The Relation between *g* and Cognitive Speed in a College Sample with Mathematics Difficulties

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Study Results and Implications

- Chronometric (Reaction Time) tasks appear to function similarly in students with math difficulties as they do in the population in general with respect to ***g***.
- Chronometric tasks warrant further study as alternative psychometric measurement tools, since there appears to be no systematic differences in the way chronometric tasks measure ***g*** between the population with math difficulties and the general population.
- With further study, chronometric tasks may (a) provide a more comprehensive understanding of how individuals process various types of information, (b) assess and better understand the underlying processing difficulties in the computing algorithms used by individuals with mathematics difficulties, and (c) provide better data upon which to recommend academic strategies.

Data

Participants were 170 undergraduates with math difficulties who volunteered to participate in this research project. They were given four test batteries: (a) Wechsler Adult Intelligence Scale-III (WAIS-III), (b) the standard battery (minus S*tory Recall*) of the Woodcock-Johnson III Tests of Achievement (WJ-III), (c) Wechsler Memory Scale-III (WMS-III), and (d) selected mental chronometric tasks from the *Cognometer* battery. IQs ranged from 85 to 139, and ages ranged from 18-45 (70% were 24 years old or younger). The variables used were the 12 WAIS-III subtests (excluding *Object Assembly*), 6 WJ-III subtests, 6 WMS-III subtests, and 3 mental chronometric tasks.

Chronometric Tasks

For the purposes of this analysis, three of the eight chronometric tasks were used.

Task 3 (T3), *Cognitive Choice Reaction Time*, requires the participants to learn a response corresponding to a stimulus; then, following the learned response, a rule-changing cue is introduced at random time periods, which alters the type of correct response required. Of the three chronometric tasks, T3 requires the fewest bits of information to process to obtain a correct answer, and thus could be considered the easiest.

Task 4 (T4), *Working Memory Speed and Efficiency*, requires participants to indicate whether a picture matches a descriptive word shown on a nearby computer screen. However, when a rule-altering cue is present, the participant must reverse the answer. This is one of the most complex chronometric tasks, and could be considered the hardest.

Task 7 (T7), *Visual-Spatial Reflexes*, is a variation of Frearson & Eysenck (1986) "Odd Man Out" task. The stimulus consists of three random lights being lit within a semi-circular bank of 8 lights on a nearby computer screen. The participant visually inspects the arrangement of the three lights and then indicates on the response console which light is the farthest away from the other two. This chronometric tasks requires more bits of information processing than T3, but less than T4, so could be considered intermediary in difficulty.

For all tasks, both median reaction time (RT) and the RT variability (SD) were measured.

Method

The general intelligence (***g***; Spearman, 1904) loadings for the psychometric tests battery was extracted using a Principal Axis extraction of the variables' correlation matrix, followed by an orthogonal rotation developed by Schmid and Leiman (1957) that allows for a a single higher-order factor extraction (***g***) as well as lower order factors that are uncorrelated with the higher-order factor. The variables' ***g*** loadings are shown in in Table 1.

Method of Correlated Vectors

The method of correlated vectors (MCV) tests whether ***g***, extracted from a battery of diverse psychometric tests, is related to another variable (e.g., a chronometric task) that is external to the psychometric battery. If the degree to which each test is loaded on ***g*** significantly predicts the relative magnitudes of the various tests' correlations with the chronometric variables, one can conclude that the chronometric task is related to ***g*** (independent of whether or not it is related to other factors or test specificity). The significance level is determined from the rank-order correlation between the elements in the ***g*** vector and the vector of the tests' correlations with the chronometric task (Jensen, 1998). By comparing how the attenuated and disattenuated ***g*** loadings correlate with the chronometric task, one can then tell if the relationship that exists is affected by measurement error. Results from the MCV are shown in Table 2.

Results

From the factor extraction and orthogonal rotation, it was found that ***g*** explains approximately 30% of the variables' total variance—more than any other factor. This extracted ***g*** factor was correlated with 3 chronometric tasks (see Table 2 for coefficients). The results align themselves with ***g*** theory (Jensen, 1998), namely that ***g*** has a significant relationship to both RT and SD of T4 (the most complex chronometric task), a marginally significant relationship to RT and SD of T7(a task of medium complexity), and no significant relationship to the RT or SD of T3 (a relatively non-complex task). None of these relationships were markedly affected by the error embedded in the psychometric tests. What makes these findings novel is that the participants all had math difficulties, yet the data forms the same pattern as with the general population, i.e., the more complex the task, the larger the magnitude of the relationship with ***g*** (Jensen, 1993, 1998). Implications from this study are noted above.

References

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Table 1
g *Loadings Obtained from 25 Psychometric Tasks.*

Variable:	***g***	Rank Order(***g***)	***g'***
WAIS Vocabulary	0.422	20	0.437
WAIS Similarities	0.362	11	0.395
WAIS Digit Span	0.274	4	0.287
WAIS Information	0.310	7	0.323
WAIS Comprehension	0.414	19	0.452
WAIS Letter-Number Sequencing	0.411	17	0.468
WAIS Picture Completion	0.399	15	0.436
WAIS Coding	0.205	3	0.225
WAIS Block Design	0.398	14	0.419
WAIS Matrix Reasoning	0.400	16	0.422
WAIS Picture Arrangement	0.367	12	0.423
WAIS Symbol Search	0.339	8	0.395
WMS Auditory Immediate	0.468	24	0.485
WMS Visual Immediate	0.411	18	0.449
WMS Auditory Delayed	0.458	23	0.491
WMS Visual Delayed	0.426	21	0.464
WMS Auditory Recognition Delayed	0.285	5	0.321
WMS Working Memory	0.476	25	0.510
WJ-III Letter-Word Identification	0.296	6	0.310
WJ-III Passage Comprehension	0.455	22	0.525
WJ-III Reading Fluency	0.349	9	0.365
WJ-III Calculation	0.114	2	0.123
WJ-III Applied Problems	0.349	10	0.362
WJ-III Math Fluency	0.045	1	0.048
WAIS Arithmetic	0.377	13	0.401

Note. Variable names are on left. ***g***: attenuated *g* loadings. ***g'***: disattenuated *g* loadings.

Table 2
Results from the Correlated Vectors Analysis

	WAIS (FSIQ)	WMS (General Memory)	WJ-III (Total Achivement)	***g***	Rank Order (***g***)	***g'***
Chronometric Tasks:						
T3 (RT)	**-0.278***	-0.079	**-0.187***	0.153	0.207	0.1491
T3 (SD)	**-0.199***	-0.01	-0.092	-0.032	-0.138	-0.057
T4 (RT)	**-0.414***	-0.103	**-0.426***	**0.446***	**0.385***	**0.4456***
T4 ln(SD)	**-0.207***	-0.096	**-0.32***	**0.372***	**0.394***	**0.3738***
T7 ln(RT)	**-0.284***	-0.104	-0.136	0.335	0.22	**0.3411***
T7 ln(SD)	**-0.275***	-0.068	-0.097	0.291	0.175	0.2895

Note. *: $p < .10$, $df = 23$ except WAIS, WMS, and WJ-III, where $df = 168$. FSIQ: Full Scale IQ. ***g***: attenuated *g* loadings. ***g'***: disattenuated *g* loadings.