



THE RELATIONSHIP BETWEEN N-BACK MEASURES OF WORKING MEMORY AND NEUROPSYCHOLOGICAL TESTS OF COGNITIVE FUNCTIONING

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INTRODUCTION

Working memory refers to the type of memory involved in temporary maintenance as well as manipulation of information required for an on-going cognitive task. Recognized tests used to measure the capacity for working memory include the Digit and Spatial Span Backward, Subtests of the Wechsler Memory Test; the Paced Auditory Serial Addition Task; and Symbol Digit Modalities Test. However, a disadvantage of many of these tests is their inability to be used in conjunction with physiological procedures such as Event-Related Brain Potentials or fMRI. The N-back task, a sequential memory task that is thought to measure working memory, has been used with physiological measures of brain function. An advantage of the N-back task is that it allows for the parsing of simple and complex forms of processing speed and working memory performance. A recent study (Miller et al, 2009) has questioned the utility of the N-back as a measure of working memory. In the present study, we compared several N-back behavioral measures (accuracy, reaction time, and standard deviation of reaction time) with data obtained from a battery of classical neuropsychological tasks thought to measure processing speed and memory. We hypothesized that these neuropsychological tests would be related to specific behavioral N-back measures.

RESULTS

Regression Equation:
 Criterion = (Slope x Predictor) + Intercept

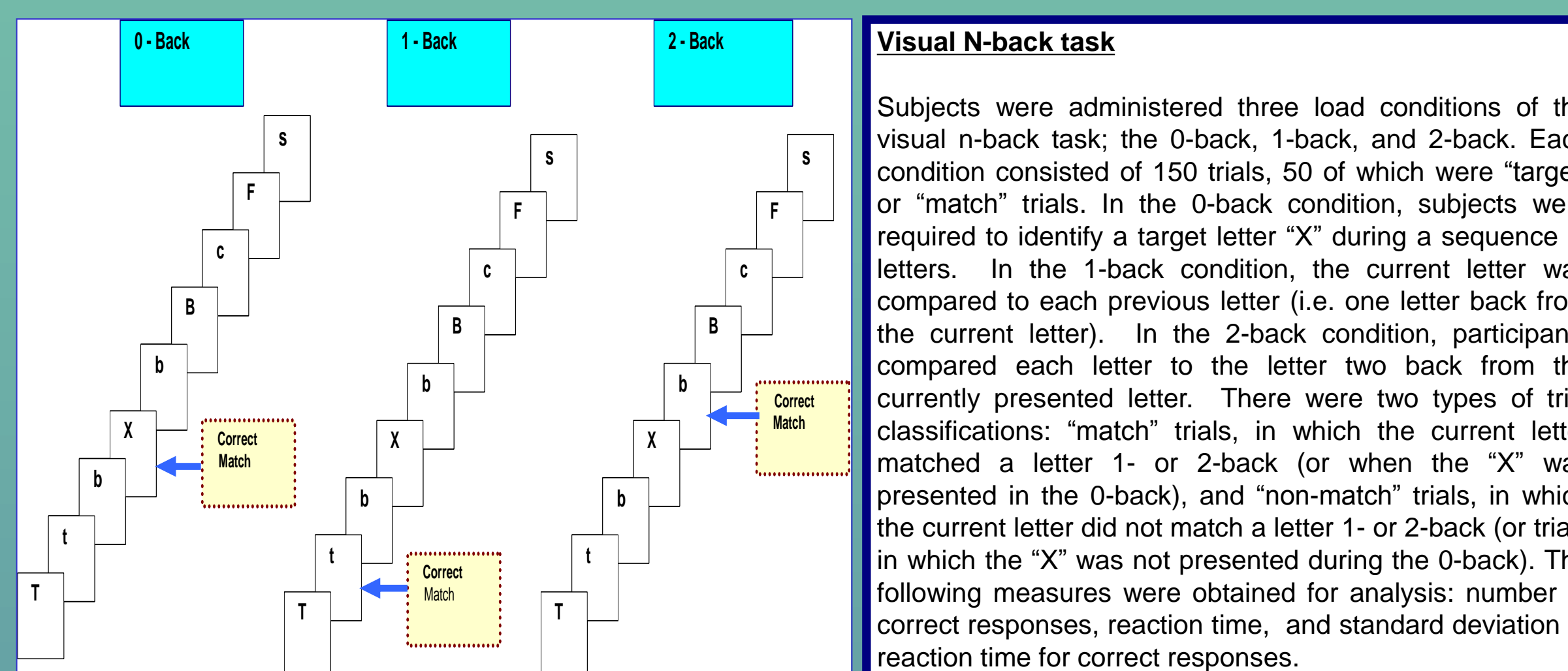
0-back

Accuracy			Reaction Time			Standard Deviation of Reaction Time		
Model R ² :			Model R ² :			Model R ² :		
Model R ² :	.520		Model R ² :	0.471		Model R ² :	0.58	
Model Significance:	0.001		Model Significance:	0.001		Model Significance:	<0.001	
Predictors	β	p	Predictors	β	p	Predictors	β	p
Age	0.11	0.400	Age	0.19	0.161	Age	-0.03	0.84
Sex	0.09	0.513	Sex	-0.35	0.014	Sex	-0.35	0.015
Education	0.11	0.408	Education	-0.02	0.898	Education	0.16	0.234
Stroop Color-Word	0.64	<0.001	PASAT 3.0 sec	-0.67	0.01	PASAT 3.0 sec	-0.45	0.002
BVMTR Discrimination Index	-0.35	.011	Stroop Color-Word	0.38	0.014	Wechsler Memory Scales Spatial Span Forward	0.46	0.002
PASAT 3.0 sec	-0.32	.034			Stroop Color-Word Interference	-0.36	0.011	
					BVMT Trial 1	-0.38	0.012	

METHODS

Participants:

44 healthy volunteers (39 females, 5 males) participated. Mean age of 44±10.4 and 15.3±1.8 years of formal education. Volunteers were screened prior to testing and were excluded if they had any head trauma, hearing problems, learning disorders, psychiatric conditions, neurological conditions, or any other major medical conditions.



1-back

Accuracy			Reaction Time			Standard Deviation of Reaction Time		
Model R ² :			Model R ² :			Model R ² :		
Model R ² :	0.345		Model R ² :	0.475		Model R ² :	0.652	
Model Significance:	0.006		Model Significance:	0.001		Model Significance:	<0.001	
Predictors	β	p	Predictors	β	p	Predictors	β	p
Age	0.01	0.94	Age	-0.002	0.987	Age	0.11	0.392
Sex	0.40	0.007	Sex	-0.28	0.051	Sex	-0.19	0.161
Education	-0.09	0.537	Education	0.23	0.132	Education	0.20	0.124
Wechsler Memory Scales Spatial Span Backward	0.43	0.007	9-Hole Peg Dom. Hand	0.49	0.002	PASAT 3.0 sec	-0.41	0.006
			Stroop Color-Word	-0.31	0.046	Wechsler Memory Scales Spatial Span Forward	0.37	0.005
						Stroop Color-Word Raw	-0.37	0.010
						9-Hole Peg Dom. Hand	0.33	0.031

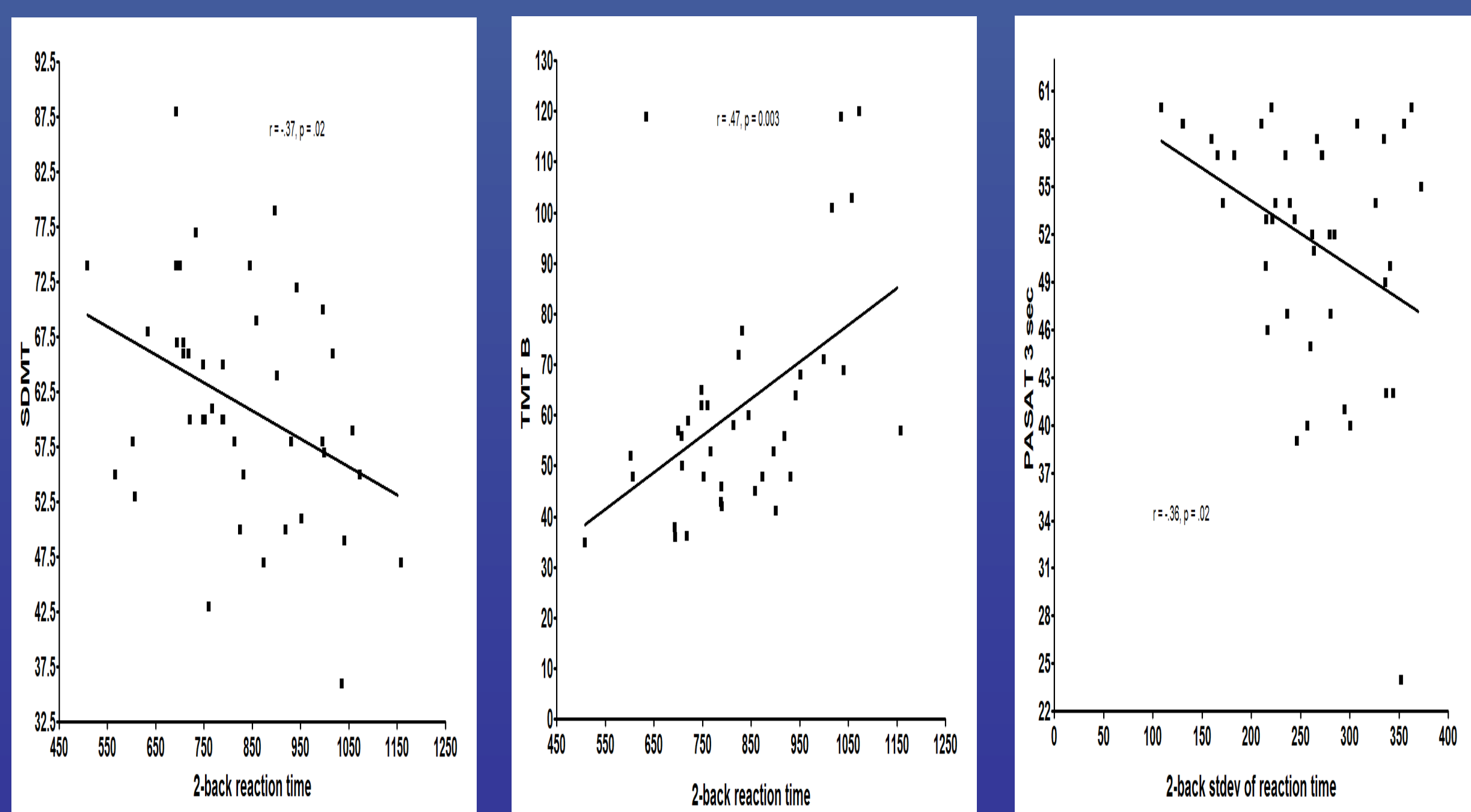
Neuropsychological Tests

Test	Cognitive Domain	Measure	Test	Cognitive Domain	Measure
North American Adult Reading Test (NAART)	Verbal IQ	number of correctly pronounced words	Paced auditory serial addition test (PASAT)	auditory working memory, processing speed	number of correct responses; two ISI conditions (3 sec & 2 sec)
9 Hole Peg Test	fine motor skills, coordination	time to place & remove 9 pegs	Symbol Digit Modalities Test (SDMT)	working memory, processing speed, visual scanning	number of correct symbol/number matches in 90 seconds
Controlled Oral Word Association Test (COWAT) letter fluency	word association fluency	number of words generated	Trail making (A and B)	working memory, processing speed	time to complete sequence
Wechsler Memory Scale Digit Span	short term memory, working memory	number of digits in longest sequence recalled	Wechsler Memory Scale Spatial Span	short term memory, working memory executive functions: planning, deductive reasoning	Number of correct blocks touched in order
California Verbal Learning Test, 2nd Edition (CVLT-II)	verbal memory	number of correct recalled words (trials 1-5, total for all trials, recall, recognition)	Delis Kaplan Executive Function System (D-KEFS) Sorting		total number of correct sorts & correct sort descriptions
Brief Visual-Spatial Memory Test, Revised (BVMTR)	visuospatial memory	number of correct recalled (trials 1-3, total for all trials, recall, recognition)	Stroop Test	focused attention, mental control, response inhibition	Number of correct responses during Word, Color, and Color-Word subtests & interference score

2-back

Accuracy			Reaction Time			Standard Deviation of Reaction Time		
Model R ² :			Model R ² :			Model R ² :		
Model R ² :	0.125		Model R ² :	0.352		Model R ² :	0.645	
Model Significance:	0.339		Model Significance:	0.015		Model Significance:	<0.001	
Predictors	β	p	Predictors	β	p	Predictors	β	p
Age	-0.16	0.333	Age	-0.21	0.224	Age	-0.01	0.952
Sex	0.05	0.768	Sex	-0.12	0.42	Sex	0.01	0.93
Education	-0.08	0.626	Education	0.04	0.801	Education	0.27	0.034
PASAT 3.0 sec	0.36	0.048	Trail Making B Time	0.37	0.03	PASAT 3.0 sec	-0.35	0.011
			SDMT Oral	-0.38	0.036	BVMT Trial 3	0.52	<0.001
						CVLT Trial 5	-0.42	0.002
						SDMT Oral	-0.36	0.016
						CVLT Trial 1	0.29	0.023

Selected Bivariate Correlations



SUMMARY & CONCLUSIONS

- Measures of the N-back task were predicted by neuropsychological measures of attention and working memory, including the PASAT, SDMT, Trail Making Test, Spatial Span Backward, and Stroop Test.
 - These findings are in contrast to the Miller et al. paper in which the measures of working memory and processing speed used (Stroop, Trail Making Test A, and Digit Span) were not found to be associated with N-back measures.
- The PASAT, a measure often used to assess working memory and processing speed in clinical populations, was predictive of N-back performance, reaction time, and standard deviation of reaction time across most conditions. In particular, it was strongly associated with standard deviation of reaction time across all N-back conditions.
- The SDMT, which is also a test used in clinical populations, was predictive only during the 2-back condition (highest working memory load) for reaction time and standard deviation of reaction time.
- We conclude that the N-back task is a useful test of information processing speed and working memory with both experimental and potential clinical utility.

ACKNOWLEDGEMENTS

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REFERENCES

Miller, K. M., Price, C.C., Okun, M. S., Montijo, H., & Bowers, D. (2009). Is the n-back task a valid neuropsychological measure for assessing working memory? *Archives of Clinical Neuropsychology* 24, 711-717.