



# Research Report

## A Two-Factor Theory for Concussion Assessment Using ImPACT: Memory and Speed.

Authors: Phillip Schatz and Arthur Maerlender

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### Overview

This paper investigates two new factor scores for the ImPACT Neurocognitive test battery and demonstrates the reliability and validity of the test for middle school, high school and collegiate athletes. The two-factor structure yields improved test-retest reliability with no loss of sensitivity/specificity and improves the interpretability of test results.

### Research Purpose

ImPACT has become the most widely used neurocognitive test for the management of concussion. ImPACT currently provides a number of subscale scores as well as five composite or summary scores that were originally developed to increase the clinical utility of the test battery in making decisions regarding cognitive processes following concussion. Although multiple peer-reviewed research studies have demonstrated both the reliability and validity of the composite scores, these scores may be difficult to interpret when there is not uniformity in the scores. For instance, following concussion, one of the scores may improve (due to practice or other effects), while other scores may decline in a particular athlete.

The two-factor theory was developed and validated to increase the interpretability of ImPACT in terms of the major two attributes of the test battery: its ability to measure cognitive speed and important components of memory. The factor scores are constructed not to substitute for the original composite scores, but to supplement the composite scores.

### Methodology and Results

This research conducted a confirmatory factor analysis on both large baseline and post-injury samples of middle school, high school and collegiate athletes utilizing the composite scores (Verbal Memory, Visual Memory, Processing Speed and Reaction Time). The factor analysis was designed to evaluate a three factor structure consisting of Memory, Speed and a self-reported Symptoms factor. As anticipated, Verbal Memory, and Visual Memory formed a unique “Memory” factor and Visual Motor Speed and Reaction time formed a “Speed” score. For the baseline sample, the factor analysis accounted for 72.5 percent of the variance and for the concussion sample and the factor analysis accounted for 78.8 percent of the variance. The results of the factor analysis are provided below:

### Reliability of the Two-Factor Model:

Once the initial factor analyses were completed, the model examined test-retest reliability in one-month, one-year and two-year samples. Test-retest reliability scores were high for all three samples, ranging from .76 to .81 for Memory and .76 to .88 for the Speed factor. This research demonstrated that combining the results of the composite scores into Memory and Speed factors actually improved reliability over prior studies that have investigated the reliability of ImPACT.

### Sensitivity and Specificity of the Two-Factor Model:

In addition to evaluating the reliability of the new Speed and Memory scores, this study also evaluated the ability to correctly classify concussed athletes statistically using the factors (sensitivity) and the ability of the factors to correctly classify non-concussed athletes (specificity). The sensitivity of the two factor model was 89 percent. In other words, based on statistical analyses only, the two factors were able to correctly classify 89 percent of the concussed sample. The specificity was 70 percent. It should be kept in mind that these numbers reflect statistically based decisions only and not decisions made by trained health care providers, which would clearly result in even higher accuracy.

### Implications of Findings

The evaluation of recovery from concussion can be difficult under the best of circumstances. It is well-known that athletes are often not able or willing to accurately report symptoms after concussion and may actually hide symptoms from coaches, parents and health care providers. In addition, the interpretation of cognitive performance can be challenging. An athlete may have specific deficits in a specific area of functioning while performing normally in other areas of functioning. The development of the two-factor model provides an

### Factor analysis results

Composite	Baseline Sample*		Concussion Sample**	
	Factor 1	Factor 2	Factor 1	Factor 2
Verbal Memory	.120	<b>.824</b>	<b>.876</b>	.212
Visual Memory	.143	<b>.808</b>	<b>.823</b>	.307
Visual Motor Speed	<b>.831</b>	.231	.183	<b>.893</b>
Reaction Time	<b>-.887</b>	-.062	-.362	<b>-.772</b>

\* Baseline sample: N= 21,357

\*\* Concussion sample: N=560

additional and valid/reliable way of evaluating neurocognitive performance. It is the belief of the authors that the addition of these Speed and Memory scores will “improve the understanding and communicability of baseline and post-concussion test results for clinicians, athletes, sports medicine professional, parents and coaches.”

### ImPACT Research Studies Published in 2013.

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### ImPACT Commitment to Ongoing Research

ImPACT encourages independent, academically based research and is proud to present the listing below of peer-reviewed papers that were published in 2013. In the coming year, ImPACT will continue to encourage research regarding the ImPACT program and on concussion management in general.