

and to ensure that outcomes are theoretically valid and meaningful. In their study, the authors grouped neuropsychological tests from the reviewed studies into 5 outcomes: executive function, processing speed/attention, global cognition, working memory, and visuospatial processing/memory. However, the validity of these broad cognitive domains is uncertain; no cognitive model or theory was cited as a rationale for their creation, their definition was not described, and no data were provided to show which neuropsychological tests were included in each domain. Consequently, the patterns of cognitive improvement with exercise remain uncertain. The large number of neuropsychological tests used across studies poses unique challenges for systematic reviews. However, extensive factor analytic work has provided evidence-based “cognitive maps” akin to the periodic table of elements.<sup>2-4</sup> This framework can be used to guide the handling and analysis of cognitive outcomes in reviews, helping to eliminate bias and ensuring that cognitive domains are theoretically valid and meaningful.<sup>5</sup>

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## Author Response: Exercise for cognitive brain health in aging: A systematic review for an evaluation of dose

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*Neurology: Clinical Practice* October 2018 vol. 8 no. 5 366–368 doi:10.1212/CPJ.0000000000000532

We thank Dr. Pase for his comments regarding our systematic review.<sup>1</sup> We share Dr. Pase’s concern that a very large number of different cognitive tasks have been used in past studies on the effects of exercise, which poses substantial challenges to systematic reviews. Furthermore, as pointedly stated by Colcombe and Kramer<sup>2</sup> in a review of exercise and cognitive function, considerable overlap in cognitive constructs exists. We appreciate Dr. Pase’s suggestion of considering the framework offered by cognitive maps and agree with their promise and value. Having the ability to prescribe the correct exercise dose for a specific cognitive domain would provide a wonderful tool for clinicians that would push the field beyond theoretical status into an established, evidence-based treatment.

Providing an exhaustive and definitive classification of cognitive domains modulated by exercise was beyond the scope of our review. The primary objective was to analyze consistent patterns in the measures of exercise for an evaluation of dose as a first step towards evidence-based prescriptions of exercise. Consequently, when assessing the consistent effects of exercise on different cognitive domains, we felt that it was most appropriate to align the methods with previously published classifications of cognitive domains within the exercise literature.<sup>2,3</sup> As stated in the methods, a board-certified, PhD-trained clinical neuropsychologist oversaw the classifications. We agree that a list of cognitive tasks that met each cognitive domain (similar to that presented in Smith et al.<sup>3</sup>) is helpful (table).

**Table** Classification of neuropsychological tests by cognitive domain

Processing speed/attention	Executive functions	Working memory	Visuospatial/memory	Global cognition
Finger tapping	Categorical fluency (animal naming)	Digit span backward	ADAS word list recall	ADAS-cog
Digit Symbol Substitution Test	Go/no-go test	N-back task	Auditory Verbal Learning Test	Neurobehavioral cognitive status examination
Attentive matrices	Raven's progressive matrices	WAIS letter-number sequencing	Benton Visual Retention Test	Mini-Mental State Examination
Ruff 2 & 7 test (letters)	RIPA organization	Letter search	RAVLT short	5-Cog
Age concentration test A and B	RIPA problem-solving	Memory for health information	RAVLT delay/retention	Dementia Rating Scale
Simple/choice time	RIPA abstract reasoning	Digit span forward	RAVLT total	Clinical Dementia Rating
Attention task	Digits (Ruff 2 & 7 test)	SOPT	RBMT faces	Neuropsychological test battery
Speed of movement	Drawing Copy Test	Spatial working memory task	Boston Naming Test	Rapid Evaluation of Cognitive Functions Test
Stroop color	Motor control (CANTAB)	Executive control task	RBMT pictures	Rey-Osterrieth complex figure
Stroop word	Set-shifting ability	Letter-number sequencing (WAIS III)	Pattern recognition memory test (CANTAB)	CAMCOG
Task-switching RT	Stroop color/word or interference	Running memory span task	RIPA auditory processing	
Trail-making test part A	Trail-making test part B	Spatial working memory (CANTAB)	RIPA immediate memory	
Digit vigilance	Useful field of view	Cooking breakfast task	RIPA recent memory	
Digit span forward	Subtraction task (dual)		Visual and verbal memory test	
Symbol search test	WAIS III (matrices and similarities)		Selective Reminding Test	
Digit Symbol Substitution Test	Wisconsin Card-Sorting Task		VLMT delayed recall	
A Quick Test of Cognitive Speed (AQT)	Randt memory test story recall		WMS logical memory, immediate	
Direction headings	Frontal Assessment Battery		WMS logical memory, delayed	
Bell cancellation test	COWAT		WMS verbal paired associates	
Number comparison test	CVFT		Hopkins verbal memory	
Plate tapping test	Color trails test		Clock-drawing test	
Digit symbol coding	Eriksen flanker test		Story recall	
Symbol Digit Modalities Test	Random number generation task		List learning (ADAS-cog)	
Wisconsin Card-Sorting Test	Letter sets test		Useful field of view test	
Useful field of view task	Congruent and incongruent reaction times		Short story module (Randt memory test)	

Continued

Author disclosures are available upon request (ncpjourn@neurology.org)

**Table** Classification of neuropsychological tests by cognitive domain (continued)

Processing speed/attention	Executive functions	Working memory	Visuospatial/memory	Global cognition
Stanford Sleepiness Scale	Matrix reasoning test		Free and Cued Selective Reminding Test	
Rapid visual information processing (CANTAB)	Trail-making test part A		Word comparison	
Digit span backward	Verbal fluency (category or letter)		Directional headings test	
Time-sharing	Local switch cost		Virtual week task	
D-cat	Category fluency (ADST)		First and second names	
Letter-digit	Turning point index		Verbal learning and memory test	
	The Adjacency Test		Cooking breakfast task	
	Runs index		Benton Visual Retention Test	
	Dots estimation		Complex Figure Test	
			VCP test	
			Delayed recall (WMS-R)	
			Finger-movement tracking test	
			Mental rotation	
			Visual paired associates	
			Letter fluency	
			Drawing copy test	
			Chinese verbal learning	
			Brief Visuospatial Memory Test	
			Word list fluency test	

Abbreviations: ADAS = Alzheimer's Disease Assessment Scale; ADAS-cog = Alzheimer's Disease Assessment Scale cognitive subscale; ADST = Amsterdam Dementia Screening Test; CAMCOG=Cambridge Cognition Examination;CANTAB = Cambridge Neuropsychological Test Automated Battery; COWAT = Controlled Oral Word Association Task; CVFT = Category Verbal Fluency Test; RAVLT = Rey Auditory Verbal Learning Test; RBMT = Rivermead Behavioral Memory Test; RIPA = Ross Information Processing Assessment; RT = reaction time; SOPT = self-ordered pointing test; VCP = Visuospatial Cognitive Performance; VLMT = Verbal Learning and Memory Test; WAIS = Wechsler Adult Intelligence Scale; WMS = Wechsler Memory Scale.

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