

Comparing Mobile Cognitive Testing with Traditional Neuropsychological Testing in Ecuadorian Adolescent and Young Adults in the ESPINA Cohort: A Single- and Burst-Administration Study



Briana N.C. Chronister¹, Avery Quynh², Kun Yang¹, Xin Tu¹, Danilo Martinez³, Jose Suarez-Torres³, Asa Bradman⁴, Jose R. Suarez-Lopez¹, Raeanne C. Moore²

Affiliations: ¹ The Herbert Wertheim School of Public Health and Human Longevity Science, University of California San Diego (UCSD), La Jolla, CA; ² Department of Psychiatry, UCSD, School of Medicine, La Jolla, CA; ³ Fundación Cimas Del Ecuador, Quito, Ecuador; ⁴ Department of Public Health, School of Social Sciences, Humanities, and Arts, University of California, Merced, CA

Background

Ecological mobile cognitive testing (EMCT) has grown in popularity due to its ability to collect real-time data outside the laboratory; its relationship with traditional neuropsychological testing among Spanish speakers remains underexplored.

Methods

ESPINA-EMCT participants completed the NIH Toolbox Cognition battery (Toolbox) and (1) a same-day single laboratory-based administration in July-August 2022 (n=488) and (2) a 10-day burst administration (2.5-4 months later) of NeuroUX mobile cognitive tests (n=323).

We examined associations between traditional and mobile tests and explored demographic associations using generalized estimating equations.

Results

Demographics were similar between the baseline and burst for age (20.29 [SD=1.83] vs 20.29 [SD=1.77]), sex (50.6% vs 55.1% Female), ethnicity (18.6% vs 17.3% Indigenous), and education (60.7% vs 57% High School Graduate or below), respectively.

Toolbox tests mean scores ranged from 114.98 – 118.65, and NeuroUX mean scores varied by test (Table 1).

Table 1. Baseline Toolbox and NeuroUX Mean Scores.

	Test	Mean (SD)	Range
Toolbox Tests	Cognitive Fluid Composite	114.98 (7.27)	88 – 136
	Dimensional Change Card Sort	111.67 (5.01)	82 – 121
	Flanker Inhibitory Control and Attention	115.35 (6.15)	85 – 126
	List Sorting Working Memory Test	116.43 (15.13)	63 – 156
	Pattern Comparison Processing Speed	118.65 (11.87)	88 – 143
NeuroUX Tests	Memory Matrix Total Score	45.56 (10.74)	3 – 88
	Matching Pair Total Score	267.36 (64.85)	98 – 458
	CopyKat Total Score	10.30 (4.92)	0 – 34
	Odd One Out Total Score	7.66 (0.76)	2 – 9.31
	Quick Tap 1 Total Score	6.39 (1.49)	1 – 9.45
	Quick Tap 2 Total Score	8.05 (0.93)	4.05 – 9.75

Burst administration scores differed from single administration scores for specific tests, showing improved performance for Memory Matrix Total Score but worse performance on Quick Tap 2 Total Score (Table 2).

Table 2. The difference the mean NeuroUX test scores comparing the Burst Administration to the Single Administration.

EMCT Test	Difference (95% CI)	p-value
Memory Matrix Total Score	1.77 (0.43, 3.11)	0.01
Matching Pair Total Score	-0.05 (-0.68, 0.58)	0.99
CopyKat Total Score	0.07 (-0.52, 0.66)	0.82
Odd One Out Total Score	-0.02 (-0.13, 0.08)	0.66
Quick Tap 1 Total Score	0.06 (-0.07, 0.19)	0.34
Quick Tap 2 Total Score	-0.24 (-0.33, -0.15)	<0.001
NeuroUX Composite Score	0.003 (-0.08, 0.08)	0.94

EMCT=Ecological Momentary Cognitive Test, CI=Confidence Interval
Models adjusted for age, gender, ethnicity, and education.

Associations between NeuroUX and Toolbox performance

Better performance on the NeuroUX tests at baseline (Table 3a) and the burst administration (Table 3b) were associated with higher scores for almost all Toolbox scores, but associations were strongest for the baseline.

Table 3. Associations between NIH Toolbox cognition battery with concurrent (baseline) single (3a; n=488) and burst administration of NeuroUX cognitive tests (3b; n=323).

	Difference in NeuroUX test score for a one unit increase in Toolbox test score. β (95% CI), p-value					
	CFC	DCCS	FICA	LSWM	PCPS	PSM
a) NeuroUX (Baseline)						
Memory Matrix Total Score	0.32 (0.17, 0.48)**	0.36 (0.21, 0.51)**	0.32 (0.09, 0.54)**	0.23 (0.09, 0.37)**	0.08 (0.01, 0.15)*	0.14 (0.06, 0.22)**
Matching Pair Total Score	2.98 (2.15, 3.82)**	3.30 (2.47, 4.13)**	2.16 (0.94, 3.38)**	1.8 (1.19, 2.76)**	0.82 (0.45, 1.19)**	1.07 (0.56, 1.58)**
CopyKat Total Score	0.19 (0.14, 0.25)**	0.19 (0.13, 0.26)**	0.21 (0.12, 0.30)**	0.16 (0.09, 0.22)**	0.03 (-0.001, 0.05)	0.10 (0.07, 0.14)**
Odd One Out Total Score	0.03 (0.02, 0.04)**	0.04 (0.02, 0.05)**	0.04 (0.02, 0.05)**	0.02 (0.01, 0.03)**	0.01 (0.01, 0.02)*	0.01 (0.002, 0.01)**
Quick Tap 1 Total Score	0.07 (0.05, 0.09)**	0.07 (0.05, 0.09)**	0.08 (0.05, 0.11)**	0.04 (0.02, 0.06)**	0.02 (0.01, 0.03)**	0.02 (0.01, 0.03)**
Quick Tap 2 Total Score	0.05 (0.03, 0.06)**	0.04 (0.03, 0.05)**	0.05 (0.03, 0.06)**	0.03 (0.02, 0.04)**	0.01 (0.01, 0.02)**	0.01 (0.01, 0.02)**
NeuroUX Composite Score	0.04 (0.04, 0.05)**	0.05 (0.04, 0.05)**	0.05 (0.03, 0.06)**	0.03 (0.02, 0.03)**	0.01 (0.01, 0.01)**	0.02 (0.01, 0.02)**
b) NeuroUX (Burst)						
Memory Matrix Total Score	0.25 (0.11, 0.39)**	0.41 (0.25, 0.57)**	0.24 (0.05, 0.42)**	0.20 (0.06, 0.33)**	0.06 (-0.002, 0.12)	0.11 (0.02, 0.21)
Matching Pair Total Score	2.24 (1.47, 3.01)**	2.82 (1.63, 4.01)**	1.68 (0.70, 2.67)**	1.50 (0.83, 2.17)**	0.51 (0.18, 0.83)**	0.86 (0.43, 1.29)**
CopyKat Total Score	0.12 (0.06, 0.18)**	0.14 (0.06, 0.21)**	0.11 (0.04, 0.19)**	0.10 (0.05, 0.16)**	0.01 (-0.02, 0.04)	0.07 (0.03, 0.10)**
Odd One Out Total Score	0.03 (0.02, 0.04)**	0.04 (0.02, 0.07)**	0.04 (0.02, 0.06)**	0.01 (0.003, 0.02)*	0.01 (0.01, 0.01)**	0.003 (-0.003, 0.01)
Quick Tap 1 Total Score	0.04 (0.03, 0.06)**	0.05 (0.03, 0.08)**	0.05 (0.03, 0.07)**	0.02 (0.01, 0.04)**	0.01 (0.002, 0.02)**	0.02 (0.01, 0.03)**
Quick Tap 2 Total Score	0.02 (0.01, 0.03)**	0.04 (0.03, 0.05)**	0.03 (0.01, 0.04)**	0.01 (-0.001, 0.02)	0.004 (-0.001, 0.01)	0.01 (0.003, 0.02)**
NeuroUX Composite Score	0.04 (0.04, 0.05)**	0.05 (0.04, 0.05)**	0.05 (0.03, 0.06)**	0.03 (0.02, 0.03)**	0.01 (0.01, 0.01)**	0.02 (0.01, 0.02)**

CFC=Cognition Fluid, Composite, DCCS=Dimensional Change Card Sort Test, FICA=Flanker Inhibitory Control and Attention, LSWM=List Sorting Working Memory Test, PCPS=Pattern Comparison Processing Speed Test, PSM=Picture Sequence Memory Test
*p<0.05 **p<0.01. Models adjusted for age, gender, ethnicity, and education.

Associations between demographic variables with Toolbox and NeuroUX Tests.

Older participants had worse performance for DCCS, Matching Pair Total Score, and CopyKat Total Score.

Males generally showed better performance on Toolbox and NeuroUX tests except for PSM (Table 4).

Individual who had “Some College” education level had better performance on both Toolbox and NeuroUX tests compared to those with the “Some High School or Below” education level.

Table 4. Associations between demographic variables with Toolbox and NeuroUX Tests.

Toolbox Tests	Difference in NeuroUX Score, β (95% CI) for...			
	A year increase in age	Males, compared to Females.	High School Graduates, and Some College education, compared to Some High School or Below.	
	Age	Male	High School Graduate	Some College
Cognitive Fluid Composite	-0.30 (-0.72, 0.12)	1.01 (-0.33, 2.35)	0.82 (-1.34, 2.97)	2.16 (-0.07, 4.38)*
Dimensional Change Card Sort	-0.49 (-0.87, -0.12)*	1.78 (0.74, 2.82)**	1.75 (-0.36, 3.86)	3.40 (1.18, 5.63)**
Flanker Inhibitory Control and Attention	-0.10 (-0.35, 0.16)	2.34 (1.49, 3.19)**	0.85 (-0.61, 2.30)	1.50 (-0.01, 3.02)
List Sorting Working Memory Test	-0.36 (-0.76, 0.04)	0.95 (-0.28, 2.18)	1.52 (-0.26, 3.29)	2.37 (0.39, 4.34)**
Pattern Comparison Processing Speed	0.07 (-0.71, 0.86)	1.41 (-1.28, 4.10)	-2.61 (-6.28, 1.07)	-3.51 (-7.66, 0.64)
Picture Sequence Memory Test	-0.29 (-0.89, 0.31)	-3.16 (-5.19, -1.13)*	0.41 (-2.70, 3.52)	3.51 (0.24, 6.78)*
Memory Matrix Total Score	-0.45 (-0.98, 0.09)	1.87 (-0.03, 3.77)	0.44 (-2.56, 3.44)	1.39 (-1.86, 4.64)
Matching Pair Total Score	-4.66 (-8.16, -1.15)*	-0.25 (-11.66, 11.12)	5.79 (-12.15, 23.74)	19.99 (0.98, 39.00)*
CopyKat Total Score	-0.37 (-0.61, -0.13)**	1.68 (0.84, 2.52)**	1.60 (0.43, 2.76)*	2.47 (1.18, 3.77)**
Odd One Out Total Score	0.01 (-0.05, 0.074)	0.25 (0.02, 0.47)*	0.33 (-0.06, 0.73)	0.57 (0.20, 0.94)**
Quick Tap 1 Total Score	0.06 (0.01, 0.12)*	-0.04 (-0.23, 0.15)	0.18 (-0.18, 0.53)	0.13 (-0.22, 0.49)
Quick Tap 2 Total Score	-0.04 (-0.09, 0.01)	0.37 (0.21, 0.53)*	0.31 (0.05, 0.58)*	0.46 (0.19, 0.72)*
NeuroUX Composite Score	-0.001 (-0.04, 0.04)	-0.05 (-0.16, 0.07)	0.05 (-0.15, 0.24)	0.16 (-0.02, 0.34)

Conclusion

There were significant association between mobile and traditional neuropsychological tests, with stronger associations when the mobile tests are administered in a lab setting (concurrently) compared to daily life 3.5 months later.

Per these findings, administering NeuroUX tests in a laboratory and real-world setting performs similarly to traditional tests, while administration in daily life allows for “Cognition in Context.”

These findings demonstrate EMCT can effectively assess cognitive function in Spanish-speaking populations, emphasizing the importance of evaluating cognition in real-world contexts, especially in culturally diverse and rural populations.

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