (Linguistic and Logic-Mathematical), Artistic Intelligence (Musical, Bodily-Kinesthetic, Visual-Spatial) and Personal Intelligence (Interpersonal and Intrapersonal), this initial structure was better reproduced in the lower ability students.

With this data, we can argue that the intercorrelations between these task results don't represent a general dimension or a *g* factor of intelligence, but the way in which the different intelligences interact (Waterhouse, 2006). However, as shown in Table 4, Visual-Spatial tasks have higher loadings in the first factor (Traditional Intelligence) than in the second factor (Artistic Intelligence). Against the pretensions of Gardner, the Visual-Spatial tasks seem to be more of cognitive intelligence than a creative dimension linked to the Artistic Intelligences. However, it is important to include new tasks, namely the Interpersonal and Intrapersonal intelligence tasks in order to understand other possible factors associated to the Personal Intelligences.

Finally, our data behaves differently depending on the characteristics of the sample. When adopting the general sample, we contradict the idea of independent intelligences as initially proposed by Gardner (1983). On the other hand, when exploring samples of subjects with different abilities and performances, we identify a no structural invariance. The high ability children denoted a more independent factorial structure (with three independent factors), whereas in the lower performance group, we found the initial structure of Traditional and Artistic intelligences proposed by Gardner in 1999. In an approach to Spearman's law of diminishing returns (Reynolds & Keith, 2007; Reynolds, Keith, & Beretvas, 2010; Spearman, 1927), our results provided evidence for a factor in which the multiple intelligences that are more related to the classical psychometric testing converge (i.e., Linguistic, Visual-Spatial, Logical-Mathematical intelligences)

along with the Naturalist intelligence, which involves reasoning processes such as classification, categorization and inference (very close to a factor of reasoning) regarding the low ability group.

According to our results, psychometric studies concerning the MI tasks must be conducted using different samples and students with lower and higher abilities. Our data reinforces the importance to carefully interpreting the MI structure because its initial conception and development was conducted with a sample of at-risk children or students with poor performance (Messick, 1992).

Acknowledgments

References

Ackerman, Ph.L. (1994). Intelligence, attention, and learning: Maximal and typical performance. In D.K. Detterman (Ed.), *Current topics in human intelligence: Theories of intelligence* (vol. 4; pp. 1-27). Norwood, NJ: Ablex Publ.

Almeida, L.S., Prieto, M.D., Ferreira, A.I., Bermejo, M.R., Ferrando, M., & Ferrándiz, C. (2010). Intelligence assessment: Gardner multiple intelligence theory as an alternative. *Learning and Individual Differences*, 20, 225-230.

Arbuckle, J.L. (2005), Amos 6.0 User's Guide, Chicago, IL: SPSS Inc.

Bentler, P.M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, 107, 238-246.

Bernard, L., & Olivarez, A. (2007). Self-estimates of multiple, *g factor*, and school-valued intelligences. *North-American Journal of Psychology, 9*, 501-510.

Bollen, K.A. (1989). *Structural equations with latent variables*. New York: John Willey.

Carroll, J.B. (1993). *Human cognitive abilities: A survey of factor analytic studies*. New York: Cambridge University Press.

Carroll, J.B. (1996). The three-stratrum theory of cognitive abilities. In D.P. Flanagan, J.L. Genshaft, & P.L. Harrison (Eds.), *Contemporary intellecual assessment: Theories, tests, and issues* (pp. 122-130). New York: Guilford Press.

Carroll, J.B. (2003). The higher-stratum structure of cognitive abilities: Current evidence supports *g* and about ten broad factors. In H. Nyborg (Ed.), *The scientific study of general intelligence: Tribute to Arthur R. Jensen* (pp. 5-22). San Diego: Pergamon.

Castejón, J.L., Pérez, A., & Gilar, R. (2010). Confirmatory factor analysis of Project Spectrum activities. A second-order g factor or multiple intelligences? *Intelligence*, 38, 481-496.

Cattell, R.B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, 54, 1-23.

Cheung, G.W., & Rensvold, R.B. (1999). Testing factorial invariance across groups: A reconceptualization and proposed new method. *Journal of Management, 25*, 1-27.

Eysenck, H.L. (1988). The biological basis of intelligence. In S.H. Irvine & J.W. Berry (Eds.), *Human abilities in cultural context*. New York: Cambridge University Press.

Ferrandiz, C. (2004). *Evaluación y desarrollo de la competencia cognitiva: un estudio desde el modelo de las Inteligencias Múltiples. I Premio Nacional de Investigación Educativa. Modalidad Tesis doctoral*. MEC: CIDE.

Ferrándiz, C., Prieto, M.D., Ballester, P., & Bermejo, M.R. (2004). Validez y fiabilidad de los instrumentos de evaluación de las Inteligencias Múltiples en los primeros niveles instruccionales. *Psicothema*, 16, 7-13.

Ferrándiz, C., Prieto, M.D., Bermejo, M.D., & Ferrando, M. (2006). Fundamentos psicopedagógicos de las Inteligencias Múltiples. *Revista Española de Pedagogía, 233*, 5-20.

Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Gardner, H. (1999). *Intelligence reframed: Multiple intelligences for the 21st*. New York: Basic Books.

Gardner, H. (2006). On failing to grasp the core of MI theory: A response to Visser et al. *Intelligence, 34,* 503-505.

Gardner, H., Feldman, D., & Krechevsky, M. (1998a). *Project Spectrum: Building on Children's Strengths: The Experience of Project Spectrum*. New York: Teachers College Press.

Gardner, H., Feldman, D., & Krechevsky, M. (1998b). *Project Spectrum: Early Learning Activities*. New York: Teachers College Press.

Gardner, H., Feldman, D., & Krechevsky, M. (1998c). *Project Spectrum: Preschool Assessment Handbook*. New York: Teachers College Press.

Gottfredson, L.S. (1997). Why g matters: The complexity of everyday life. *Intelligence*, 24, 79-132.

Gottfredson, L.S. (2003). On Sternberg's… reply to Gottfredson. *Intelligence, 31,* 415-424.

Gridley, B.E. (2002). In search of an elegant solution: Reanalysis of Plucker, Callahan, & Tomchin, with respect to Pyryt and Plucker. *Gifted Child Quarterly, 46*, 1-11.

Horn, J.L., & Cattell, R.B. (1966). Refinement and test of the theory of fluid and crystallized intelligence. *Journal of Educational Psychology, 57*, 253- 270.

Horn, J.L., & Noll, J. (1997). Human cognitive capabilities: Gf-Gc theory. In D.P. Flanagan, J.L. Genshaft, & P.L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests and issues* (pp. 53-91). New York: Guilford.

Hu, L.T., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Coventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1-55.

Jensen, A.R. (1987). Psychometric g as a focus of concerted research effort. *Intelligence, 11*, 193-198.

Jensen, A.R. (1998). *The g factor: The science of mental ability (Human evolution, behavior, and intelligence)*. Westport: Praeger.

Kyllonen, P.C., & Christal, R.E. (1990). Reasoning ability is (little more than) working-memory capacity?! *Intelligence, 14,* 389-433.

Larson, G.E., & Saccuzzo, D.P. (1989). Cognitive correlates of general intelligence: Toward a process theory of g. *Intelligence, 13*, 5-31.

Lubinski, D. (2004). Introduction to the special section on cognitive abilities: 100 years after Spearman (1094) «General Intelligence», objectively determined and measured. *Journal of Personality and Social Psychology, 86*, 96-111.

Messick, S. (1992). Multiple intelligences or multilevel intelligence? Selective emphasis on distinctive properties of hierarchy: On Gardner's Frames of Mind and Sternberg's Beyond IQ in the context of theory and research on the structure of human abilities. *Journal of Psychological Inquiry, 1*, 305-384.

Neisser, U., Boodoo, G., Bouchard, T.J., Boykin, A.W., Brody, N., Ceci, S.J., Halpern, D.F., Loehlin, J.C., Perloff, R., Sternberg, R.J., & Urbina, S. (1996). Intelligence, knowns, and unknowns. *American Psychologist, 51,* 77-101.

O'Connor, B.P. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instrumentation, and Computers, 32,* 396-402.

Plucker, J.A., Callahan, C.M., & Tomchin, E.M. (1996). Wherefore art thou, multiple intelligences? Alternative assessment for identifying talent in ethnically diverse and low income students. *Gifted Child Quarterly*, *40,* 81-92.

Pyryt, M.C. (2000). Finding g: Easy viewing through higher order factor analysis. *Gifted Child Quarterly, 44,* 190-192.

Reynolds M.R., & Keith, T.C. (2007). Spearman's law of diminishing returns in hierarchical models of intelligence for children and adolescents. *Intelligence 35,* 267-281.

Reynolds, M.R., Keith, T.Z., & Beretvas, S.N. (2010). Use of factor mixture modeling to capture Spearman's law of diminishing returns. *Intelligence, 38,* 231-241.

Rindermann, H. (2007). The big g-factor of national cognitive ability. *European Journal of Personality, 21,* 767-787.

Scarr, S. (1985). An autor's frame of mind: Review of Frames of Mind by Howard Gardner. *New Ideas in Psychology, 3,* 95-100.

Spearman, C. (1904). «General intelligence» objectively determined and measured. *American Journal of Psychology, 15,* 201-293.

Spearman, C. (1927). *The abilities of man: Their nature and measurement.* New York: Macmillan.

Steiger, J.H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research, 25,* 173-180.

Sternberg, R.J. (1985). *Beyond IQ: A triarchic theory of human intelligence.* New York: Cambridge University Press.

Sternberg, R.J. (1994). Human intelligence: Its nature, use, and interaction with context. In D.K. Detterman (Ed.), *Current topics in human intelligence* (vol. 4, pp. 361-407). Norwood, NJ: Ablex.

Thurstone, L.L. (1938). *Primary mental abilities.* Chicago: University of Chicago Press.

Vernon, P.E. (1965). Ability factors and environmental influences. *American Psychologist, 20,* 723-733.

Visser, B.A., Ashton, M., & Vernon, P.A. (2006). *G* and the measurement of multiple intelligences: A response to Gardner. *Intelligence, 35,* 507-510.

Waterhouse, L. (2006). Multiple intelligences, the Mozart effect, and emotional intelligence: A critical review. *Educational Psychologist, 41,* 207-225.

Watkins, M.W., & Canivez, G.L. (2004). Temporal stability of WISC-III composite strengths and weaknesses. *Psychological Assessment, 16,* 133-138.

Watkins, M.W., Wilson, S.M., Kotz, K.M., Carbone, M.C., & Babula, T. (2006). Factor structure of the Wechsler Intelligence Scale for Children-Fourth Edition among referred students. *Educational and Psychological Measurement, 66,* 975-983.