

Gender Differences in Cognitive Development

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The potential effect of gender on intellectual abilities remains controversial. The purpose of this research was to analyze gender differences in cognitive test performance among children from continuous age groups. For this purpose, the normative data from 7 domains of the newly developed neuropsychological test battery, the Evaluación Neuropsicológica Infantil [Child Neuropsychological Assessment] (Matute, Rosselli, Ardila, & Ostrosky-Solis, 2007), were analyzed. The sample included 788 monolingual children (350 boys, 438 girls) ages 5 to 16 years from Mexico and Colombia. Gender differences were observed in oral language (language expression and language comprehension), spatial abilities (recognition of pictures seen from different angles), and visual (Object Integration Test) and tactile perceptual tasks, with boys outperforming girls in most cases, except for the tactile tasks. Gender accounted for only a very small percentage of the variance (1%–3%). Gender \times Age interactions were observed for the tactile tasks only. It was concluded that gender differences during cognitive development are minimal, appear in only a small number of tests, and account for only a low percentage of the score variance.

Keywords: gender differences, cognitive development, neuropsychological assessment, Evaluación Neuropsicológica Infantil [Child Neuropsychological Assessment], children

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Gender differences in cognitive abilities have been widely analyzed in the psychological and neuropsychological literature (e.g., Halpern, 1992; Hedges & Nowell, 1995; Kimura, 1999; Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003). Three major differences in cognitive abilities between men and women have generally been reported: (a) higher verbal abilities, favoring women; (b) higher spatial abilities, favoring men; and (c) higher arithmetical abilities, also favoring men. However, differences in calculation abilities have, at times, been interpreted as a result of men's superior spatial abilities (Benbow, 1988; Geary, 1996); hence, these three differences could be reduced to just two.

Nonetheless, gender differences in children's cognitive abilities remain an area of controversy (for a review, see the supplemental materials). Whereas some studies have found such differences, others have not been able to isolate them. There is no question that additional analyses of the potential gender differences in cognitive development are needed. These analyses should include a large sample with an ample age range, which may help to clarify

the interaction between gender and age in relation to cognition. In the present study, we analyzed gender differences in a large sample of Spanish-speaking children, using the Attention, Perceptual, Language, Metalinguistic Awareness, Memory (Coding), Constructional, and Spatial subtests of the Evaluación Neuropsicológica Infantil [Child Neuropsychological Assessment] (ENI; Matute et al., 2007). The performance of boys and girls in seven cognitive domains was compared across six age groups that ranged from 5 to 16 years old. On the basis of previous findings, we expected that girls would outperform boys on verbal tasks, whereas boys would outperform girls on spatial tasks. A Gender \times Age interaction was also anticipated in these tasks. No significant gender differences were expected in any of the other cognitive tests applied.

Method

Participants

The data used in this study were taken from the normative scores of 788 participants (5–16 years old; 350 boys, 438 girls) who were monolingual Spanish speakers from Colombia (Manizales, population approximately 400,000 inhabitants) and Mexico (Guadalajara, population approximately 3,500,000 inhabitants; Tijuana, population approximately 1,000,000 inhabitants; Matute et al., 2007; Rosselli et al., 2004). Participants were selected from both private and public schools. The mean educational levels of the fathers and mothers of the children from public schools were 10.75 years ($SD = 3.83$) and 10.18 ($SD = 3.60$), respectively; the mean

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Table 1
General Characteristics of the Sample by Age Group, Gender, Country of Residence, and Handedness

Age group	Boys						Girls						Total	Total	
	Colombia		Mexico			Total	Colombia			Mexico					Total
	Right	Mixed	Right	Left	Mixed		Right	Left	Mixed	Right	Left	Mixed			
5–6 years	16	0	23	5	4	48	26	0	0	29	2	2	59	107	
7–8 years	14	1	37	3	0	55	24	3	0	43	0	1	71	126	
9–10 years	15	0	49	1	2	67	26	2	0	52	3	1	84	151	
11–12 years	14	0	53	3	1	71	21	4	1	57	1	1	85	156	
13–14 years	15	1	45	0	1	62	25	1	0	46	6	0	78	140	
15–16 years	15	1	26	3	2	47	22	1	0	33	4	1	61	108	
Total	89	3	233	15	10	350	144	11	1	260	16	6	438	788	

educational levels of the fathers and mothers of the children from private school were 14.71 ($SD = 3.09$) and 15.18 years ($SD = 1.97$), respectively. All children voluntarily agreed to participate after obtaining permission from their parents or legal guardians. An informed consent form was signed and returned by each child's parent or legal guardian. We screened all participants for any history of neurological or psychiatric problems and for mental retardation and learning disabilities, using a structured interview for parents that is included in the ENI. Although no formal testing was done to rule out intellectual or learning disabilities, we screened for grade retention and ascertained that no chronological age/grade-level disparity was present and that the children's performance in reading and math agreed with their chronological grade levels according to school records. Handedness was assessed with the relevant questions from the ENI. Table 1 presents the frequency distribution of the sample by gender, age, and handedness.

Instrument

The following seven domains of the ENI test battery were included in the analysis. A description in English of the complete battery can be found in a recent article by Rosselli, Ardila, Navarrete, and Matute (2010).¹

Constructional abilities. This domain assesses visuospatial and visuomotor processing. It includes four subtests.

Stick Construction. Children copy four designs (one at a time), using 3, 4, 8, or 12 toothpicks. Two points are given for each figure copied correctly. One point is given if one or two errors are made, and zero points are given if more than two errors are made. Maximum score is 8.

Copying Simple Figures. Children copy six figures presented separately, and each figure is scored separately. Two points are given if the figure has the appropriate size, location of lines, precision, and number of elements. One point is given if the figure is identifiable but one or two errors are made. Zero points are given when the figure is not identifiable or more than two errors are made. Maximum score is 12.

Drawing a Human Figure. Children are asked to draw a human figure. One point is given for each correct feature in the drawing. Fourteen basic elements are recorded, and up to six extracorporal elements are accepted, such as eyebrows, eyelashes,

beard, teeth, mustache, and so forth. All points are added up to obtain the total score. Maximum score is 20.

Copying a Complex Figure. Children copy a complex figure, which is presented on a card. Each unit that forms the figure is scored separately. Maximum score is 15. The Cronbach's α for this domain was .835.

Memory coding.

Verbal Memory Coding: Word Learning. A list of two-syllable words related to animals, fruits, and body parts is presented for four consecutive trials. This list of words is used again 30 min later in a delayed-recall auditory memory task. One point is given for each correct word. The final score is the total number of points from all the trials. The maximum score is 48. The Cronbach's α for the items included in this domain was .83.

Visual Learning. This test consists of nine figures for children ages 5 to 8 and 12 figures for children ages 9 to 16. Figures are made up of circles, squares, and triangles as in the Copying a Complex Figure task and are presented one at a time on cards at a speed of 1 s per card. After finishing the presentation, the children reproduce the figures. Four trials are carried out. To be scored as correct, a figure has to be recognizable as the figure stimulus. For each correct figure, one point is given. If a figure is repeated (perseveration), it is noted, but it only counts as one correct point. All of the correct answers from each test are added up, and the final score is the total number of points from all trials. The maximum score for children between ages 5 and 8 is 36, and the maximum score for children between ages 9 and 16 is 48. The Cronbach's α for this domain in the population studied was .95.

Sensory perception. This domain includes the following two tests.

Table 2
Factor Analyses

Component	Eigenvalues		
	Total	% of variance	Cumulative %
1	16.471	48.443	48.443
2	1.636	4.813	53.256
3	1.281	3.769	57.025
4	1.046	3.076	60.101

Table 3
Means and Standard Deviations by Age and Gender in the Different ENI Domains

Variable (maximum score)	5-6 years			7-8 years			9-10 years			11-12 years			13-14 years			15-16 years						
	Male		Female	Male		Female	Male		Female	Male		Female	Male		Female	Male		Female				
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD				
Constructional abilities (55)	24.1	0.7	2.5	0.7	33.3	0.7	33.8	0.6	38.6	0.6	39.6	0.5	41.9	0.6	41.8	0.5	44.2	0.6	44.6	0.8	44.9	0.7
Memory (96)	34.9	12.6	36.8	12.2	48.7	11.9	49.5	11.7	67.7	11.8	66.1	13.9	74.4	11.1	70.6	14.3	78.8	13.4	81.9	11.9	79.6	11.3
Sensory-perception (65)	39.1	5.6	40.42	5.2	46.5	5.0	46.4	4.8	51.2	4.8	51.4	4.9	55.6	4.3	53.0	4.7	57.3	3.7	55.2	5.3	57.1	3.3
Oral language (86)	58.46	7.77	56.22	10.05	68.2	7.4	66.5	6.6	73.6	6.9	72.1	6.3	76.3	4.3	74.6	4.8	77.8	4.3	77.4	4.6	79.4	3.5
Metalinguistic awareness (32)	4.7	6.1	5.4	7.1	17.7	6.6	18.1	6.4	21.6	5.0	22.6	5.0	24.1	5.3	23.9	4.3	26.4	3.8	26.7	3.2	27.2	3.7
Spatial abilities (40)	20.7	9.5	19.3	8.9	29.5	6.0	28.8	7.5	35.5	3.4	34.5	4.5	35.5	4.8	34.6	4.2	37.5	2.0	36.0	3.2	38.0	1.8
Attention (141)	29.7	12.3	30.5	11.9	48.3	12.8	44.9	12.4	64.0	11.5	66.5	15.6	77.2	15.3	79.5	16.1	88.2	12.7	90.3	11.5	93.1	12.1

Note. ENI = Evaluación Neuropsicológica Infantil [Child Neuropsychological Assessment].

Table 4
Age and Gender Effects for Each Cognitive Domain Using Total Scores

Variable	Age			Gender			Age × Gender		
	F	p	η ²	F	p	η ²	F	p	η ²
Constructional abilities	223.292	.0001	.590	1.091	.297	.001	0.549	.739	.004
Memory (coding)	213.155	.0001	.590	3.040	.082	.004	1.207	.302	.008
Sensory-perception	188.884	.0001	.608	3.93	.048	.006	2.31	.042	.019
Oral language	164.787	.0001	.396	9.142	.003	.015	0.944	.944	.002
Metalinguistic awareness	254.626	.0001	.675	0.310	.578	.001	0.378	.864	.003
Spatial abilities	140.410	.0001	.536	7.104	.007	.012	0.178	.971	.001
Attention	395.974	.0001	.721	0.857	.355	.001	0.897	.483	.006

Note. Values in bold are significant at $p < .05$.

Visual Perception. This test assesses the ability to identify visual stimuli. It involves recognizing 16 superimposed figures, recognizing blurry images of four objects, identifying eight incomplete drawings (visual closure), integrating the parts that make up four objects (e.g., identifying a table by looking at its parts), and recognizing eight facial emotional expressions. Maximum score is 50. The Cronbach's α for this domain in the population studied was .709.

Tactile Perception. This test evaluates the ability to identify 16 objects by touching them with the right or the left hand. Maximum score is 16. The Cronbach's α for this domain in the population studied was .843.

Oral language. This domain evaluates the ability to produce spontaneous speech, name common objects, repeat verbal information, and understand commands. It includes three subtests: Language Repetition (Syllables [maximum score = 8], Words [maximum score = 8], Nonwords [maximum score = 8], and Sentences [maximum score = 8]); Language Expression (Naming 15 Images [maximum score = 15] and Narrative Coherence in Repeating a Story [maximum score = 6]); and Language Comprehension (Images Pointing [maximum score = 15], Oral Commands [maximum score = 10], and Discourse Comprehension [maximum score = 8]). The Cronbach's α in this study for this domain was .708.

Metalinguistic awareness. This domain assesses the ability to process the units of language by counting or blending phonemes in words, spelling words, and counting the number of words in sentences. This domain includes the following subtests: Phonemic Counting (maximum score = 8) and Phoneme Blending Within a Word (maximum score = 8), Spelling (maximum score = 8), and Word Counting Within a Sentence (maximum score = 8). The Cronbach's α for this domain was .90.

Spatial abilities.

Verbal. This test includes tasks that assess the ability to express and comprehend verbal spatial terms, such as *right* and *left*. The child is required to perform right-left orientation commands with a map (maximum score = 8) and to express right-left orientation commands to move a little doll across the same map (maximum score = 8). A task involving pictures at different angles

tactile perception. Additionally, the visuospatial subtests loaded together with the visual perceptual tests. Finally, language subtests seem to load into one component.

Procedure

Children were randomly selected from various classrooms, and their parents were contacted and interviewed. Children with no history of school failure or of neurological or psychiatric disorders were chosen and individually tested at their schools or homes in one or two sessions. From the children who met the inclusion criteria, we included only those whose parents (and themselves) agreed to participate and signed informed consent forms. Each child received a small gift (e.g., a box of crayons, a candy) after participating in the study.

Statistical Analyses

To analyze the influence of gender and age on the total score for each cognitive domain (constructional abilities, memory coding, sensory perception, oral language, metalinguistic awareness, spatial abilities, and attention), we used seven two-way analyses of variance with age group (5–6 years, 7–8 years, 9–10 years, 11–12 years, 13–14 years, and 15–16 years) and sex as the independent variables. Additional two-way analyses of variance were performed for each one of the subtests included in the domain in which gender was found to have a significant effect. The sizes of the effects discovered were assessed with partial η^2 for overall group differences. Bonferroni adjustments were used within each domain to correct for experimentwise error due to multiple comparisons.

Results

Tables 3 and 4 present the effects of gender and age on the total scores for each of the seven cognitive domains. Although age had a significant effect in all domains, statistically significant differences between boys and girls were observed in only three of them: sensory-perceptual, oral language, and spatial abilities, in all of which boys outperformed girls. However, partial η values in these three sections were low, suggesting that gender accounted for only a very small percentage of the variance in the scores. In the other

four domains of the ENI, total scores did not significantly differ between boy and girls. No significant Age \times Gender interactions were found for any of the total domain scores. No floor or ceiling effects were observed across age groups in most of the cognitive domains, except for the perceptual, spatial abilities, and metalinguistic domains in which some ceiling effects were observed in the older groups.

In an attempt to pinpoint the gender differences more precisely, the effects of both gender and age were further analyzed for each one of the subtests included in the sensory-perceptual, oral language, and spatial abilities domains. The category of sensory-perceptual tests included tactile and visual subtests (Table 5). In this area, although girls outperformed boys in the Tactile Recognition of Common Objects, boys outperformed girls in the Perception of Blurred Figures, Figure Closure, and Visual Integration of Objects. No gender differences were found for Superimposed Figures and Perception of Emotional Expressions. A significant Age \times Gender interaction was found for the tactile subtest, in which girls outperformed boys only in the younger age groups. Age was determined to be a significant variable for all subtests, but none of the Age \times Gender interactions were significant for the visual and auditory subtests (Table 6). After we used Bonferroni correction to adjust for multiple comparison error within this domain, the age differences remained significant for all subtests, whereas the gender disparities remained only for the tactile perception and object integration subtests.

The area of language tests included the Language Repetition, Language Expression, and Language Comprehension subtests (Table 7). No gender differences were observed in the Language Repetition test, but significant differences were found in the Language Expression subtest and especially in the Language Comprehension subtest. In the Language Expression subtest, the total mean score for boys was 15.5 ($SD = 4.0$), whereas for girls this score was 15.0 ($SD = 4.1$; a difference of approximately 3%; $\eta = .009$). On the Language Comprehension tests, the total mean scores for boys and girls were 29.1 ($SD = 3.2$) and 28.4 ($SD = 3.5$), respectively (a difference of approximately 2.5%; $\eta = .014$), which represents a significant difference. After adjusting for multiple comparison error within this domain, the differences in Language Comprehension were the only ones that remained significant.

Table 6
Age and Gender Effects for Each Sensory-Perceptual Test

Variable	Gender								Age			Age \times Gender		
	Male		Female		F	p	$p\eta^2$	F	p	$p\eta^2$	F	p	$p\eta^2$	
	M	SD	M	SD										
Tactile														
Right and Left Hand	15.3	1.3	15.64	0.90	10.9	.001	.01	29.6	.0001	.16	4.63	.0001	.03	
Visual														
Superimposed Figures (8)	11.9	2.8	11.8	2.7	0.27	.593	.00	132.5	.0001	.52	1.14	.33	.01	
Blurry Images	7.5	1.5	7.3	1.7	4.2	.045	.01	33.7	.0001	.27	1.38	.22	.01	
Visual Closure	5.1	1.8	4.7	1.8	9.7	.023	.02	17.3	.0001	.12	0.61	.69	.01	
Facial Expressions	6.8	1.3	6.9	1.2	0.31	.576	.00	23.5	.0001	.10	0.92	.46	.00	
Object Integration	4.4	1.8	4.0	1.7	8.3	.004	.01	46.0	.0001	.27	2.17	.06	.02	

Note. Values in bold are significant at $p < .05$.

Table 7
Means and Standard Deviations by Age and Gender in the Language and Spatial Abilities Tests

Variable	5–6 years		7–8 years		9–10 years		11–12 years		13–14 years		15–16 years													
	Male		Female		Male		Female		Male		Female													
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>												
Language																								
Repetition (32)	24.3	3.2	23.1	4.3	27.1	2.8	26.8	2.6	28.1	2.2	28.1	2.1	28.6	1.7	28.3	2.4	29.1	1.7	29.0	1.8	29.2	1.8	29.5	1.5
Expression (21)	9.3	3.3	9.3	3.7	13.6	3.4	12.9	3.4	15.9	2.8	15.4	3.4	16.6	2.7	15.9	3.0	18.1	2.0	17.9	2.4	18.7	1.7	17.6	1.9
Comprehension (33)	24.7	2.9	24.0	4.7	27.8	2.7	27.2	2.6	29.3	3.1	28.5	2.2	30.2	1.6	29.7	1.8	30.7	1.7	30.4	1.5	31.2	1.5	30.5	1.6
Spatial abilities																								
Right–Left																								
Comprehension (8)	3.8	2.3	3.7	2.1	5.0	2.0	5.5	2.1	6.3	1.3	6.4	1.2	6.5	1.6	6.1	1.6	6.9	1.1	6.5	1.1	7.5	0.7	6.6	1.1
Right–Left																								
Expression (8)	3.5	2.4	3.2	1.9	4.8	2.1	5.3	2.2	6.6	1.4	6.7	1.5	6.8	1.9	6.5	1.5	7.4	0.7	7.2	1.0	7.5	0.7	7.1	1.1
Pictures From																								
Different Angles (8)	4.9	2.5	4.1	2.5	6.4	1.8	5.6	2.1	7.1	1.2	6.5	2.1	7.0	1.6	6.8	1.6	7.4	1.1	7.1	1.5	7.3	1.3	7.0	1.7
Line Orientation																								
(8)	3.5	2.3	3.3	2.5	5.6	1.9	5.2	1.8	6.8	1.3	7.0	1.3	7.2	1.1	7.1	1.2	7.6	0.5	7.5	0.8	7.6	0.6	7.4	0.8
Coordinates																								
Location (8)	4.9	3.2	4.9	3.4	7.4	1.3	7.1	1.9	7.7	1.1	7.8	0.8	7.9	0.2	7.9	0.9	7.9	0.3	7.7	1.1	7.9	0.3	7.9	0.2

The spatial ability section included Right–Left Comprehension, Right–Left Expression, Pictures From Different Angles, Line Orientation, and Coordinates Location (Table 7). Significant gender differences were seen only for the Pictures From Different Angles test. This difference remained significant after the Bonferroni correction for multiple comparisons. On this test, the total mean score for boys was 6.8 ($SD = 1.8$), whereas the score for girls was 6.2 ($SD = 2.2$; a difference of approximately 10%; $\eta = .026$). Age had a significant effect on all of the language and spatial subtests; this significance remained after the Bonferroni correction for multiple comparisons. No significant Age \times Gender interactions were found (Table 8).

Discussion

The results of this study support the assumption that gender differences in language and other cognitive abilities are usually

nonsignificant or very small; indeed, gender differences were found only in three domains: language (but only on the Language Expression and Language Comprehension subtests), spatial abilities (but only on the Pictures From Different Angles subtest), and on several sensory–perceptual tests.

Our results indicate the existence of a larger number of gender similarities than gender differences across a relatively large age range (5–16 years) and with a relatively large sample of children (788 participants). This supports the assumption that gender differences during cognitive development are minimal, appear in only a small number of tests, and account for only a low percentage of the score variance. It is likely, therefore, that certain cultural factors may be responsible for at least some of the gender differences that appeared in test scores. One limitation of the current study is that the domains used as dependent measures cannot be considered to be underlined by unique cognitive factors as indi-

Table 8
Age and Gender Effects for Each Language and Spatial Abilities Test

Variable	Gender								Age			Age \times Gender		
	Male		Female		<i>F</i>	<i>p</i>	$p\eta^2$	<i>F</i>	<i>p</i>	$p\eta^2$	<i>F</i>	<i>p</i>	$p\eta^2$	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>										
Language														
Repetition	27.9	2.7	27.6	3.2	2.66	.103	.003	80.3	.0001	.34	1.20	.30	.01	
Expression	15.5	4.0	15.0	4.1	6.71	.010	.009	142.3	.0001	.48	0.54	.74	.00	
Comprehension	29.1	3.2	28.4	3.5	8.58	.004	.014	92.4	.0001	.43	0.15	.97	.00	
Spatial abilities														
Right–Left Comprehension	6.0	2.0	5.8	1.8	2.57	.112	.004	55.9	.0001	.31	1.95	.08	.01	
Right–Left Expression	6.1	2.2	6.0	2.1	0.81	.364	.001	89.5	.0001	.42	1.00	.41	.01	
Pictures From Different Angles	6.8	1.9	6.2	2.3	13.7	.001	.020	37.1	.0001	.19	0.66	.65	.00	
Line Orientation	6.4	2.0	6.3	2.1	1.26	.267	.000	119.1	.0001	.49	0.43	.82	.00	
Coordinates Location	7.3	1.7	7.2	1.8	1.0	.304	.000	53.8	.0001	.25	0.25	.94	.00	

Note. The Story Recall subtest from the memory coding domain and the auditory perception domain from the original Evaluación Neuropsicológica Infantil [Child Neuropsychological Assessment] were excluded from the analysis because they presented low internal consistency within domain; alpha coefficient was below .50.

cated by the factor analyses. Future research should confirm null results of gender differences in cognitive tasks with unique underlying cognitive processes.

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