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# The Wechsler Adult Intelligence Scale–III and Malingering in Traumatic Brain Injury

## Classification Accuracy in Known Groups

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A known-groups design was used to determine the classification accuracy of Wechsler Adult Intelligence Scale–III (WAIS-III) variables in detecting malingered neurocognitive dysfunction (MND) in traumatic brain injury (TBI). TBI patients were classified into the following groups: (a) mild TBI not-MND ($n$ = 26), (b) mild TBI MND ($n$ = 31), and (c) moderate/severe (M/S) TBI not-MND ($n$ = 26). A sample of 80 general clinical patients was used for comparison. Verbal IQ, Verbal Comprehension Index, and Working Memory Index detected approximately 25% of malingerers with a false positive (FP) error rate of approximately 5% in the mild TBI group. Comparable FP rates were obtained in M/S TBI. FP rates for Performance IQ, Perceptual Organization Index, and Processing Speed Index were acceptable in mild TBI but too high in M/S TBI. Previously studied specialized indicators (Vocabulary minus Digit Span and the Mittenberg formula) failed to differentiate malingerers from nonmalingerers. The clinical application of these findings is discussed.

***Keywords:*** *Wechsler Adult Intelligence Scale; malingering; traumatic brain injury; effort; classification accuracy; known groups*

The Wechsler Adult Intelligence Scale, currently in its third edition (WAIS-III; Wechsler, 1997a), is the most used neuropsychological measure of intellectual functioning (Rabin, Barr, & Burton, 2005) and is often used to assess deficits following brain trauma (Lezak, Howieson, & Loring, 2004; Millis, Ross, & Ricker, 1998). Research has shown a dose–response relationship between intellectual impairment and the severity of the brain injury sustained (Dikmen et al., 1994; Dikmen, Machamer, Winn, & Temkin, 1995; Rohling, Meyers, & Millis, 2003; Schretlen & Shapiro, 2003). In mild traumatic brain injury (TBI), return to preinjury levels of functioning is expected within months, and persisting neuropsychological impairments are uncommon (Alexander, 1995; Binder, Rohling, & Larrabee, 1997; Carroll et al., 2004). Nonetheless, some individuals do exhibit persisting deficits (Alexander, 1995; Binder et al., 1997). In these cases, alternate explanations for persistent symptomatology must be considered (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Bianchini, Curtis, & Greve, 2006; Binder et al., 1997; Greve, Bianchini, Mathias, Houston, & Crouch, 2003; Carroll et al., 2004; Mittenberg, Theroux-Fichera, Zielinski, & Heilbronner, 1995).

In a recent meta-analysis, Belanger et al. (2005) identified litigation and malingering as the primary factors associated with persisting cognitive deficits in mild TBI. Malingering is a significant issue in the neuropsychological assessment of TBI, occurring in as many as 40% of cases with financial incentives (Larrabee, 2003; Mittenberg, Patton, Canyock, & Condit, 2002) and accounting for more variance in test scores than injury severity itself (Green & Iverson, 1998, 2001; Green, Rohling, Iverson, & Gervais,

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2003). The assessment of response/performance validity and malingering is now considered an essential element of any neuropsychological assessment of cases in litigation or that might reasonably be expected to become litigated (American Academy of Clinical Neuropsychology, 2007; Bush et al., 2005; Iverson, 2005). The past 20 years have seen extensive development of methods to detect malingering (see Boone, 2007, and Larrabee, 2007, for an extensive review of these methods). Because of ubiquitous use in neuropsychological assessment, the clinical utility of malingering indicators derived from both the WAIS-R and WAIS-III has been extensively studied.

Approaches to studying and detecting malingering on the WAIS include the following: (a) group comparisons of IQ, index, and individual standardized subtest scores in various clinical populations (Etherton, Bianchini, Ciota, Heinly, & Greve, 2006; Etherton, Bianchini, Heinly, & Greve, 2006; Iverson & Tulsky, 2003; Johnstone & Cooke, 2003; Langeluddecke & Lucas, 2003; Loring, Lee, & Meador, 2005; Trueblood, 1994); (b) examination of discrepancy scores between predicted and obtained IQ scores (Demakis et al., 2001; Greve, Lotz, & Bianchini, 2008; Trueblood, 1994); (c) examining difference scores between age-corrected scaled scores on certain subtests, specifically Vocabulary and Digit Span (Iverson & Tulsky, 2003; Miller, Ryan, Carruthers, & Cluff, 2004; Mittenberg et al., 1995; Mittenberg et al., 2001); and (d) developing and analyzing discriminant function equations aimed directly at differentiating malingered from nonmalingered cognitive performance (Mittenberg et al., 1995; Mittenberg et al., 2001).

Two approaches, in particular, have been extensively studied: the Vocabulary minus Digit Span (VDS) score and the Mittenberg formula. Since their development, the efficacy of VDS and the Mittenberg formula in detecting malingering has been primarily examined using simulation designs (Demakis, 2004; Mittenberg et al., 1995; Mittenberg et al., 2001), although studies using clinical populations also exist (Axelrod & Rawlings, 1999; Miller, Ryan, Carruthers, & Cluff, 2004; Mittenberg et al., 2001; Williams & Carlin, 1999). Despite fairly consistent results regarding the accuracy of VDS and the Mittenberg formula to differentiate malingerers from nonmalingerers, these studies are limited by their use of simulators and/or small samples of simulators and clinical patients.

Although simulator designs have been shown to be useful in determining whether a variable would be efficacious in malingering detection, there has been criticism regarding the generalizability of simulator data to that seen in actual clinical patients with external incentive to perform poorly (Demakis, 2004; Greve et al., 2003; Millis et al., 1998). Furthermore, many of the existing studies did not use criteria that adequately defined malingering. Greve and Bianchini (2004) emphasized the importance of studying malingering indicators using well-defined known-groups methodology and, if possible, including a variety of nonmalingering clinical patients to establish the limits of specificity. The application of the "known-groups" methodology was facilitated by the publication of criteria for the diagnosis of malingered neurocognitive dysfunction (MND; Slick, Sherman, & Iverson, 1999), which were substantially built on the research criteria developed by Greiffenstein, Baker, and Gola (1994). These criteria can be used to establish a "known" malingering group and can facilitate the creation of a likely nonmalingering control group.

In one of the first true known-groups studies using the WAIS-R, Trueblood (1994) examined the performance of three groups of mild TBI patients (malingerers, patients with "questionable validity" performance, and a control group). Overall, both the malingering and "questionable validity" groups scored lower on IQ and subtest standard scores compared with their matched controls, with the malingering group scoring the lowest. In another known-groups study, this time examining VDS and the Mittenberg formula, Millis et al. (1998) found that 72% and 88% of incentivized mild TBI patients had performance suggestive of malingering on the VDS and Mittenberg formula, respectively. Greve et al. (2003) conducted one of the first studies using well-defined known-groups methodology in their examination of malingered performance, with several cutoffs for both the VDS and Mittenberg formulas using both the WAIS-R and WAIS-III. Whereas specificity associated with two Mittenberg formula cutoffs (using the WAIS-III) was higher in the mild group (100% at both cutoffs), sensitivity was better for the moderate/severe (M/S) TBI group (67% at both cutoffs) than it was for the mild TBI group at both cutoffs (57%). For WAIS-III VDS, using a cutoff of two resulted in the best sensitivity for both injury severity levels (36% for mild TBI and 50% for M/S TBI) compared with the other cutoffs with corresponding specificities of ≥69%.

In terms of WAIS-III index scores, research examining the accuracy of these scores in malingering detection has shown promise in chronic pain populations using known-groups methodology (Etherton,

Bianchini, Ciota, et al., 2006; Etherton, Bianchini, Heinly, et al., 2006). In a multipart study conducted by Etherton, Bianchini, Ciota, et al. (2006), performance on the WAIS-III Working Memory Index (WMI) was compared between three groups of healthy college students (control, cold-pressor induced pain, and pain simulator conditions), chronic pain, and neurological patients. The lowest scores were observed in the simulator group and malingering clinical pain patients. Similar findings were observed by Etherton, Bianchini, Heinly, et al. (2006) examining the effectiveness of the Processing Speed Index (PSI) of the WAIS-III in malingering detection using the same experimental design.

Therefore, the purpose of this study was twofold. First, classification accuracy of VDS and the Mittenberg formula were examined in a well-defined TBI sample such as that used in Greve et al. (2003). Second, performance on the WAIS-III IQ and index scores was examined to identify patterns that may exist that contribute to the differentiation of malingerers from nonmalingerers. If shown to be just as, or more accurate than, complex discriminant formulas at differentiating malingering from nonmalingering performance, it may be more clinically practical to use these index scores.

To accomplish these goals, the classification accuracy of VDS, the Mittenberg formula, and IQ and index scores from the WAIS-III were examined using a known-groups design in a sample of TBI and general clinical patients. Specifically, this study extends the existing literature in a number of ways: (a) classification accuracy data are provided for a broad range of scores rather than preselected cutoffs; (b) clinically diagnosed malingering TBI patients rather than simulators are used; (c) malingering is operationalized using the Slick et al. (1999) criteria (a description of this classification system is described in the Method section); (d) data for a large sample of general clinical patients without incentive are included to provide information on the effects of different conditions to further clarify issues related to specificity. The results are presented in cumulative frequency tables that can be easily referenced in clinical practice.

## Method

### Participants

*Traumatic brain injury.* Patients in this group were drawn from a cohort of 233 persons who were referred to a southeastern neuropsychological practice for a neuropsychological evaluation after suffering an apparent TBI. To avoid confounding educational factors and ensure clinically useful comparisons, patients were excluded from the study if they had less than 8 or more than 14 years of education or if their malingering status could not be reliably determined. Altogether, 94 TBI patients met these criteria for inclusion. However, because there were so few M/S TBI malingerers ($n$ = 11), these patients were also excluded, resulting in a TBI sample of 83 patients. These patients were referred by physicians ($n$ = 33, 39.8%), case managers ($n$ = 22, 26.5%), and attorneys ($n$ = 18, 33.7%).

Patients were considered to have suffered a mild TBI if they met the criteria set by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine (1993): (a) posttraumatic amnesia not greater than 24 hours; (b) after 30 minutes, an initial Glasgow Coma Scale of 13 to 15; (c) loss of consciousness (LOC) of approximately 30 minutes or less. Any patient who did not meet all the mild TBI criteria and/or who had positive neuroradiological findings (e.g., skull fracture, hemorrhage, hematoma) or focal neurological signs was coded as M/S TBI for purposes of the study.

The mild TBI criteria were used in this study to separate mild from M/S cases, not to determine if a patient actually experienced a TBI. For purposes of this study, a patient was placed in the TBI group if they presented with or claimed to have had a head injury. They were then classified as M/S, if appropriate, as described above. The details of their head injury claim were examined as part of the malingering classification process (see below). Thus, the mild TBI group contained only persons who clearly had no worse than a mild TBI and might have had no TBI. Altogether, 57 patients were placed into the mild TBI group, and 26 were classified as M/S TBI patients. See Table 1 for the demographic and injury-related characteristics of the TBI groups.

*General clinical sample.* This group consisted of 80 patients (meeting the same education criteria as the TBI patients) with a variety of neurological and psychiatric diagnoses who were seen in the course of general neuropsychological practice. A majority of the patients had either suffered cerebrovascular accident (CVA; $n$ = 27) or were independently diagnosed with a memory disorder ($n$ = 28) associated with a progressive neurological condition. Clinical patients were excluded if they were seen in a compensation-seeking

**Table 1**
**Descriptive Characteristics of the Current Sample by Clinical Diagnosis and Malingering Status**

| | Sample Size | | Age | | Education | | Gender | Months Since Injury | |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | Percentage | *M* | *SD* | *M* | *SD* | Percentage Female | *M* | *SD* |
| Diagnoses | | | | | | | | | |
| Mild TBI Not MND | 26 | 31.3 | 38.6 | 13.6[a] | 12.0 | 1.3 | 26.9 | 13.4 | 14.4 |
| Mild TBI MND | 31 | 37.3 | 42.4 | 10.3[a] | 11.7 | 1.6 | 38.7 | 24.4 | 21.4 |
| M/S TBI Not MND | 26 | 31.3 | 30.2 | 11.8[b] | 11.6 | 1.2 | 15.4 | 18.2 | 32.3 |
| Total TBI | 83 | 100.0 | 37.4 | 12.8 | 11.7 | 1.4 | 27.7 | 18.9 | 23.9 |
| Other diagnoses | | | | | | | | | |
| Stroke (CVA) | 27 | 33.8 | 57.3 | 14.6 | 12.8 | 1.3 | 51.9 | | |
| Memory disorder | 28 | 35.0 | 69.4 | 9.6 | 12.3 | 1.1 | 60.7 | | |
| Substance abuse | 1 | 1.3 | 46.0 | — | 13.0 | — | 100.0 | | |
| Encephalopathy | 4 | 5.0 | 50.8 | 5.0 | 11.3 | 1.5 | 0.0 | | |
| Infection | 5 | 6.3 | 57.0 | 23.6 | 11.8 | 1.3 | 40.0 | | |
| Multiple sclerosis | 1 | 1.3 | 44.0 | — | 13.0 | — | 100.0 | | |
| Psychiatric | 8 | 10.0 | 45.6 | 23.3 | 12.4 | 1.6 | 50.0 | | |
| Seizure | 3 | 3.8 | 40.7 | 15.0 | 13.0 | 1.0 | 33.3 | | |
| Tumor | 3 | 3.8 | 63.0 | 6.2 | 12.0 | 0.0 | 33.3 | | |
| Total other | 80 | 100.0 | 59.3 | 16.3 | 12.4 | 1.2 | 51.3 | | |

Note: *SD* = standard deviation; TBI = traumatic brain injury; M/S = moderate/severe; CVA = cerebrovascular accident. ANOVA for age showed that the mild TBI patients were significantly older than M/S TBI patients ($F(2, 80) = 7.6$; $p < .01$). Months since injury could not be found for four patients in the total TBI sample (mild TBI $n = 3$; M/S TBI $n = 1$).
a, b. Column means with the same letter are not significantly different from each other.

context. See Table 1 for the diagnostic breakdown and demographic characteristics of this sample.

## Malingering Classification

Patients were categorized on the basis of Slick et al. (1999) criteria for MND using a diagnostic decision tree such as that presented by Millis (2004). In determining the presence of MND, the case must be evaluated on the basis of four criteria: (a) presence of substantial external incentive, (b) evidence from neuropsychological testing (Criteria B1 through B6), (c) evidence from self-report (Criteria C1 through C5), and (d) behaviors meeting the necessary B and C criteria that are not fully accounted for by psychiatric, neurological, or developmental factors. This criterion means that malingering cannot be ruled out unless it can be reasonably demonstrated that positive B and/or C criteria are "fully" accounted for by psychological or neurological disturbance and are not at all motivated by any identifiable external incentives. Using this system, all diagnoses of malingering require the presence of external incentive (Criterion A) plus Criterion B and/or C evidence as noted below. For the purposes of this study, only B1, B2, and C5 criteria were used for malingering group classifications as these criteria consist of indicators specifically designed to detect malingering (Ord, Greve, & Bianchini, 2008).

The most powerful Criterion B evidence is documentation of a negative response bias on the basis of performance on a "forced-choice" symptom validity test (SVT; e.g., Portland Digit Recognition Test [PDRT] or Test of Memory Malingering [TOMM]; see Bianchini, Mathias, & Greve, 2001, for others). Performance on a forced-choice measure can indicate either "definite" response bias (B1: obtained score is significantly below chance at $\alpha < .05$, two-tailed) or "probable" response bias (B2: obtained score on a well-validated measure of response bias is in a range consistent with exaggeration or feigning). Other malingering tests and indices from standard clinical measures can also meet B2. Criterion B2 could be met on the basis of a positive finding on either the PDRT (Binder, 1993) or TOMM (Tombaugh, 1996), or by two or more positive findings on well-validated clinical indicators. Clinical indicators used in this study included the Millis formula from the California

**Table 2**
**Cutoffs for Tests and Indicators Used to Meet Criteria B2 and C5**

| Indicator/Test | Cutoff | Reference for cutoff |
|---|---|---|
| Criterion B2 | | |
| Portland Digit Recognition Test | | |
| Easy | <19 | Binder (1993) |
| Hard | <18 | |
| Total | <39 | |
| Test of Memory Malingering | | |
| Trial 2, retention | <45 | Tombaugh (1996) |
| California Verbal Learning Test | | |
| Millis formula | <0 | Millis, Putnam, Adams, and Ricker (1995) |
| Wisconsin Card Sorting Test | | |
| Suhr formula | >3.68 | Greve, Bianchini, Mathias, Houston, and Crouch (2002) |
| Unique responses | >1 | |
| Criterion C5 | | |
| Minnesota Multiphasic Personality Inventory–2 | | |
| F, Fb | >80 | Greve, Bianchini, Love, Brennan, and Heinly (2006) |
| Fp | >75 | |
| FBS | >27 | |
| DS-r | >70 | |
| F-K | >5 | |
| O-S | >140 | |
| Meyers index | >5 | |
| ES | <20 | |

Note: All cutoffs used in the current study for the Portland Digit Recognition Test were derived from Binder (1993). All cutoffs used in the current study for the Wisconsin Card Sorting Test indicators (Suhr formula and unique responses) were derived from the Greve et al. (2002) study. All cutoffs used in the current study for Minnesota Multiphasic Personality Inventory–2 indicators were derived from the Greve et al. (2006) study.

Verbal Learning Test (Millis, Putnam, Adams, & Ricker, 1995) and the Suhr formula (Suhr & Boyer, 1999) and Unique responses (Greve, Bianchini, Mathias, Houston, & Crouch, 2002) from the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993).

Criterion C5 includes evidence of exaggeration or fabrication of psychological symptoms on self-report measures with well-validated validity scales (e.g., Minnesota Multiphasic Personality Inventory–2 [MMPI-2]; Butcher, Dahlstrom, Graham, Tellegren, & Kaemmer, 1989). Criterion C5 was considered positive if any MMPI-2 validity scale scores were greater than the score associated with a 5% FP error rate for all TBI patients reported by Greve, Bianchini, Love, Brennan, and Heinly (2006). See Table 2 for the specific cutoffs related to these indicators. For obvious reasons, WAIS-III indicators (Greiffenstein et al., 1994; Mittenberg et al., 1995) were not used for group assignment in this study.

In the context of external incentives, a B1 finding is sufficient for a diagnosis of "definite MND." A diagnosis of "probable MND" can be made with two types of Criterion B evidence or one type of Criterion B evidence and one or more types of Criterion C evidence. Criterion C evidence is not sufficient for a diagnosis in the absence of Criterion B evidence.

Based on the above-described classification system, the TBI sample was divided into three groups. The first group, the mild TBI not-MND group ($n$ = 26), consisted of mild TBI patients with no incentive to malinger (i.e., no evidence of external incentive making them negative on Criterion A; $n$ = 3) along with patients who had incentive but showed no evidence of suspect effort or malingering (i.e., negative on all B and C criteria; $n$ = 23). These incentive-only patients had to have completed at least one forced-choice SVT and the MMPI-2 to be included in the not-MND group. They also had to be negative on all available indicators, including the MMPI and SVT. The second group, the mild TBI MND group ($n$ = 31), consisted of patients meeting Slick et al. (1999) criteria for probable MND ($n$ = 26) and definite MND ($n$ = 5). The third group, M/S TBI not-MND group ($n$ = 26), was included to serve as a comparison group. This group met the same criteria as the not-MND mild TBI group.

## Procedure and Variables

The WAIS-III (Wechsler, 1997a) was administered by experienced psychometrists as part of a comprehensive neuropsychological evaluation using a flexible battery approach with a consistent core battery of tests that are supplemented based on the presenting complaint and referral question. As a result, not all patients completed exactly the same set of tests. Indicators examined in this study included those previously examined in the malingering research (e.g., VDS and the Mittenberg formula) as well as the standard IQ and index scores: Verbal IQ (VIQ), Performance IQ (PIQ), Full Scale IQ (FSIQ), Verbal Comprehension Index (VCI), Perceptual Organization Index (POI), WMI, and the PSI.

## Statistical Analyses

Analysis of these data proceeded in the following manner. Preliminary analyses examined group effects on demographic variables. The primary analyses of the ability of the WAIS-III variables to differentiate between malingerers and nonmalingerers was conducted in the following ways. First, analyses of variance (ANOVA) were conducted to examine mean group differences on the WAIS-III variables. However, although ANOVAs provide information regarding how the groups differ in terms of their mean scores, they do not provide a direct indication as to how well the variables distinguish malingerers from nonmalingerers. Therefore, receiver operating curve (ROC) analyses were conducted between (a) the malingering and nonmalingering mild TBI sample and (b) the malingering sample and the combined nonmalingering patients. The ROC analysis does not provide information regarding how well the variables work at specific cutoffs. Therefore, the classification accuracy (described in terms of sensitivity, false positive [FP] error rate, and likelihood ratios [LRs]) at specific cutoffs is reported in tabular form. Finally, individuals in the nonmalingering groups who scored at the 5% FP error rates were examined to ensure that they had been appropriately classified.

# Results

## Sample Characteristics

Using only the TBI sample, a series of ANOVAs were conducted comparing differences on demographic and injury-related characteristics. In terms of age, both mild TBI patient groups were significantly older than M/S TBI patients. There were no significant differences in education or months between injury and evaluation. Months between injury and evaluation was not indicated for four (4.8%) patients. In terms of gender, there were significantly more males than females in the sample ($\chi^2[1] = 16.5$, $p < .001$), but the proportion of men to women within each TBI group did not statistically differ ($\chi^2[2] = 3.9$, $p >$ ns). In terms of ethnic composition of the sample, there were significantly more Caucasian patients than other races ($\chi^2[3] = 71.6$, $p < .001$); however, there was no significant difference between the groups as regards the proportions of Caucasian, African American, or Hispanic individuals ($\chi^2[6] = 11.6$, $p >$ ns). Results of these analyses are presented in Table 1.

## WAIS-III Score Group Analyses

The two malingering indicators, IQ, and index scores were submitted to a series of univariate ANOVAs to examine group differences. The means and standard deviations for the mild TBI, M/S TBI, and clinical groups as well as the ANOVA results are presented in Table 3. Using a Bonferroni-adjusted alpha level of .006 (.05/9), the IQ and index scores were found to be statistically significant, with 30% to 39% of the variance in the scores accounted for by group membership. The mild TBI MND group scored significantly lower on VIQ, FSIQ, VCI, and WMI compared with all other groups. On the other hand, this same group did not differ from the M/S TBI and clinical patients on PIQ, POI, and PSI. For the most part, the mild TBI not-MND group scored significantly higher than the three groups on these same indices. No group differences were observed for either of the malingering indicators.

## Receiver Operating Curve Analysis

An ROC analysis examines the overall classification accuracy of a test and reflects the degree to which malingerers are differentiated from nonmalingerers at all possible score levels. Table 4 presents areas under the curve (AUCs), standard errors, and 95% confidence intervals (CI) for the mild TBI not-MND sample compared with the mild TBI MND group as well as a comparison of the mild TBI MND group with the entire nonmalingering sample. In the mild TBI sample, the AUCs for the WAIS-III IQ and index scores ranged from .73 (acceptable discriminability; Hosmer & Lemeshow, 2000) to .80 (excellent discriminability). In the second comparison, the AUCs were comparable with those obtained in the first comparison for VIQ and

**Table 3**
**Comparison of Mean Wechsler Adult Intelligence Scale-III Scores by Malingering Status and Clinical Group**

| | Mild TBI Not MND | | Mild TBI MND | | M/S TBI Not MND | | General Clinical | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* | Mean | *SD* | *F* | *p*[c] | $\eta^2$ |
| Vocabulary minus digit span | –1.3 | 3.4 | –0.6 | 2.9 | –1.6 | 2.8 | –0.4 | 2.9 | 1.4 | ns | .03 |
| Mittenberg formula | –0.8 | 1.0 | –0.3 | 0.8 | –1.1 | 1.1 | –0.5 | 0.9 | 4.0 | ns | .07 |
| Verbal IQ | 91.5 | 14.6[a] | 77.9 | 12.7[b] | 91.5 | 10.0[a] | 89.2 | 13.0[a] | 8.0 | <.001 | .13 |
| Performance IQ | 95.7 | 17.1[a] | 80.2 | 14.0[b] | 86.6 | 14.1[b] | 87.1 | 15.4[b] | 5.2 | .002 | .09 |
| Full Scale IQ | 92.9 | 16.1[a] | 77.0 | 13.5[b] | 88.5 | 11.7[a] | 87.3 | 13.2[a] | 7.2 | <.001 | .12 |
| Verbal Comprehension Index | 91.1 | 15.0[a] | 78.9 | 13.9[b] | 91.1 | 9.6[a] | 90.4 | 13.9[a] | 6.4 | <.001 | .11 |
| Perceptual Organization Index | 99.5 | 17.1[a] | 83.5 | 15.8[b] | 92.2 | 14.1[ab] | 90.0 | 15.6[ab] | 5.0 | .002 | .09 |
| Working Memory Index | 95.5 | 16.7[a] | 78.0 | 12.6[b] | 94.1 | 13.0[a] | 87.8 | 14.4[a] | 9.0 | <.001 | .15 |
| Processing Speed Index | 88.6 | 13.1[a] | 75.5 | 11.5[b] | 79.8 | 12.6[b] | 82.4 | 13.4[ab] | 5.1 | .002 | .09 |

Note. TBI = traumatic brain injury; MND = malingered neurocognitive dysfunction; M/S = moderate/severe; *SD* = standard deviation.
a, b. Row means with the same letter are not significantly different from each other.
c. Significance based on Bonferroni adjustment (.05/9 = .006).

**Table 4**
**Receiver Operating Curve Analysis for Each WAIS-III Score Comparing the Mild TBI MND Sample With the Nonmalingering Sample**

| | | | | 95% CI | |
|---|---|---|---|---|---|
| WAIS-III Variable | Area Under the Curve | Standard Error | *p* | Lower Bound | Upper Bound |
| Mild TBI not MND versus mild TBI MND comparison | | | | | |
| VDS | .57 | .08 | ns | .42 | .73 |
| Mittenberg formula | .67 | .07 | .03 | .53 | .81 |
| VIQ | .75 | .07 | .001 | .63 | .88 |
| PIQ | .79 | .06 | .000 | .67 | .91 |
| FSIQ | .78 | .06 | .000 | .66 | .90 |
| VCI | .73 | .07 | .004 | .59 | .86 |
| POI | .77 | .06 | .001 | .65 | .89 |
| WMI | .80 | .06 | .000 | .69 | .92 |
| PSI | .78 | .06 | .000 | .66 | .90 |
| Mild TBI MND versus all not MND (mild not MND, M/S not MND, clinical) | | | | | |
| VDS | .51 | .06 | NS | .39 | .62 |
| Mittenberg formula | .60 | .05 | NS | .49 | .70 |
| VIQ | .76 | .05 | .000 | .66 | .85 |
| PIQ | .69 | .06 | .001 | .58 | .80 |
| FSIQ | .74 | .05 | .000 | .64 | .84 |
| VCI | .74 | .05 | .000 | .64 | .84 |
| POI | .68 | .06 | .002 | .57 | .79 |
| WMI | .75 | .05 | .000 | .65 | .84 |
| PSI | .68 | .06 | .003 | .57 | .78 |

Note: WAIS-III = Wechsler Adult Intelligence Scale–III; CI = confidence interval; TBI = traumatic brain injury; MND = malingered neurocognitive dysfunction; M/S = moderate/severe; VDS = Vocabulary minus Digit Span; VIQ = Verbal IQ; PIQ = Performance IQ; FSIQ = Full Scale IQ; VCI = Verbal Comprehension Index; POI = Perceptual Organization Index; WMI = Working Memory Index; PSI = Processing Speed Index.

index scores; however, discriminability was markedly lower for nonverbal IQ and index scores. VDS and the Mittenberg formula failed to differentiate malingerers from nonmalingerers in both the comparisons.

## Classification Accuracy

The ROC analysis is a good way to compare overall classification accuracy of diagnostic tests. However, it does not address the accuracy of the tests at specific cutoffs. Even when overall classification accuracy is equal, the choice of cutoffs will have an important impact on the resulting type of classification error. This section, therefore, examines the classification accuracy of the WAIS-III variables at a range of cutoffs.

Table 5 provides the FP error rates, sensitivity, and LRs (sensitivity/FP error rate) across a range of score levels for the WAIS-III variables. For VDS and the Mittenberg formula, the tabled value is the percentage of patients scoring equal to or above the given score. The tabled value for the IQ and index scores represents the percentage of patients scoring equal to or below the given score. For not-MND patients, these values represent the FP error rate (1 minus specificity); for MND patients, they represent the sensitivity rate. The LR indicates the likelihood that a score was produced by a malingerer relative to nonmalingerers. An LR value of 1.0 indicates that the score does not differentiate between groups, whereas a higher LR value indicates a higher probability that someone is malingering (Grimes & Schulz, 2005). Also included in Table 5 are data from the M/S TBI not-MND group, the stroke (CVA) and memory-disordered groups, and the entire non-TBI sample and not-MND sample.

As can be seen in Table 5, the WAIS-III IQ and index scores performed well at differentiating malingerers from nonmalingerers in the mild TBI group. In general, sensitivity ranged from 26% (VIQ and WMI) to more than 35% (PIQ, PSI) at high levels of specificity (≥92%). Within the M/S TBI not-MND group, IQ and index scores indicative of verbal tasks (i.e., VIQ, VCI, and WMI) had FP error rates comparable with those observed in the mild TBI group. In mild TBI, the sensitivity of PIQ, POI, and PSI at cutoffs associated with ~95% specificity averaged 36%. However, in the M/S TBI patients, the FP rate was higher at these cutoffs, especially for PIQ and PSI. In other words, the M/S TBI patients had higher FP rates than the mild TBI patients at the same score levels, indicating the need to use higher cutoffs for PIQ, POI, and PSI in M/S TBI. In contrast to the IQ and index scores, VDS and the Mittenberg formula did not significantly differentiate between malingering and nonmalingering mild TBI patients.

## Joint Classification Accuracy

Joint classification accuracy was examined using the four index scores. A standard score of 75 or less (1.66 standard deviations below the normalized mean) served as the cutoff. For each individual, the number of indices that the patient scored at or below this score was determined. Thus, the maximum aggregate score is 4. As outlined in Ord, Greve, and Bianchini (2008), this method is potentially useful because (a) it is easy to calculate; (b) it clearly differentiates malingerers from nonmalingerers; (c) the cutoff is based on a number of indices, avoiding the potential problems of aggregate FP error rates; and (d) it may be less vulnerable to FPs caused by a specific area of weakness. Table 6 shows the classification accuracy for the full range of scores. As can be seen, in the mild TBI not-MND group, 19% had scores of 2 or more, and 0% had scores of 3 or more. At the ≥2 level, sensitivity was 47%. At the more specific cutoff of ≥3, sensitivity was 37%, a minimal decline compared with dramatic improvement in specificity.

## Outlier Analysis

Individuals within the non-MND TBI sample who scored at or beyond the 5% FP error cutoffs for the WAIS-III variables were carefully examined. Within the not-MND mild TBI sample, one individual consistently scored at levels at or below the WAIS-III cutoffs. This patient was a 46-year-old male with 9 completed years of education. Emergency room records indicated that he had an LOC of less than 10 minutes but was alert and oriented at the time of admission. The patient was described as having a large laceration to his left lower lip and cheek. A CT scan conducted the same day as his accident showed complex fractures of his facial bones (most compatible with a LeFort Type III fracture) as well as a separate fracture of the left orbital ridge. No intracranial injuries were observed. In terms of neuropsychological scores, the patient scored lower than expected on WAIS-III and the Wide Range Achievement Test–III. Specifically, he scored at the third grade level (.8th percentile) on the reading subtest and at the second grade level (.5th percentile) on the spelling subtest of the Wide Range Achievement Test–III. Combined with his lower education level, these scores suggest premorbid cognitive problems. Interestingly, although there was no evidence of an

**Table 5**
**Cumulative Percentages of Patients With Scores More Extreme Than the Indicated Score for WAIS-III Variables**

| | Mild TBI | | | M/S TBI | Other Diagnosis | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Not MND ($N = 26$) | MND ($N = 31$) | LR | Not MND ($N = 26$) | CVA ($N = 27$) | Mem ($N = 28$) | Total Other ($N = 80$) | Not MND ($N = 132$) |
| Verbal IQ | | | | | | | | |
| ≤ 50 | | 0 | | | | | | |
| 55 | | 3 | | | 0 | | 0 | 0 |
| 60 | | 3 | | 0 | 4 | | 1 | 1 |
| 65 | 0 | 13 | | 4 | 4 | 0 | 1 | 2 |
| 70 | 4 | 26 | 6.5 | 4 | 7 | 11 | 8 | 6 |
| 75 | 15 | 42 | 2.8 | 4 | 11 | 21 | 16 | 14 |
| 80 | 31 | 58 | 1.6 | 12 | 19 | 36 | 28 | 25 |
| 85 | 35 | 84 | 2.4 | 27 | 33 | 43 | 43 | 38 |
| Performance IQ | | | | | | | | |
| ≤ 50 | | 0 | | 4 | | 0 | 0 | 1 |
| 55 | | 3 | | 4 | 0 | 4 | 3 | 2 |
| 60 | | 3 | | 8 | 4 | 7 | 5 | 4 |
| 65 | | 10 | | 8 | 4 | 7 | 5 | 5 |
| 70 | 0 | 23 | | 12 | 7 | 11 | 11 | 9 |
| 75 | 4 | 39 | 9.8 | 23 | 7 | 14 | 18 | 16 |
| 80 | 19 | 71 | 3.7 | 31 | 37 | 25 | 31 | 27 |
| 85 | 39 | 81 | 2.1 | 46 | 44 | 50 | 46 | 45 |
| Full Scale IQ | | | | | | | | |
| ≤ 50 | | 3 | | | | | | |
| 55 | | 3 | | | | 0 | 0 | 0 |
| 60 | | 10 | | 0 | 0 | 4 | 1 | 1 |
| 65 | | 13 | | 4 | 4 | 7 | 6 | 5 |
| 70 | 0 | 26 | | 12 | 4 | 11 | 10 | 8 |
| 75 | 12 | 48 | 4.0 | 19 | 11 | 18 | 18 | 17 |
| 80 | 35 | 74 | 2.1 | 27 | 22 | 39 | 33 | 32 |
| 85 | 42 | 84 | 2.0 | 31 | 30 | 43 | 39 | 38 |
| Verbal Comprehension Index | | | | | | | | |
| ≤ 50 | | | | | | | | |
| 55 | | 3 | | | 0 | | 0 | 0 |
| 60 | | 3 | | | 4 | 0 | 1 | 1 |
| 65 | 0 | 19 | | 0 | 4 | 4 | 3 | 2 |
| 70 | 8 | 29 | 3.6 | 4 | 4 | 14 | 8 | 7 |
| 75 | 19 | 45 | 2.4 | 4 | 11 | 21 | 13 | 12 |
| 80 | 35 | 58 | 1.7 | 12 | 11 | 32 | 21 | 22 |
| 85 | 42 | 65 | 1.5 | 23 | 22 | 43 | 38 | 36 |
| Perceptual Organization Index | | | | | | | | |
| ≤ 50 | | 0 | | 0 | | | 0 | 0 |
| 55 | | 3 | | 4 | 0 | 0 | 1 | 1 |
| 60 | | 3 | | 4 | 4 | 4 | 4 | 2 |
| 65 | | 10 | | 4 | 4 | 7 | 5 | 3 |
| 70 | | 20 | | 8 | 4 | 11 | 10 | 4 |
| 75 | 0 | 33 | | 8 | 7 | 18 | 15 | 8 |
| 80 | 12 | 50 | 4.2 | 20 | 26 | 21 | 26 | 22 |
| 85 | 23 | 67 | 2.9 | 24 | 41 | 36 | 36 | 31 |

*(continued)*

**Table 5 (continued)**

| | Mild TBI | | | M/S TBI | Other Diagnosis | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Not MND ($N = 26$) | MND ($N = 31$) | LR | Not MND ($N = 26$) | CVA ($N = 27$) | Mem ($N = 28$) | Total Other ($N = 80$) | Not MND ($N = 132$) |
| Working Memory Index | | | | | | | | |
| ≤ 50 | | 3 | | | | 0 | 0 | 0 |
| 55 | | 3 | | | | 4 | 1 | 1 |
| 60 | | 7 | | | 0 | 4 | 4 | 2 |
| 65 | 0 | 19 | | 0 | 7 | 7 | 8 | 5 |
| 70 | 4 | 26 | 6.5 | 4 | 7 | 11 | 10 | 8 |
| 75 | 12 | 48 | 4.0 | 12 | 11 | 29 | 23 | 18 |
| 80 | 15 | 61 | 4.1 | 19 | 22 | 32 | 33 | 27 |
| 85 | 23 | 77 | 3.3 | 23 | 33 | 39 | 43 | 35 |
| Processing Speed Index | | | | | | | | |
| ≤ 50 | | | | | | | 0 | 0 |
| 55 | | 0 | | 0 | 0 | 0 | 1 | 1 |
| 60 | 0 | 10 | | 8 | 4 | 7 | 5 | 5 |
| 65 | 4 | 16 | 4.0 | 12 | 7 | 7 | 8 | 8 |
| 70 | 8 | 36 | 4.5 | 20 | 19 | 14 | 19 | 16 |
| 75 | 15 | 55 | 3.7 | 36 | 22 | 25 | 26 | 26 |
| 80 | 27 | 68 | 2.5 | 52 | 56 | 43 | 45 | 43 |
| 85 | 42 | 81 | 1.9 | 68 | 63 | 54 | 58 | 57 |

Note: TBI = traumatic brain injury; LR = likelihood ratio; not MND = combined no incentive and incentive only; MND = combined probable and definite malingered neurocognitive dysfunction; M/S = moderate/severe; CVA = cerebrovascular accident; Mem = memory disordered; total other = all non-TBI diagnoses combined; total not MND = all patients including TBI who were not malingering. An LR value of 1.0 indicates that the indicator does not significantly differentiate malingerers from nonmalingerers.

**Table 6**
**Cumulative Percentages of Patients With Total Number of WAIS-III Index Scores at or Below 75**

| | Mild TBI Not MND ($N = 26$) | Mild TBI MND ($N = 31$) | LR | M/S TBI Not MND ($N = 26$) | Clinical ($N = 80$) |
|---|---|---|---|---|---|
| 4 | | 13 | | 0 | 5 |
| 3 | 0 | 37 | | 4 | 10 |
| 2 | 19 | 47 | 2.5 | 12 | 18 |
| 1 | 27 | 73 | 2.7 | 40 | 39 |
| 0 | 100 | 100 | 1.0 | 100 | 100 |

Note: TBI = traumatic brain injury; LR = likelihood ratio, calculated by dividing sensitivity (mild TBI MND) by specificity (mild TBI not MND); not MND = combined no incentive and incentive only; MND = combined probable and definite malingered neurocognitive dysfunction; M/S = moderate/severe.

attempt to intentionally feign cognitive impairment as indicated by Reliable Digit Span (RDS; Greiffenstein, Baker, & Gola, 1994), PDRT, TOMM, and the Fake Bad Scale (Lees-Haley, English, & Glenn, 1991) scores, the patient obtained a variety of low scores that were greater than expected given the nature of his injury. Furthermore, this patient often exhibited low scores on simple tasks of attention, motor functioning, and memory but higher scores on more complex tasks in these domains. This pattern of results, combined with mild psychological distress (MMPI-2 Scale 2 = 80) suggests that there may be some psychological and/or motivational issues that were affecting his neuropsychological performance. Finally, three M/S TBI patients in the non-MND group consistently scored beyond the 5% FP error cutoff on WAIS-III variables. These patients (Case numbers 915, 1453, and 2185) experienced severe brain injuries as evidenced by their Glasgow Coma Scale scores, excessive length of LOC, and neuroradiological scans.

## Discussion

A known-groups design was used to examine the classification accuracy of previously researched

WAIS-III variables as well as the standard IQ and index scores. The specificity of these indicators was also examined in a variety of clinical and medical conditions in the absence of incentive. Tables 4 through 6 provide ROC analysis results and cumulative frequency tables showing the ability of the WAIS-III indicators to discriminate malingerers from nonmalingerers within the mild TBI group. Previously researched WAIS-III indicators (VDS and the Mittenberg formula) did not differentiate malingerers from nonmalingerers. In short, this study does not support the use of these indicators in TBI. In contrast, VIQ, VCI, and WMI scores differentiated malingerers from nonmalingerers with a high degree of accuracy, detecting ≥26% of malingerers with an FP rate of ~5%. Interestingly, although the FP rates for PIQ, POI, and PSI in the mild TBI group remained low (≤8%), the sensitivity of PIQ, POI, and PSI was considerably higher than VIQ, VCI, and WMI. PIQ exhibited the highest accuracy with an LR of 9.8 compared with VIQ, which was the most accurate verbal indicator with an LR of 6.5.

The FP rates for VIQ, VCI, and WMI in the M/S TBI were comparable with those seen in the mild TBI patients. In contrast, the FP rates for the M/S TBI were unacceptably high for PIQ, POI, and PSI. It appears that slowed processing strongly influenced the FP rate in that group. For the most part, the M/S TBI patients and the general clinical patients performed comparably. The exception was that the memory disorder patients performed particularly poorly on WMI, with an FP rate of 29% at a score of ≤75 compared with 12% in M/S TBI and 11% in CVA. These findings have two implications. First, these WAIS scores should be used very cautiously in patients with objective evidence of neurological dysfunction. Second, in the absence of objective evidence of neurological injury or illness (e.g., mild TBI), low WAIS scores can be considered an indication of intentional underperformance in those with external incentives.

The finding that the nonverbal IQ and index scores are more sensitive to brain dysfunction than the verbal scores is consistent with previous research. Axelrod, Fichtenberg, Liethen, Czarnota, and Stucky (2001) showed that PSI was significantly lower than the other index scores in 46 individuals with at least mild to moderate brain injury. Fisher, Ledbetter, Cohen, Marmor, and Tulsky (2000) found that M/S TBI patients scored lower on all the IQ and index scores compared with mild TBI patients and matched controls. Effect sizes were largest for performance-related tasks, with the PSI showing the largest effect size. Finally, Langeluddecke and Lucas (2003) obtained similar findings when they compared individual subtest scores, index scores, and IQ in a sample of moderate, severe, and extremely severe TBI patients. Overall, a dose–response relationship between injury severity and all WAIS-III scores was observed, with PSI showing the largest effect size. These authors caution against the use of the performance indices for malingering detection in patients with documented, especially severe, brain pathology.

## Limitations

There is a small risk of including malingerers in the nonmalingering sample using the present classification methodology. The potential consequence of inadvertently including one or more malingering cases in the nonmalingering group is that of higher FP rates at a given cutoff, and thus, more extreme scores would be required for a score to be considered positive. The scientific cost of this limitation is a less precise estimate of FP rates; the practical/clinical cost is that some malingerers may go undetected with this specific indicator. This is an acceptable consequence because clinicians would rather miss a malingerer than incorrectly call a genuine performance invalid (Boone & Lu, 2003; Greve & Bianchini, 2004; Larrabee, 2008; Larrabee & Berry, 2007).

At the same time, the risk of incorrectly including a malingerer in the nonmalingering group is probably low in this study. To be classified as nonmalingering, a patient must have completed at least one stand-alone SVT and the MMPI. Most had data on several other indicators. Thus, in reality, the vast majority were negative on a wide variety of measures. Specifically, 17 (of 26) mild nonmalingering patients completed two SVTs in addition to having at least one embedded indicator. Eight mild nonmalingering patients had one SVT but had at least two embedded indicators. Only one person in the mild nonmalingering group completed only one SVT and did not have embedded indicators, and that person was not a positive case. There was only one WAIS-positive nonmalingering mild TBI case, and that person did not show evidence of performance invalidity on any malingering indicators. Ultimately future research using different classification techniques may address the methodological limitations of this and similarly designed studies.

## Clinical Application

Regardless of the classification accuracy of any single indicator of response bias, malingering detection

techniques are not perfect and should not be used in isolation for the clinical diagnosis of malingering. As has been noted in many articles, manuals, and book chapters, and systematized by Slick et al. (1999) criteria, a formal diagnosis of malingering should be based on the integration of diverse clinical information. Unlike stand-alone SVTs which were specifically designed to detect malingering, the WAIS-III indicators are clinical measures of intellectual ability, so they should be applied to Slick et al.'s criterion B6.

Criterion B6 is met when an individual's scores on neuropsychological tests are discrepant with what would be expected based on their documented neurological and psychiatric history. In other words, if an individual with no objective neuroradiological or initial mental status findings is scoring at a level that is consistent with performance by individuals with severe neurological trauma, this discrepancy would qualify as meeting Criterion B6. The Slick criteria state, however, that a positive finding is needed on two indicators to meet Criterion B6. Using the joint classification data in Table 6 would address this detail. However, recent commentary in the area of malingering using known-groups methodology has indicated that the use of two indicators to meet B6 may not be necessary (Larrabee, Greiffenstein, Greve, & Bianchini, 2007), so this is less of an issue.

Application of these results will be limited to some extent by our exclusion of persons with less than 9 years or more than 14 years of education. These data cannot be applied to persons with less than 9 years of education and should be applied cautiously to persons who may have more years of completed education if they were not in regular classes or have other reliable independent evidence of limited educational attainment (e.g., special class placement, learning disability; the mild TBI patient described in the outlier analysis is a good example of this type of case). These data can be reasonably applied to persons with higher education because scores in the malingering range would be even less likely in well-educated persons. It is important to understand that in these persons, false negative errors are more likely to occur, in contrast to the FP errors likely seen in less-educated persons. In patients with higher educational achievement, sensitivity may be enhanced (without adversely affecting specificity) by using observed–estimated IQ difference scores such as those examined in Greve, Lotz, and Bianchini (2008). Simply, any elevation of these indicators in high school (or higher) educated persons with a history of a single, uncomplicated mild TBI is a solid indication of negative response bias.

It is important to emphasize that the intent of this article is to provide a supplementary method to directly assess the validity of performance on the WAIS, particularly in patients without objective evidence of brain pathology like the mild TBI patients used in this study and patients with chronic pain described elsewhere (Etherton, Bianchini, Ciota, et al., 2006; Etherton, Bianchini, Heinly, et al. 2006). Moreover, the National Academy of Neuropsychology (Bush et al., 2005) and American Academy of Clinical Neuropsychology (2007) both advise the use of multiple measures of performance validity, including embedded indicators, as part of any neuropsychological examinations in which incentive to underperform may be present. Finally, it has been suggested that embedded indicators may be less vulnerable to the effects of coaching or other efforts to manipulate the outcome of neuropsychological assessment. In short, this study provides neuropsychologists with an additional tool with which to better ensure the accuracy of their evaluations.

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