Relationship Between Executive Functioning and Metacognitive Monitoring Following Traumatic Brain Injury

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BACKGROUND

Theoretical models of executive functioning and metacognitive processes have both been described to operate on multiple levels; a higher regulatory process that monitors and controls more basic cognitive processes (Norman & Shallice, 1986; Nelson & Narens, 1994). Evidence from neuroimaging studies also suggest that both processes share a common neural substrate in the frontal lobes. Due to these theoretical and physiological similarities, it has been hypothesized that the two processes may be related.

Frontal lobe injury and deficits in the domains of executive functioning and metacognition have all been observed following traumatic brain injury (TBI). Studies to date have documented a relationship between executive functioning and general self-awareness; however, the majority of findings are based upon subjective self-report inventories. This study examined the specific relationship between executive functioning and metacognitive ability using objective comparisons of retrospective confidence judgments (RCJs) and actual cognitive performance.

Hypotheses:

1. Participants with TBI will perform worse than healthy adults on tasks of executive functioning and metacognition.
2. There is a positive correlation between performance on executive functioning and metacognitive ability.
3. Metamemory and meta-mental flexibility are different domains of metacognition.

METHODOLOGY

PARTICIPANT DEMOGRAPHICS

	N	Age	Years of Education	Time Post Injury
TBI (8 female, 10 male) Average GCS = 5.5	18	33.2 years (SD=13.9)	14.0 years (SD=2.6)	5.4 years (SD=5.4)
Healthy Adults (12 female, 8 male)	20	34.4 years (SD=14.7)	14.9 years (SD=2.3)	--

TESTS ADMINISTERED

Construct Tested	*Neuropsychological Test Used*	*Indices*	
Executive Functioning	Stroop Color Word Test	Switching/inhibition	
	Trailmaking B		
	Verbal Fluency (DKEFS)	Verbal fluency	
Metacognition	Matrix Reasoning from WAIS-III	Meta-mental flexibility	Problem solving
	Shipley's Abstraction		
	Hopkins Verbal Learning Test-R	Metamemory	

- Tests of metacognition were modified by requiring participants to report how confident they were that their answers were correct using a 6-point Likert scale following each item on the task.
- Goodman Kruskal's gamma coefficients were calculated using confidence rating and actual performance. A Fisher's r to z transform was used to convert coefficients into z scores for comparison analyses with executive functioning performance.

RESULTS

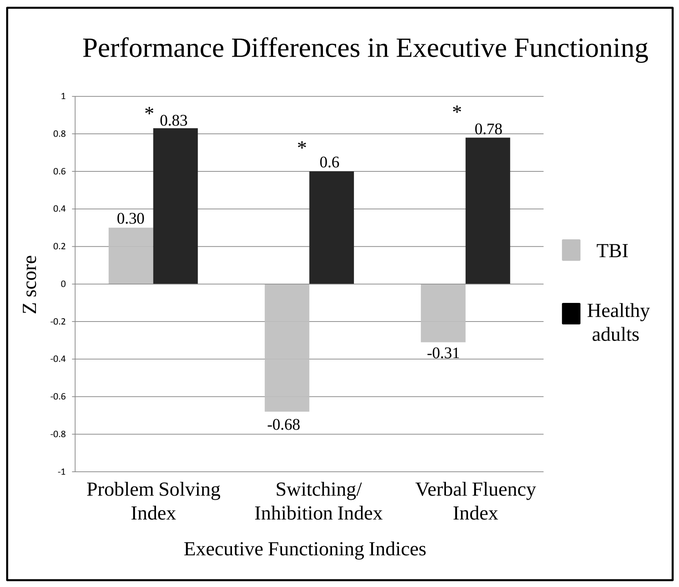

Figure 1. Graph demonstrating performance differences between healthy adults and participants with TBI for the 3 executive functioning indices. * denotes significance at $p \leq 0.005$. Significant differences were found for all 3 indices: problem solving ($t(36)=-3.14$, $p=0.003$), switching ($t(26.4)=-2.81$, $p=0.009$), and verbal fluency ($t(36)=-3.39$, $p=0.002$).

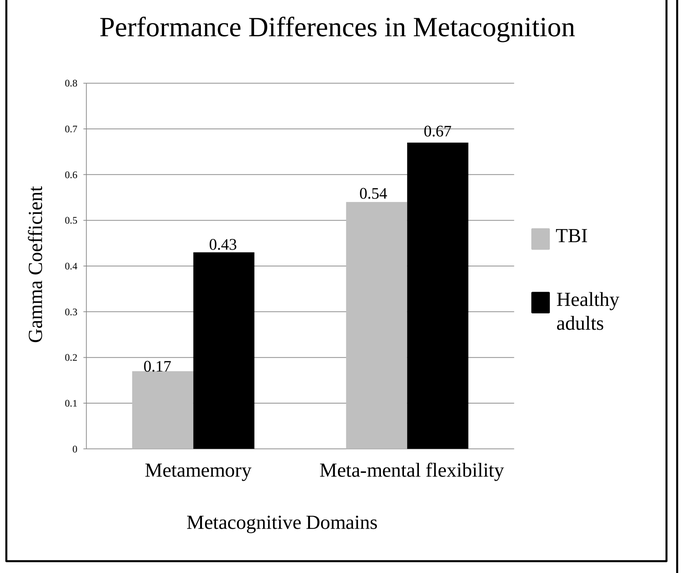

Figure 2. Graph demonstrating difference in metacognitive accuracy between participants with TBI and healthy adults. No statistically significant differences were found in metamemory ($t(36)=-1.44$, $p=0.16$) or meta-mental flexibility ($t(36)=-1.32$, $p=0.21$).

Relationship Between Performance on Executive Functioning and Metacognitive Accuracy

	TBI		Healthy Adults	
	Meta-mental flexibility *r(p)*	Metamemory *r(p)*	Meta-mental flexibility *r(p)*	Metamemory *r(p)*
Problem Solving Index	0.30(0.24)	0.52(0.03)*	0.12(0.61)	-0.47(0.05)*
Switching/Inhibition Index	0.30(0.24)	-0.19(0.44)	-0.20(0.39)	-0.10(0.70)
Verbal Fluency Index	0.29(0.26)	0.05(0.84)	0.03(0.26)	0.12(0.64)

Table 1. Table showing Pearson's correlation coefficients of performance between executive functioning and metacognitive accuracy. *denotes significance for alpha at 0.05 level.

Performance in Different Domains of Metacognition (All participants)

	Mean (Gamma Coefficient)	Standard Deviation	*F* statistic Repeated Measures ANOVA	Correlation *r(p)*
Metamemory	0.31	0.56	$F(1,37)=8.46$, $p=0.006$	-0.26(0.88)
Meta-mental flexibility	0.61	0.31		

Table 2. Table showing performance differences in metamemory and meta-mental flexibility tasks, as well as no significant correlation between the two domains.

CONCLUSIONS

- Findings supported the hypothesis that participants with TBI perform worse than healthy adults on tasks of executive functioning. There was a trend toward lower metacognitive performance in participants with TBI; however, this was not statistically significant. This suggests that this sample of adults with TBI did not experience impairments in metacognitive function following injury.
- A relationship between executive functioning performance and metacognitive ability was found only between metamemory and problem solving. Interestingly, the direction of the relationship differs for participants with TBI and healthy adults. Alternatively, the lack of relationship between executive functioning and metacognition could imply that neural substrates other than the frontal lobes are involved (Chua, Schacter, & Sperling, 2009).
- All participants performed better on tasks of meta-mental flexibility than metamemory; furthermore, there was no correlation between performance in the two domains. This suggests that meta-mental flexibility and metamemory may be different processes.

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