

# Examining the Differential Sensitivity of a Virtual Reality Measure of Executive Functioning in Traumatic Brain Injury



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## Background

- Evidence of mild traumatic brain injury recovery within 1-3 months of injury (Alexander, 1995; Ponsford et al., 2000; Voller et al., 1999)
- Many patients report persistent difficulties in aspects of every day living related to executive dysfunction (Conboy, Barth, & Boll, 1986; Konrad et al., 2011).
- Contradictory findings may reflect a lack of ecological validity, specifically verisimilitude, in traditional tests of executive function (EF)
  - Verisimilitude refers to the degree to which a test resembles a task found in every day life (Franzen & Wilhelm, 1996)
- It was believed that the immersive virtual environment, and relatable task of delivering packages, would provide increased verisimilitude over traditional tests of executive functioning
- The purpose of this study was to compare the ability a virtual reality test of EF– the Virtual Reality Office Task (VROT) – in order to determine its potential in discerning ongoing executive dysfunction in traumatic brain injury patients beyond the expected recovery time

## Hypotheses

- No significant differences will be found between the performance of non-injured control subjects and traumatic brain injury patients on traditional tests of executive function.
- Significant differences will be found between the performance of non-injured control subjects and traumatic brain injury in the VROT.
- The greatest magnitude of difference in performance, as measured by Cohen's *d* effect sizes, between the two groups will be found in the VROT.

## Methods

- 30 healthy control subjects were drawn from the community and a first year undergraduate participant pool
- 5 traumatic brain injury patients past their expected recovery time were drawn from a neuropsychology clinic
- Executive functioning was assessed using a variety of traditional tests
  - Tower of London-Drexel University Second Edition (TOL)
  - 64-card Wisconsin Card Sort Test (WCST-64)
  - Ruff Figural Fluency Test (RFFT)
- Executive functioning was also assessed using the novel VROT
  - Brief virtual reality test modeled on the WCST
  - Subjects deliver a series of poorly labeled packages (45-50) to the correct of four possible doors in an office building
  - Subjects were given feedback (“CORRECT” or “INCORRECT”) for every package delivered
  - No time limit, subjects continue task until all packages are delivered

## Results

### Participants:

- Control → age:  $M = 20.1$ ,  $SD = 5.67$ ; range = 18-49 years
- TBI Patients → age:  $M = 40.0$ ,  $SD = 26.5$ ; range = 20-83 years

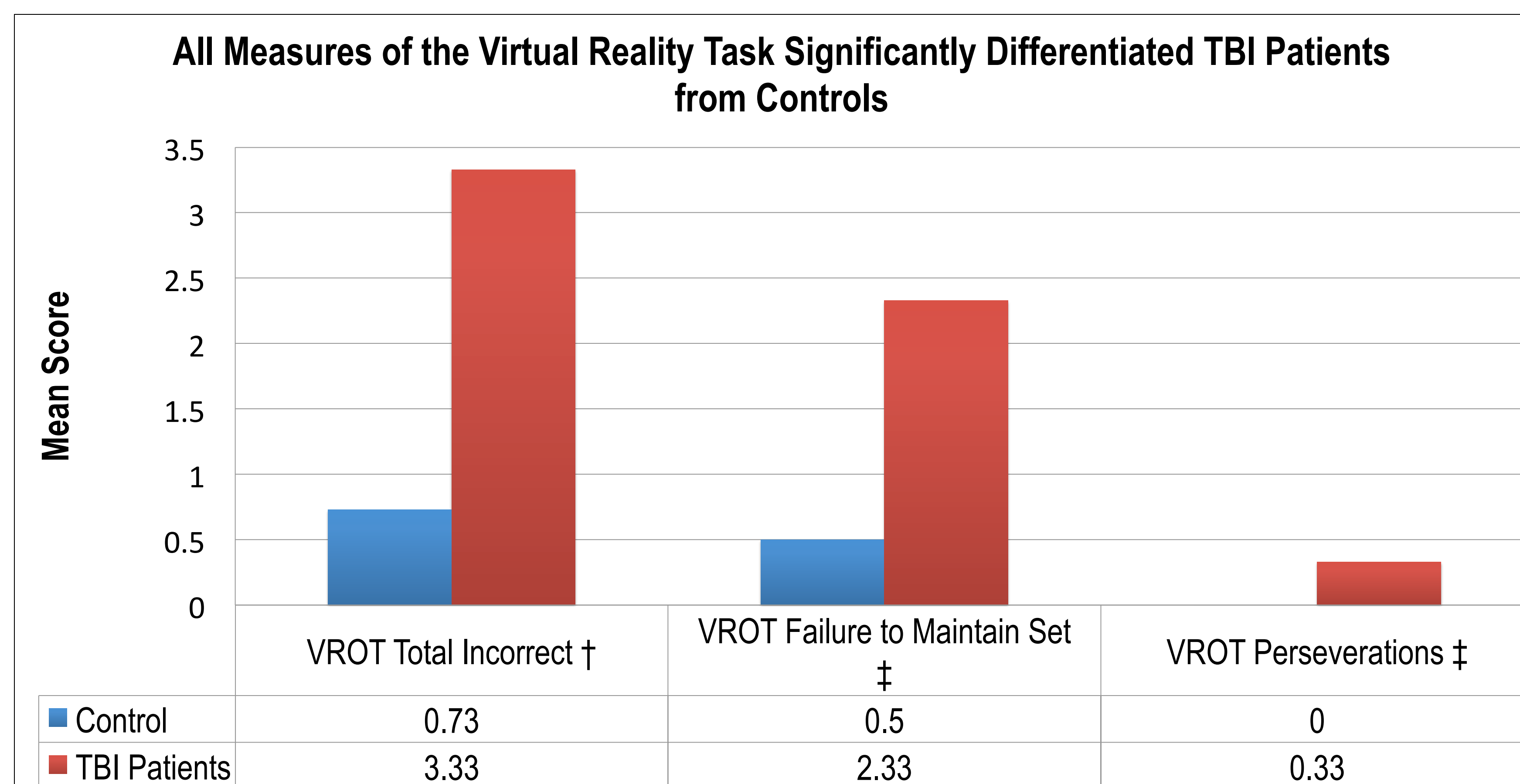
### Hypothesis 1: Performance on Traditional Tests of EF

- The vast majority of traditional tests of EF showed no significant difference
- Exception being the TOL total execution time

Test	Control		TBI		p
	n	M(SD)	n	M(SD)	
<b>WCST</b>					
Number of Errors Z-score	29	0.37(0.98)	4	0.28(0.43)	N.S.
Categories Completed	29	3.69(1.27)	4	4.25(2.22)	N.S.
Trials to First Category	29	13.52(6.28)	4	14.00(4.08)	N.S.
Failure to Maintain Set	29	0.34(0.77)	4	0.50(0.58)	N.S.
<b>RFFT</b>					
Unique Designs Z-score	30	-1.23(1.20)	4	-1.87(0.43)	N.S.
Error Ratio Z-score	30	-0.26(0.91)	4	-0.48(1.04)	N.S.
<b>TOL</b>					
Total Move Z-score	30	-0.12(1.25)	4	-0.73(0.78)	N.S.
Total Correct Z-score	30	-0.02(1.27)	4	-0.58(0.73)	N.S.
Total Initiation Time Z-score	30	0.50(0.83)	4	-0.03(0.52)	N.S.
Total ExecutionTime Z-score	30	-0.02(0.69)	4	-1.10(0.83)	<0.05
Total Time Z-score	30	-0.25(0.68)	4	-0.78(0.50)	N.S.
Number of Time Violations Z-score	30	0.00(0.74)	4	-0.63(0.19)	N.S.
Type 2 Violations Z-score	30	0.13(0.43)	4	0.25(0.50)	N.S.

### Hypothesis 2: Performance on the VROT

- TBI patients significantly underperformed on the VROT in comparison to control subjects



Note. †,  $p < 0.05$ ; ‡,  $p < 0.01$

## Results (continued)

### Hypothesis 3: Magnitude of Performance Difference

- The greatest magnitude of performance difference was found on subject performance of the VROT (Cohen's *d* effect size)

Test	<i>d</i> (min, max)	Overlap %
<b>WCST</b>		
Number of Errors Z-score	0.10 (-2.10, 2.30)	92.3
Categories Completed	0.41 (1, 6)	72.0
Trials to First Category	-0.08 (10, 37)	93.8
Failure to Maintain Set	-0.21 (0, 3)	84.6
<b>RFFT</b>		
Unique Designs Z-Score	0.56 (-3.38, 0.78)	63.7
Error Ratio Z-Score	0.24 (-1.76, 1.36)	82.7
<b>TOL</b>		
Total Move Z-Score	0.50 (-2.40, 1.73)	66.6
Total Correct Z-Score	0.45 (-1.87, 2.13)	69.6
Total Initiation Time Z-Score	0.65 (-0.40, 3.20)	59.4
Total Execution Time Z-Score	1.52 (-2.00, 1.33)	28.8
Total Time Z-Score	0.79 (-2.00, 0.80)	53.0
Number of Time Violations Z-Score	0.89 (-2.13, 0.53)	48.8
Type 2 Violations Z-Score	-0.27 (0, 2)	80.7
<b>VROT</b>		
Total Incorrect	-2.33 (0, 6)	13.9
Failure to Maintain Set	-2.54 (0, 3)	11.4
Perseverations	-2.25 (0, 1)	15.0

## Implications & Limitations

- Virtual reality testing offers an ecologically valid method through which neuropsychologists can investigate cognitive dysfunction from the convenience of the clinic
- The VROT is an ecologically valid tool that has the potential to assess the presence of persistent executive dysfunction, otherwise undetected by traditional neuropsychological measures
- Further study is required in order to increase sample size, develop normative data for the VROT, and better assess its ecological validity in terms of patient ability to function in the real world

## References

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