



PII S0887-6177(98)00159-0

# Correlation Between Intelligence Test Scores and Executive Function Measures

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*In this study, some executive function measures (Wisconsin Card Sorting Test [WCST], verbal fluency, and Trial Making Test [TMT], Form A and Form B) were correlated with Wechsler Intelligence Scale for Children-Revised (WISC-R) scores. Fifty 13- to 16-year-old normal children were selected. It was found that verbal fluency tests correlated about 0.30 with Verbal Intelligence Quotient (IQ) and Full Scale IQ. In the WCST only Perseverative Errors negatively correlated with Verbal IQ and Full Scale IQ. Two correlations were found to be significant with regard to the TMT: TMT Form B Errors negatively correlated with WISC-R Vocabulary subtest; and TMT Form A Time negatively correlated with Performance IQ. These results support the assumption that traditional intelligence tests are not appropriately evaluating executive functions. © 1999 National Academy of Neuropsychology. Published by Elsevier Science Ltd*

*Keywords: intelligence, executive functions, cognitive testing, frontal lobe*

Prefrontal lobes activity has been associated with self-regulation, control of cognition (metacognition), temporal organization of behavior, monitoring of behavior, selective inhibition of responses to immediate stimuli, planning behavior, and control of attention (Brown, 1985; Damasio & Anderson, 1993; Fuster, 1989; Hécaen, 1964; Luria, 1966, 1969, 1973, 1980; Perecman, 1987; Pribram, 1973; Stuss & Benson, 1983, 1986, 1987). The name *executive function* has been proposed to refer to the multi-operational system mediated by prefrontal areas of the brain and their reciprocal cortical and subcortical connecting pathways (Stuss & Benson, 1986). Executive dysfunction may be summarized in two cardinal defects: controlling behavior and organizing cognition.

For a long time it has been noted that frontal damage does not result in evident deficits in psychometric intelligence tests (Hebb, 1939; Hebb & Penfield, 1940). This is true even in cases of bilateral frontal lobectomy. It was somehow surprising to find that intelligence quotient (IQ) in patients with frontal lobe damage could be normal (Hebb, 1945). These initial observations carried out during the 1940s have been further well-documented in neuropsychology (e.g., Brazzelli, Colombo, Della Sala, & Spinnler, 1994; Damasio & Anderson, 1993). Milner (1983), for instance, reported a mean loss of only 7.2 IQ points following dorsolateral frontal lobectomies, with mean postoperative IQ scores remaining in the average range. More recently, Damasio and Anderson (1993) analyzed 10 patients with ventrolateral and dorsolateral frontal lesions that were caused by either vascular events or surgical resection for treatment of tumors. The most notable feature of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) testing in these patients was the consistent preservation of the cognitive abilities required to perform the various intellectual tasks following frontal lobe damage. This observation means that psychometric intelligence tests are not sensitive to frontal lobe deficits (“executive dysfunctions”).

Very few studies have analyzed the association between executive function measures and psychometric intelligence test scores. Welsh, Pennington, and Groisser (1991) observed in children that most of the executive function tasks (Visual Search [Teuber, Battersby, & Bender, 1955]; Verbal Fluency [McCarthy, 1972]; Motor Planning [Golden, 1981]; Tower of Hanoi [Simon, 1975]; Wisconsin Card Sorting Test [WCST; Heaton, 1981]; and Matching Familiar Figures Test [Kagan, 1964]) were uncorrelated with IQ. Visual Search, Verbal Fluency, WCST, and Tower of Hanoi did not correlate with any IQ measure (Verbal, Quantitative, and Nonverbal) from the Iowa Test of Basic Abilities. Using a 300-subject college-student sample, Ardila, Galeano, and Rosselli (1998) observed that Verbal Fluency tests presented a low but significant correlation (0.20–0.25) with some WAIS verbal subtests, particularly Digits, Arithmetic, and Information. However, WCST scores did not correlate at all with the Verbal, Performance, or Full Scale IQ. The independence of executive functions from psychometric intelligence may be conjectured.

The purpose of this research was to analyze the association between executive function measures and psychometric intelligence test scores in adolescents. This study represents a secondary analysis of the data collected in the norming study of some neuropsychological tests carried out in Colombia, using a Spanish-speaking population.

## METHOD

### *Participants*

Fifty 13- to 16-year-old male children ( $M = 14.38$ ;  $SD = 1.02$ ) were taken. Children were selected from the public schools of Medellín city (Colombia, population about 2 million). All children were monolingual native Spanish speakers. Their mean school level was 8.66 years ( $SD = 1.22$ ; range = 7–10). They voluntarily agreed to participate with the purpose of obtaining norms for some psychological and neuropsychological tests. All of the subjects were in a low socioeconomic status.

Testing was performed by graduate neuropsychology students from San Buenaventura University, under the supervision of a professor. Evaluation was performed in three sessions, each one lasting about 40 minutes. Tests were administered in the following sequence: Wechsler Intelligence Scale for Children-Revised, Spanish version (WISC-R;

Wechsler, 1993); Verbal Fluency; Trial Making Test (TMT; Reitan & Wolfson, 1985); and WCST. No subject had been on medication during the week prior to the testing, had a history of behavioral or attentional problems, or had evidence of psychiatric or neurological disorders.

### Instruments

The following tests were individually administered to the experimental and control subjects: (a) WISC-R, Spanish version (Wechsler, 1993). The Spanish version was translated and adapted by De La Cruz, Lopez, and Cordero-Pardo (Wechsler, 1993). This version of the WISC has been previously standardized and normalized in Spain. Four verbal subtests (Information, Similarities, Arithmetic, and Vocabulary) and four performance subtests (Picture Completion, Picture Arrangement, Block Design, and Digit-Symbol) were used. (b) WCST (Heaton, 1981). Areas scored were categories achieved, perseverative errors, nonperseverative errors, and failure to maintain set. This test has been previously normalized in Spanish-speaking children (Rosselli & Ardila, 1993) and has been found to be sensitive to frontal lobe pathology (Lezak, 1995). (c) Verbal fluency (phonologic—/f/, /a/, and /s/; and semantic—animals and fruits). Verbal fluency was measured by the number of words produced in a particular category within a 1-minute time limit. The verbal fluency test has been described in the clinical neuropsychology literature as an executive function test (Ardila, Rosselli, & Puente, 1994; Lezak, 1995). (d) TMT, Forms A and B (Reitan & Wolfson, 1985). Set shifting ability is supposed to be evaluated with this test.

**TABLE 1**  
**Means (*M*) and Standard Deviations (*SD*) Found in the Different Tests**

Test	<i>M</i>	<i>SD</i>
WISC-R		
Information	10.82	3.63
Similarities	10.44	3.93
Arithmetic	10.10	2.09
Vocabulary	10.38	3.00
Picture completion	9.32	2.46
Picture arrangement	10.08	3.03
Block design	8.84	2.23
Digit-symbol	10.29	3.20
Verbal IQ	102.84	16.18
Performance IQ	92.86	10.82
Full Scale IQ	97.76	13.54
Verbal Fluency		
Phonologic	26.22	8.91
Semantic	30.22	5.12
Wisconsin Card Sorting Test		
Categories	4.68	1.53
Perseverative errors	21.42	13.17
Nonperseverative errors	17.90	8.07
Fail maintain set	1.30	1.35
Trail Making Test		
Form A: Time	70.92	35.29
Errors	0.32	0.74
Form B: Time	52.18	28.92
Errors	0.26	1.33

Note. WISC-R = Wechsler Intelligence Scale for Children-Revised.

**TABLE 2**  
**Correlation Matrix Between WISC-R Scores and Executive Function Measures**

	Wisconsin Card Sorting Test															
	Verbal Fluency			Perseverative Errors				Non-perseverative Errors			Fail maint		TMT A		TMT B	
	Phonol	Semant	Categ	Errors		Errors	Fail maint	Time	Errors	Time	Errors	Time	Errors			
Information	0.34*	0.51***	0.04	-0.28*	-0.20	0.20	0.14	-0.09	0.00	-0.07	0.04	-0.23	-0.07			
Similarities	0.32*	0.44***	0.03	-0.27*	-0.07	0.11	0.14	-0.22	0.04	-0.22	0.04	-0.23	-0.23			
Arithmetic	0.02	-0.01	0.19	-0.36**	-0.23	0.08	0.02	-0.17	0.05	-0.17	0.05	-0.14	-0.14			
Vocabulary	0.40**	0.38***	0.24	-0.12	-0.23	0.22	0.02	-0.13	0.00	-0.13	0.00	-0.34*	-0.34*			
Picture completion	0.10	-0.12	-0.21	0.19	0.05	-0.17	-0.06	-0.30*	0.13	-0.30*	0.13	-0.03	-0.03			
Picture arrangement	0.11	0.04	-0.18	-0.02	0.17	0.19	-0.25	-0.03	-0.14	-0.03	-0.14	-0.39	-0.39			
Block design	0.22	0.20	0.11	-0.37**	0.02	0.18	0.14	0.06	-0.24	0.06	-0.24	0.05	0.05			
Digit-symbol	0.13	0.26	0.02	-0.02	0.00	-0.14	-0.19	0.08	-0.17	0.08	-0.17	0.03	0.03			
Verbal IQ	0.32*	0.39***	0.14	-0.37**	-0.20	0.08	0.11	-0.20	0.00	-0.20	0.00	-0.25	-0.25			
Performance IQ	0.18	0.18	-0.12	-0.08	0.11	0.01	-0.31*	-0.07	-0.20	-0.07	-0.20	-0.16	-0.16			
Full Scale IQ	0.30*	0.24*	0.04	-0.30*	-0.09	0.07	0.04	-0.18	-0.08	-0.18	-0.08	-0.26	-0.26			

TMT = Trail Making Test.  
 \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

## RESULTS

Table 1 presents the general results in the different tests. Mean Full Scale IQ was 97.76. Verbal IQ was higher than performance IQ. This difference, however, was lower than 1 standard deviation.

Table 2 presents the correlations between WISC scores and executive function measures. Verbal fluency tests correlated with Verbal IQ and Full Scale IQ. As a matter of fact, Verbal fluency tests significantly correlated with all the WISC-R verbal subtests, excepting Arithmetic. On the WCST, only Perseverative Errors negatively correlated with Verbal IQ and Full Scale IQ. WCST Perseverative Errors also correlated with four the WISC-R subtests (Information, Similarities, Arithmetic, and Block Design). Only two correlations were found to be significant with regard to the TMT: TMT Form B Errors negatively correlated with Vocabulary subtest; and TMT A Time negatively correlated with Performance IQ. No other significant correlation was observed.

## CONCLUSIONS

Few significant correlations were found between WISC-R scores and executive function measures. Verbal IQ and Full Scale IQ significantly correlated with verbal fluency tests. Verbal IQ and Full Scale IQ also correlated with WCST perseverative errors. These correlations, although significant, were rather low. This finding may emphasize that the WCST is indeed measuring an ability (concept formation, executive function) not traditionally included in psychological intelligence test batteries.

Performance IQ did not correlate with any executive function test score, except TMT Form A: Time. This was also a low correlation. Full Scale IQ correlated only with the Verbal Fluency tests, and WCST-Perseverative errors. The rest of the correlations were nonsignificant.

These results support the assumption that traditional intelligence tests do not appropriately evaluate executive functions. It must be concluded that either executive functions should not be included as elements of “intelligent behavior,” or that psychometric intelligence tests are insufficient in testing for intelligence. These tests are not sensitive to the most important elements of “intelligence”: “to act purposefully” (i.e., controlling and planning behavior), and “to think rationally” (i.e., organizing and directing cognition), according to Wechsler’s (1944) own definition of intelligence.

The conclusion is evident: Psychometric intelligence tests do not appropriately appraise intelligence. Or, at least, they are not appraising abilities that, from a neuropsychological perspective (and also, from the point of view of Wechsler’s intelligence testing), should be understood as the most important elements in cognition.

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