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Preliminary psychometric validation data for a non-clinical South African sample using a neuroscience-based computerized battery

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Abstract

Normative psychometric test data for computerized neuro-cognitive batteries are scarce in the South African testing literature. The research explores the psychometric test properties of a computerized neuropsychological test battery in a non-clinical South African sample. A non-experimental correlational design was employed to collect data (N=594) and assess internal consistency indices on a number of executive and emotions tasks. The study also investigated the potential effect that certain socio-demographic factors may have on neuropsychological performance indicators and included mother's education, father's education, language used in high school, home language and quality of education. In keeping with current research it was found that even though socio-demographic factors do play a role in test performance, the psychometric properties of the battery remain consistent across different groups and further research utilising this tool is encouraged as the battery evidences construct validity.

Keywords: Neuropsychology, computerized, psychometric, tool, South Africa.

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Introduction

Computerized neuropsychological assessment measures are rarely utilised in South Africa for diagnostic assessment, research or therapeutic purposes. The aim of this research is two-fold; to ascertain psychometric functioning of the test battery within a South African context and to determine if socio-demographic factors impact on cognitive performance. Advantages of computerized assessment include, among others, ease of use, speed of data collection and increased measurement accuracy. Gur, Erwin and Gur (1992); Gur, Ragland, Moberg, Bilker, Kohler, Siegel and Gur (2001) as well as Gur, Ragland, Moberg, Turner, Bilker, Kohler, Siegel, and Gur (2001) have described the development, validation and use of The University of Pennsylvania Computerized Neuropsychological Test Battery (PennCNP) in both clinical and non-clinical populations. A systematic and detailed overview of the initial construct validation of the tool is addressed in Gur, Richard, Hughett, Calkins, Macy, Bilker, Brensinger and Gur (2010). Cassimjee and Murphy (2010), Murphy and Cassimjee (2011) as well as Cassimjee and Murphy (2012) explored the use of the computerized non-verbal neuropsychological assessment tool in a non-clinical South African sample. Results indicated that the assumption that non-verbal test scores were independent of socio-demographic factors needed to be revisited. In addition, results also confirmed the importance of addressing the endophenotypic (temperament) correlates of individual differences in neuropsychological performance in both clinical and non-clinical studies in South Africa. In this paper it is hypothesized that a computerized neuropsychological test battery would function in a psychometrically equivalent manner within the South African sample compared to the normative samples utilised in the battery development. It is also hypothesized that socio-demographic factors will impact on cognitive test performance.

According to Rosselli and Ardila (2003), education can be regarded as an element of culture, which includes literacy and schooling. In a sample of black South Africans, Shuttleworth-Edwards, Kemp, Rust, Muirhead, Hartman and Radloff (2004) found that quality and not level of education emerged as a significant moderating variable on cognitive performance. Non-verbal neuropsychological tests have been considered to be relatively culture independent tests (Ardila & Keating, 2007; Sugarman, 2007).

In a South African study, Shuttleworth-Edwards and Kemp et al. (2004) found that in their sample of African first language groups, performance on non-verbal tasks was significantly related to level and quality of education. The view that language appears to be integrated with elements of education and socio-economic status is often taken into account when tests of reading ability are conducted (Cockcroft & Blackburn, 2008). Proficiency in English (reading and speech ability), for example, is associated with better quality of education (Nelson & Pontón, 2007; Shuttleworth-Edwards, Donnelly, Reid & Radloff, 2004). Recently, Cockroft and Israel (2011) concluded that performance on the Advanced Matrices was statistically significantly related to the verbal-analytic constructs assessed in other intelligence sub-tests. However, these relationships did not differ across home languages. This finding is less reported than findings attesting to differences between language groups on measures of fluid intelligence (Raven, Raven & Court, 1998). Quality and type of schooling are external socio-cultural environmental aspects that appear to influence cognitive and neuropsychological test performance (Grieve & van Eeden, 2010). Increased access to education and improved quality of education can partly explain the gradual convergence of intelligence test scores of different language speakers in South Africa for instance (Te Nijenhuis, Murphy & Van Eeden, 2011). Parental education as an internal socio-cultural environmental aspect has also been found to influence cognitive performance (Ardila, Roselli, Matute, & Guajardo, 2005). The current study investigated the psychometric validity of this state tool in a South African context and also investigated the potential effect that certain socio-demographic factors may have on neuropsychological performance indicators. We investigated whether mother's education, father's education, language used in high school, home language and quality of education would have any differential effect on the psychometric properties of the neuroscience-based computerized battery.

Methodology

Research design

A non-experimental correlational design was employed. The University of Pennsylvania Computerized Neuropsychological Test Battery was used for this study (PennCNP). The executive function and abstract reasoning as well as emotions test batteries were administered. In addition, a self completion questionnaire was designed to capture basic data about respondents' gender, age, handedness, language of schooling (primary and high), home language, quality of education (primary and high) and parental education (mother's and father's) levels.

Measuring instruments

The PennCNP begins with a general sensory-motor and familiarisation trial (MPRAXIS) so as to allow participants to become comfortable with the computer-based testing procedure. The Executive Functioning and Abstract Reasoning battery consists of the following tests: the Penn Abstraction, Inhibition and Working Memory Task (AIM); The Letter-N-Back (LNB2), the Penn Conditional Exclusion Task (PCET); the Penn Short Logical Reasoning Test (SPVRT) and Short Raven's Progressive Matrices (SRAVEN). The Emotions battery consists of the following tests: the Penn Facial Memory Test (CPF), the Penn Emotion Recognition Task (ER40), the Penn Emotion Discrimination Task (EDF40) and the Penn Emotional Acuity Test (PEAT40).

Sample participants and procedure for selection

The data were collected from a sample comprising first year psychology students at a residential university in South Africa. Six hundred and thirty students from the 1,124 registered students voluntarily agreed to participate in the study as part of experiential learning in their undergraduate course in cognition. There were no negative repercussions of non-participation. Participants were required to choose a scheduled session and were assigned to groups. In total 30 group sessions were scheduled. Each group comprised a maximum of 25 participants. In addition to three attending researchers, eight research assistants were trained in the administration of the battery. Each research assistant was responsible for the simultaneous monitoring of 4 participants. Research assistants were postgraduate students participating as part of their course requirements in applied cognition. Thirty-six cases were deleted due to incomplete records and cases with medical history (epilepsy, head injury, depression). A realized sample of 594 was utilised for the final data analyses. The sample comprised 84% female participants with a total sample mean age of 19.67 (2.7). Table 1 illustrates demographic participant descriptive information presented as percentages. The nature of schooling was recorded as either state-subsidized or privately funded. Parental education was recorded as either at or below high school or beyond high school level. Of participants who spoke an indigenous language at home, far fewer were educated in their home language. More participants' parents had received education beyond high school.

Table 1: Descriptive demographic analyses of the South African sample (n=594)

School	**Language in high school**				**Home language**			
	Eng	*Afr*	*Ind*	*(Sub-Tot)*	*Eng*	*Afr*	*Ind*	*(Sub-tot)*
Private	35.2	16.7	0.9	(52.8)	19.6	20.3	13.0	(52.8)
State	16.5	25.8	4.8	(47.2)	7.8	26.7	12.6	(47.2)
Total	(51.8)	(42.5)	(5.7)	(100)	(27.4)	(47)	(25.6)	(100)

	Father's Education		
Mother's Education	*HS and below*	*Beyond HS*	*Total*
HS and below	24.2	15.1	39.3
Beyond HS	10.7	50.0	60.7
Total	34.9	65.1	100

Eng = English; Afr = Afrikaans; Ind = Indigenous; Sub-tot = subtotal; HS = High School

Method of administration

Ethical clearance for the study was obtained from the relevant departmental and faculty committees at the University. The PennCNP was administered using clickable icons on desktop computers, in a fixed order. The tests were implemented on IBM® computers. An Applescript® routine was used to collect participant IDs and basic demographic information and to present the tests in a prescribed order. The results were uploaded to a data repository using an automated script, and scored using a program written in the Python programming language (Gur et al. 2010). There was no timelag effect and internet connectivity speed was not a confounding issue.

Results

Performance and internal consistency

Means, standard deviations and Cronbach's alpha coefficients for the tests in the battery are detailed in Table 2. The reliability estimates ranged from moderate to high with internal consistency estimates being generally higher for speed than for accuracy. The PCET measure yielded both low accuracy and speed reliabilities while emotion recognition yielded a low reliability coefficient for accuracy but a high estimate for speed. The motor test as well as the facial memory test yielded low reliability estimates but the latter yielded a moderate reliability estimate. The PennCNP normative sample consists of 18-75year olds. The data evidences similar response patterns for both groups and is suggestive of test equivalence across different groups.

Table 2: Means, standard deviations (SD) and Cronbach's alpha coefficients for the tests in the battery (n=594) with the South African sample and the PennCNP normative sample data

Domain	Test	Source	Accuracy			Speed		
			Mean # correct	SD	Alpha	Mean (ms)	SD	Alpha
Abstraction, concept formation and working memory	Abstraction, inhibition and working memory (AIM)	South African	47.84	6.25	0.83	1822.12	497.5	0.82
		PennCNP	*48.19*	*6.60*		*1847.62*	*589.95*	
Attention and working memory	Letter-N-Back (LNB2)	South African	42.94	3.09	0.7	442.03	112.74	0.85
		PennCNP	*42.75*	*2.83*		*523.36*	*129.35*	
Abstraction in executive functioning	Conditional exclusion test (PCET)	South African	38.20	7.77	0.43	2012.97	574.91	0.43
		PennCNP	*36.19*	*9.44*		*2392.21*	*1278.33*	
Verbal intellectual ability	Logical reasoning test (SPVRT)	South African	15.02	4.95	0.69	8687.48	2733.02	0.83
		PennCNP	*19.13*	*6.07*		*10689.85*	*5453.14*	
Fluid intelligence	Progressive matrices (SRAVEN)	South African	42.31	9.89	0.72	19056.32	8426.31	0.81
		PennCNP	*41.41*	*12.27*		*15859.05*	*14992.73*	
Sensory-motor ability	Motor praxis (MPRAXIS)	South African	19.99	0.20	_	700.05	207.92	0.57
		PennCNP	*19.92*	*0.69*		*745.59*	*260.79*	
Facial memory	Facial memory test (CPF)	South African	32.97	3.49	0.72	1673.75	370.91	0.5
		PennCNP	*32.12*	*4.06*		*1849.13*	*629.48*	
Emotion recognition	Emotion recognition task (ER40)	South African	34.01	2.78	0.51	1894.33	368.37	0.85
		PennCNP	*33.66*	*3.10*		*2056.58*	*623.68*	
Emotion discrimination	Emotion discrimination task (EDF40)	South Africa	12.56	2.44	0.66	5383.84	2698.4	0.85
		PennCNP	*12.38*	*3.35*		*5175.44*	*2603.14*	

Intercorrelations among the performance indices for tests included in the battery are presented in Table 3. Average intercorrelations for speed were twice the size of the average intercorrelations for accuracy. There were a greater number of significant intercorrelations for speed than for accuracy. Other intercorrelations ranged from nil to slightly moderate supporting the construct validity of the battery. Generally, the intercorrelations are low but significant.

Table 3: Intercorrelations among the performance indices for tests included in the battery used in South Africa (n=594)

Accuracy > Speed V	AIM	LNB2	PCET	SPVRT	SRAVENS	MOTOR	CPF	ER40	EFD40	PEAT40
AIM	-	**.107**	-.009	**.267**	**.340**	.013	**.226**	**.276**	**.235**	**.115**
LNB2	**.283**	-	-.028	.064	**.189**	-.002	**.119**	*.097*	.049	.063
PCET	**.514**	**.312**	-	-.080	-.053	-.014	.059	-.001	-.064	-.018
SPVRT	**.218**	.070	**.203**	-	**.379**	-.011	**.199**	**.192**	**.243**	.069
SRAVENS	**.213**	*.105*	**.251**	**.441**	-	-.024	**.241**	**.238**	**.214**	**.120**
MOTOR	**.324**	**.289**	**.330**	**.137**	**.155**	-	.051	.003	-.002	.066
CPF	**.164**	*.103*	**.250**	**.220**	.061	*.092*	-	**.400**	**.223**	**.189**
ER40	**.348**	**.253**	**.403**	**.246**	.060	**.212**	**.458**	-	**.270**	**.291**
EDF40	**.200**	.023	**.192**	**.246**	.038	*-.083*	**.413**	**.385**	-	.044
PEAT40	**.300**	**.179**	**.325**	**.226**	.043	.061	**.435**	**.561**	**.565**	-

The upper diagonal shows correlations with accuracy and the lower diagonal shows correlations for response time. Correlations significant at the 0.05 level are italicised while those at the 0.01 are bolded.

Correlations with socio-demographic variables

Mothers' and fathers' education is positively correlated with increased accuracy on tasks assessing abstraction, abstraction and mental flexibility, logical reasoning, facial memory, emotion recognition as well as increased response time for motor speed and emotion recognition. The higher the parental education level the better the overall performance. Quality of education (private schooling vs. State-subsidised schooling) is also correlated with performance. The better the quality of education, the more accurate the responses on abstraction, abstraction and mental flexibility, emotion recognition and emotional acuity. Response times for the logical reasoning task were faster for those who had a better quality education. Home language was also shown to have a differential effect on accuracy and performance. Those who spoke English at home tended to evidence more accurate results in abstraction, logical reasoning, fluid intelligence, facial memory, emotion recognition and emotional acuity. Response times were generally faster for those speaking English at home for the conditional exclusion task, fluid intelligence, abstraction, letter-N-back and motor, emotion recognition and emotional acuity tasks. Interestingly, those who were schooled in a Black language performed slightly better on the fluid intelligence test than those who were schooled in either English or Afrikaans. However, response times to logical reasoning were slower for this same group. Correlations ranged from very small to moderate for these associations on the above-mentioned socio-demographic variables. Very small correlations were evidenced for parental education as well as language at school but moderate for home language.

Discussion

Internal consistency of the computerized neuropsychological test battery in the South African sample ranged between 0.43-0.94 across domains. This range is in keeping with those obtained by Gur et al. (2010) with alpha coefficients ranging between 0.55-0.97. Attention and working memory tests yielded similar coefficients for the two samples; the South African sample yielded a range of 0.70-0.85 for both accuracy and speed respectively. Gur et al. (2010) found a range of 0.77-0.81. Similarly, emotion recognition yielded similar internal consistencies across groups with the South African sample showing a range of 0.51-0.85 in keeping with a similar range for Gur et al. (2010) of 0.58-0.91. In addition to this, our findings corroborate those of Gur et al. (2010) regarding a generally higher internal consistency for speed results as opposed to lower internal consistencies for accuracy indicators. The former sample showed less of a discrepant range however, than did the sample used by Gur et al. (2010). Mean scores on the different performance tests were also quite similar across the groups with a lowered score being evidenced for the South African sample on the logical reasoning test.

Internal consistency measures were lower in general in the South African sample for both the verbal intellectual ability indices and facial memory indices. Gur et al. (2010) report a range between 0.87-0.91 for the logical reasoning test whilst the South African sample yielded a range between 0.69-0.83. Likewise, Gur et al. (2010) show a range between 0.92-0.95 for the facial memory test whilst the South African data show a range between 0.72-0.5. Two possible reasons for this could be, that in the case of the logical reasoning test, language plays a mediating role in test performance which has been shown in the literature to be a factor in cognitive test scores (Cockcroft & Blackburn, 2008; Nelson & Pontón, 2007; Shuttleworth-Edwards, Donnelly, Reid, & Radloff, 2004; Shuttleworth-Edwards, Kemp, Rust, Muirhead, Hartman & Radloff, 2004). Regarding the facial memory test, lowered internal consistency coefficients may be due to lack of familiarity with international faces which impacts on speed and accuracy of recognition. This possible explanation has been echoed in previous related research in facial recognition across cultures (Coetzee, Greeff, Barrett & Henzic, 2009; Elfenbein & Ambady, 2003).

Consistent with the findings from Gur et al. (2010) our findings also showed that the measures were more highly intercorrelated for speed than for accuracy. Gur et al. (2010) maintain that construct validation of the battery is partly evidenced from the range of correlations between the various tests. Similar findings resulted from the analyses of the South African data. Regarding mother's and father's education, as higher levels of education were attained overall performance increased. Once again, these findings are in accord with those of Gur et al. (2010). It is an established fact that higher parental education positively influences test performance outcomes on a broad range of cognitive measures (Braga, 2007; Cockcroft, Amod & Soellaart, 2008; Hoff, 2003).

Conclusion

The South African context is heterogeneous and research evidences the differential impact that socio-demographic and socio-economic factors have on cognitive test performance. In order to determine the functioning of an international computerized test battery we investigated whether socio-demographic variables in the South African sample influenced test performance. In keeping with prior research it was found that even though socio-demographic factors do play a role in test performance, the psychometric properties of the battery remain consistent across different groups and further research utilising this tool is encouraged.

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