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Ability of the Cognitive Behavioral Driver's Inventory to Distinguish Malingerers From Brain-Damaged Subjects

Edward C. Ray

University of Tennessee, Knoxville, TN

Eric S. Engum

Neuropsychological Consultants

E. Warren Lambert

Center for Mental Health Policy, Vanderbilt University, Nashville, TN

Ginger F. Bane and Michael R. Nash

University of Tennessee, Knoxville, TN

Odie L. Bracy

Neuroscience Center of Indianapolis

The Cognitive Behavioral Driver's Inventory[1] (CBDI) was analyzed for its ability to discriminate brain-damaged patients from intact subjects who feigned brain-damage. In a sample of 251 neurologically impaired patients and 48 malingering volunteers, the computer-administered distinguished most malingerers from genuine patients. A jackknifed count revealed that the CBDI had 90% sensitivity for detecting malingerers, and 98% specificity for detecting non-malingering brain damaged patients. Success was due to the inability of malingerers to avoid quantitative errors: excessive response latencies, unusual error rates, inflated variability in response latencies, and excessive within-subject, between-item variability. The computer-administered battery may be an effective clinical tool for identifying patients who malinger brain-damage in neuropsychological testing. © 1997 National Academy of Neuropsychology. Published by Elsevier Science Ltd

Malingering has been identified as ". . . the intentional production of false or grossly exaggerated physical or psychological symptoms, motivated by external incentives such as

[1] Version 2.0 of the CBD1 programmed by Odie L. Bracy, Ph.D. was used in this study.

Address correspondence to Michael R. Nash, University of Tennessee, West Cumberland Ave., SW, Knoxville, TN 37916.

avoiding work, obtaining financial compensation, avoiding military duty, evading criminal prosecution, avoiding punishment for criminal behavior, or obtaining drugs" (Binder, 1992, p. 353). The *Diagnostic and Statistical Manual, Fourth Edition* (American Psychological Association, 1994) suggests that malingering must always be considered in a medico-legal context, particularly in cases with significant discrepancies between claimed disability and functioning in the community.

Within the neuropsychological context, the malingering client may fabricate deficits in attention and concentration, sensory input and/or motor output, memory, sequencing, speech and language skills, conceptual reasoning, problem solving, and learning. The malingering patient may also falsely report such psychological deficits as irritability, impulsivity, emotional lability, amotivational syndrome, aggression, apathy, paranoia, disinhibition, depression, or acting out. Further, there may also be different motivations and gradations of malingering, as well as varying levels of conscious and unconscious deception (Rogers, 1988).

Many malingerers evade detection and unfairly burden society through expensive trials, increased insurance premiums, and increased costly services by health care facilities and professionals. At present, there is a complex literature that addresses the difficulty in detecting individuals who malinger brain-damage. Part of the difficulty is the fact that many neuropsychologists assume their clients are truthful. Therefore, it is not surprising that clinicians have had a difficult time in developing methods of detection sophisticated enough to unmask malingerers (Rogers, 1988).

Past attempts to detect malingering have typically employed traditional neuropsychological methods to analyze test patterns from various assessment techniques such as the Minnesota Multiphasic Personality Inventory (MMPI), the Wechsler Adult Intelligence Scale-Revised (WAIS-R), and the Halstead-Reitan Battery (HRNB). Even with extensive protocols, clinicians have difficulty identifying malingerers accurately. For example, in Heaton et al. (1978) experienced clinicians examined protocols from brain-damaged subjects and malingerers. The clinicians were forewarned that 50% of the neuropsychological protocols were produced by malingerers. Results suggested that clinicians' success in separating malingering from true brain-damage ranged from chance level to about 20% better than chance. Other studies suggest that clinicians' ability to detect malingerers may be no better than chance. For example, Faust, Hart, Guilemette, and Arkes (1988) conducted two further studies of clinicians' ability to discriminate malingerers from brain-damaged subjects. In both studies, neuropsychologists reviewed neuropsychological data from a fabricated history of mild to moderate head injury for each subject. In the first study, none of the neuropsychologists detected malingering. In the second study, the clinicians' appraisals did not surpass the chance level, even though clinicians knew there was a 50% base rate for malingering.

In the past, formal methods for discriminating the performance of malingerers from that of brain-damaged patients have been disappointing. For example, both Gillis, Rogers, and Bagby (1991) and Smith and Borum (1992) demonstrated that the *M* Test produced only minimal success in detecting malingerers. Rey's 15-Item Visual Memory Test and the Symptom Validity Technique (SVT) have initially produced impressive results of 90% or better correct classification (Binder, 1990; Lee, 1992; Pankratz, 1979, 1983). However, in actual clinical applications, such techniques have been far less successful due to the transparent nature of the tasks and questions.

There are some recent methodologies for detecting malingerers on the horizon, but laboratory validation is not yet available. First, many studies utilize simple univariate statistical analyses (Bernard & Fowler, 1990; Lee, Loring, & Martin, 1992). Merely reporting that some variables have a significant ability to distinguish between malingerers and bona fide patients does not provide the clinician a definitive procedure nor does is specify what

degree of success can be expected. Methods must be designated for combining multiple indicators. The sensitivity and specificity (Kraemer, 1992) of the resulting procedure must be given to estimate how many malingerers and true patients are correctly classified.

A second limitation in some previous research is reliance on face valid variables that may be transparent to the discerning malingerer (Bickart, Meyer, and Connell, 1991; Pankratz, 1983). Quantitative measures such as response latencies for grouped and ungrouped dot-counting (Lezak, 1983, pp. 619–620) or a test utilizing computer-based reaction times, may be much more difficult for even the most shrewd malingerer to fake. In addition to appearing disabled, the malingerer must not appear so disabled as to be an outlier from patient norms. A malingering profile of timed tasks with scores invisible to the test-taker, such as between-item variances, would be even more difficult for the malingerer to fake.

A third problem is that many malingering detection methods are based on unidimensional variables such as number of errors (Bernard & Fowler, 1990; Lee et al., 1992).

Fourth, many studies use samples that are too small, for example, less than 20 malingering subjects (Binder, 1990; Faust et al., 1988; Frederick and Foster, 1991; Lee et al., 1992; Prigatano & Amin, 1993). Willson and Reynolds (1982) present a meta-analysis showing the danger of small samples. Of twelve studies reporting significant prediction, eight became nonsignificant when statistical corrections for the number of cases and variables were applied. Willson and Reynolds recommend that neuropsychological studies use many more subjects than predictors and that results be cross-validated on fresh cases before publication is appropriate. How the problem of small clinical samples applies to the present study is discussed in the Method section.

Fifth, a review of the literature reveals no statistically valid technique for measuring response consistency across numerous performances (Bernard, 1990; Binder, 1990, 1993; Faust et al., 1988; Gillis et al., 1991; Iverson et al., 1991; Mittenberg et al., 1993; Prigatano & Amin, 1993). Previous research has demonstrated that within-subject variability, or scatter variance, effectively discriminates between brain-damaged and normal performance across entire batteries (Lambert & Engum, 1990). In the present study, scatter variance was utilized to distinguish malingerers from brain-damaged patients.

Sixth, most other studies compared malingerers with normal controls rather than with brain-injured patients in a clinical setting (Bernard, 1990; Bernard & Fowler, 1990; Bernard, Houston, & Natali, 1993; Bickart, Meyer, & Connell, 1991). Distinguishing malingerers from normal controls offers no help to clinicians who must distinguish malingerers, because there is "no reason to believe the regression weights that discriminate two groups will discriminate either from a third" (Willson & Reynolds, 1982, p. 137). The present study is unique in discriminating malingerers from brain-injured patients on identical criteria.

A problem with assessment tasks administered by an examiner is the fact that malingerers are highly field dependant; that is, they constantly search for cues in the environment to suggest how they should respond (Rogers, 1988). Examiners can unknowingly provide feedback to a perceptive malingerer. A computer-administered test, such as the CBDI, provides no accidental clues to aid deception. Further, computer administration and scoring enables the experimenter to carry our exceedingly fine-grained analyses of task responses and *variances* in task responses which would be difficult, if not impossible, for malingerers to mimic.

The CBDI and Patient Sample

The CBDI was originally designed to determine which brain-damaged patients could safely operate a motor vehicle. For the standardization and norming, two samples were employed: a brain damaged sample of 271 patients and a normal control sample of 41. Of

these patients, 65 sustained left cerebral vascular accidents, 63 sustained right cerebral vascular accidents, 78 suffered traumatic head injuries, 9 suffered spinal cord injuries, and 36 experienced other disabling and debilitating neurological disorders (Lambert & Engum, 1992). The last category contained individuals suffering from Guillian-Barre syndrome, myasthenia gravis, multiple sclerosis, Alzheimer's disease, Parkinson's disease, intrinsic and extrinsic tumors of the brain, and toxic encephalopathy. The average age of patients was 48. The normal controls were hospital employees. The average age of the normal controls was 31. The descriptive statistics on these samples are further described in Engum, Lambert, and Scott (1990).

The CBDI was validated against the decisions of experienced driving instructors as to the patients' safety in operating a motor vehicle ($r = 0.81$, $p < .0001$); instructors were blind as to CBDI scores. The CBDI measures overall deficit with high internal consistency reliability (Cronbach's Alpha = 0.949).

The purpose of the present study is to determine the efficacy of the CBDI in differentiating malingerers and genuine brain-damaged subjects. There are several reasons to believe the CBDI might be effective in detecting malingering: (a) the CBDI is a timed quantitative test that might detect malingerer's scores that are either too impaired or not impaired enough; (b) CBDI scores include response latencies, within-subject variance, error rates, and performance speed that might be quite difficult for malingerers to feign; (c) quantitative CBDI scores can be summarized in a malingering profile that includes all evidence that distinguishes malingerers from brain-damaged patients.

The responses of 48 malingering subjects were compared to the responses of 251 brain-damaged patients above described. The CBDI is composed of 28 items, 25 of which were used in the present study. Five of the seven tasks utilized were scored on multiple dimensions. For example, a task such as Visual Reaction Differential Response (items 87ndash;14) contain four separate measures, including overall response latency, number of errors, variance[2] and four visual quadrant response latencies.

METHOD

Subjects

The 48 malingering subjects were volunteers from an Abnormal Psychology class of 110 students at the University of Tennessee, Knoxville. Subjects were informed before volunteering that the study involved cash rewards for those individuals who could best "fake" brain damage. It was further explained that the 20 students whose scores best matched the scores of 251 brain-damaged patients would receive as much as $50 in cash. Subjects were also informed that the cash, totaling $250, was divided as follows: $50 for first place, $40 for second place, $30 for third place, $20 for fourth place, six prizes of $10 each for fifth through tenth place, and ten prizes of $5 for eleventh through twentieth place. These awards were paid before the end of the academic quarter in which subjects participated. Each subject filled out a consent form and a medical questionnaire. The medical questionnaire was used to screen subjects who might have had prior difficulties such as head injury or learning disability. Such difficulties might have affected their CBDI scores, confounding malingering with true organic brain damage. A confidential master sheet with the students' names was kept in order to notify the winners.

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[2] Variance literally, the sum of the squared deviation of 27 scores about the standardized mean of the 27 scores. This inherently quantitative measure is easy for a computer program to calculate from a list of scores, but very difficult for an unaided human observer to observe and feign.

A total of 57 subjects were recruited; of these, 5 were unqualified to take part in the study due to history of head injury; another four other were excluded because of computer failures. There were 20 males and 28 females in the sample and their average age was 25.

Materials

The Cognitive Behavioral Driver's Inventory (CBDI) includes 10 tasks yielding 28 response measures dealing with such aspects of cognitive/behavioral functioning as attention, concentration, rapid decision-making, stimulus discrimination/response differentiation, sequencing, visual-motor speed and coordination, visual scanning and acuity, and attention-shifting from one task to another (Bracy, 1982, 1985). The Digit Symbol and Picture Completion tasks of the WAIS-R, along with Trails A and Trails B from the Halstead-Reitan Neuropsychological Battery compose the four paper and pencil tests, which were recorded by the experimenter. A stop-watch was used to time the subjects on the noncomputer items. CBDI Items 1–3 (brake reaction time and the left and right perimeters) require special equipment and were not utilized for this study.

On the computerized portion of the CBDI (items 8–27) subjects used an 80386 computer with MS-DOS. Subjects used a standard joystick for items 8–23 and a keyboard for items 24–27.

Procedures

Upon arriving for the experiment, subjects were provided a brief overview of the experiment with instructions to fake brain damage. They were once again informed of the cash reward contingencies and then administered the CBDI. They commenced with the WAIS-R Picture Completion task followed by the WAIS-R Digit Symbol task, both administered as described in the WAIS-R manual. Next, Trails A and Trails B from the HRNB were administered according to the Reitan and Wolfson (1985) method. Both Trails A and Trails B were administered with a 5-minute maximum allowance to complete each task, which is part of the normal administration of the CBDI (Engum, Lambert, Womac, & Pendergrass, 1988). Without such a time limitation, Trails A and B could take too long and a single outlier score could be overweighed in the results. In addition to recording times in seconds, the experimenter also registered a hand-written error count.

Next, the subjects were administered the four tasks of the computerized portion of the CBDI. Task 1 corresponds to items 8–14, task two corresponds to items 15–21, task three corresponds to items 22–23, and task four corresponds to items 24–27. Before each task, the subject was required to read the directions and commence the task when ready. When subjects finished, they were told that they would be notified before the semester ended whether they won a cash prize.

Cases, Items, and Cross-Validation

The available sample was split by a random number into two subsamples; discovery and cross-validation. In cross validation ". . . both samples are drawn independently from the same population. Often a single sample is split into two halves" (Willson & Reynolds, 1982, p. 137). The cross-validation estimates the stability of results in the local sample, not how well they apply to new samples with different characteristics. The present study utilizes a sample of 48 malingerers and 251 brain-damaged patients. With 25 predictors, this results in 12 cases per variable (299/25). In this study, a 50% discovery sample would have 6 subjects per variable, less than Edwards' (1976, p. 153) recommendation "that n/k be equal to or

TABLE 1
Seven Summary Scores for Patients and Malingering Students

Summary Score	Rehab Patients (N = 251)				Malingering Students (N = 48)				Univariate ANOVA	
S's Variance Across Items	50.2	10.1	41.7	83.3	76.4	11.8	44.5	83.3	259	<.001
Range High–Low *SD* Score	50.5	10.5	36.6	82.2	103.1	52.2	44.8	282.2	214	<.001
Mean 25-Item *SD* Score	50.0	6.8	41.3	74.3	66.5	11.5	44.1	92.3	180	<.001
SD N Items Failed	49.7	9.7	39.7	75.9	62.2	7.6	39.7	69.2	72	<.001
SD N Items Passed	50.6	9.6	35.3	68.6	61.5	6.0	42.7	66.1	58	<.001
Average of 10 Most Valid Items	50.1	8.2	39.0	75.5	57.3	7.9	39.3	70.6	32	<.001
S's *SD* Skew	49.7	10.1	19.6	88.4	57.1	13.7	20.8	92.5	19	<.001

Note. All scores have a mean of 50 and SD = 10 for the original research sample used to norm the CBDL.
The univariate ANOVAs (df = 1,297) compare 251 patients with 48 malingering students.
A seven-variable two-group MANOVA found listwise significance for these seven variables across the two groups [$F(7, 291) = 102$, $p < .001$].

greater than 10," a little more than Tabachnick and Fidell's (1989) "bare minimum . . . [of] five times more cases than IVs [independent variable]." Green's (1991) rule-of-thumb states that the minimum number of subjects must be N greater than 50 + 8 × the number of items. For the present study, this translates into 50 + 8 * 25 = 250 cases. By Green's standard, 500 cases would be needed for a 50-50 split. To balance the conflicting demands for a large discovery group and cross-validation, 75% of the cases were assigned to the discovery sample, 25% to cross-validation sample. A formula for distinguishing malingerers from bona fide patients was discovered using 75%, then its stability was tested on the 25% subsample. If discovered results capitalize on chance, accuracy should be considerably less in the cross-validation sample. This 75% to 25% compromise, compared with 50% to 50% pays for a more stable classification rule by larger standard errors in the cross-validation results.

RESULTS

An overall multivariate analysis of variance (MANOVA) compared the means of the malingerers and brain-damaged patients on the seven CBDI summary scores:

1. The subjects variance across 25 CBDI items;
2. the range from the highest to lowest CBDI standard scores;
3. the mean of the 25 CBDI items;
4. the number of CBDI items failed;
5. the number of CBDI items passed;
6. the average of the 10 most valid CBDI items; and,
7. the skew of the subject's scores about his or her own mean score.

The overall MANOVA revealed significant differences between patients and malingerers [$F(7, 291) = 102$, $p < .001$]. In addition, all univariate analyses of variance (ANOVA) revealed significant differences for the seven summary scores ($p < .001$). Means and F ratios for summary scores appear in Table 1.

For all seven summary scores, malingerers performed more pathologically than brain-damaged patients referred for driver's evaluation. The summary scores in Table 1 appear in order of significance. The two most significant summary scores for discriminating malingerers from brain-damaged subjects were both measures of within-subject variance (scatter). The average malingering subject produced both a significantly larger variance across scales and a much larger range from best to worst CBDI score. The third most significant score was

TABLE 2
Average Malingerer's Summary Scores: Percentiles in the Patient Populations

Summary Score	Malingerer's Average	Percentile Among Patients
1. S's Variance Across Items	76	99.5%
2. Range High–Low *SD* Score	103	>99.995
3. Mean 25 Item *SD* Score	66	94.52%
4. *SD N* Items Failed	62	88.49%
5. *SD N* Items Passed	61	86.43%
6. Average of 10 Most Valid Items	57	75.80%
7. S's *SD* Skew	57	75.80%

Note. Percentiles based on normal distribution.

the CBDI total score, the General Driver's Index (GDI25), which is the standardized (50, 10) mean score for 25 CBDI items. Additionally, a subject's item skew differentiated malingerers from brain-damaged subjects, with malingerers having more extreme positive skew. The findings that malingerers performed in a significantly more pathological manner was also observed for other summary scores, including total items failed, total items passed, the 10-item "short-form" of the CBDI.

Further evidence of the extreme exaggeration of the malingerers' cognitive impairment and behavioral inconsistency was revealed by comparing their scores to the normal distribution of brain-damaged patients. Examination of the percentile ranks of summary scores of malingerers compared with the patient sample revealed that the average malingerer's score, as shown in Table 2, was very high, compared with a sample of actual brain-damaged patients. The average malingerer's scores on the three best discriminators were: (a) subjects' variance (99th percentile); (b) range (99th percentile); and, (c) the GDI25 score (94th percentile). If a patient is so severely brain-damaged, one would expect signs of organicity to be clinically obvious.

Clinically, patients in the standardization sample had an average CBDI item or total standard score of 50 (*SD* = 10) and were at least moderately impaired. A patient scoring over 70 [two standard deviations (*SD*) worse than the average patient] should appear dramatically disabled; for example, suffering from a left hemiparesis, a left homonymous hemianopsia, left hemineglect, or severe visual, spatial, and perceptual deficits. If a patient has a score over 70, yet drives to the neuropsychological evaluation and behaves without obvious impairment, s/he may be malingering.

CBDI Scores

The 25 scores of the CBDI. In Figure 1, 95% confidence intervals of ± two *SD* of the CBDI scores were plotted for malingerers, brain-damaged patients, and normal controls. The normal controls, data taken from Engum, Lambert, and Scott (1990), were not brain-injured. Normal controls were administered the CBDI with instructions to do as well as they could.

In Figure 1, the patient sample scores had a mean of 50 and a *SD* of 10 for all 28 items. The error bars show intervals of 95% confidence around the means; for most CBDI items, malingerers scored more pathologically than brain-damaged patients. The three exceptions are discussed below.

Means of CBDI items 10 through 22 were excellent discriminators; these items were based on the following tasks: (a) VRDR (simple forced choice reaction time task); (b) VRDR Reversed (complex forced choice reaction time task); (c) VDDR (stimulus discrimination/

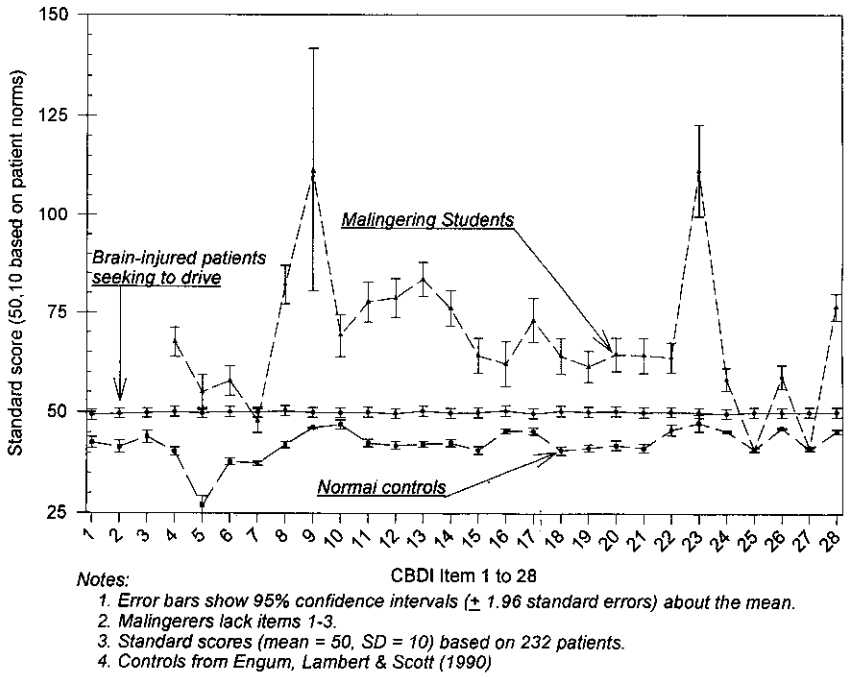

FIGURE 1. Mean standard scores for 48 malingering students, 251 brain-injured patients, and 42 normal controls.

response differentiation task). These tasks, respectively, measure: (a) attention, concentration, and basic reaction time; (b) sustained attention, dynamic cognitive processing, resistance to cognitive interference, and rapid decision-making; and, (c) all of the items mentioned for VRDR and VRDR Reversed plus stimulus discrimination and response differentiation (Engum, Lambert, & Bracy, 1990).

Two CBDI items (VRDR variance, item 9, and VDDR2 errors, item 23) were limited in discriminating ability by large *SD*) among malingerers. These items have *SD*s of 108 and 41 respectively (all items have *SD* = 10 for patients). While the malingerers have very high means on these items, the large between-subject variation limits their usefulness.

Three items with means below 50 for malingerers: Trails B (item 7), Visual Scanning 3 Left Time (item 25), and Visual Scanning 3 Right Time (item 27) initially appeared ineffective for discriminating malingerers from brain-damaged patients because their means on these items were almost identical to those of brain-damaged patients. However, a multivariate study revealed that two of these items; namely Visual Scanning Left Time (item 25) and Trails B (item 7), are among those items most useful in detecting malingering, as described below.

Incremental validity of CBDI items.

The univariate analyses above show that malingerers have significantly higher means on 22 of the 25 CBDI items. Clinical applications of the CBDI require a method to combine all relevant evidence into a single recommendation (malingerer or true patient). The stepwise discriminant analysis[3] dropped items that made no unique contribution to produce a discrim-

[3]Discriminant analysis is a multiple regression, $Y = b0 + b2X2 \ldots$ in which the Y is categorical.

TABLE 3
CBDI Items with Incremental Ability to Discriminate Malingerers from Actual Patients

CBDI Items	Stepwise p (α)	β
25. Vscan3 Left Time	<0.0001	−0.078
13. VRDR Q3 Time	<0.0001	+0.101
28. Scatter Variance	<0.0001	+0.059
23. VDDR2 *N*	<0.0001	+0.025
8. VRDR Time	<0.0001	−0.112
12. VRDR Q2 Time	<0.0001	+0.063
4. WAIS Picture Completion	<0.0001	+0.035
22. VDDR2 % Correct	<0.0001	−0.040
7. Trials B	0.0002	−0.034
16. VRDR Rev. Variance	0.0034	−0.019
24. Vscan3 Left *N*	0.0062	+0.029

Item numbers on left based on original CBDI, which has 28 items.
Items appear in order of their incremental (stepwise) ability to distinguish malingerers from patients. Item #25 is the best single item.
Trails B lacks univariate significance but contributes significantly at the ninth step.
If the signs of beta were all the same, the discriminate function would be a simple measure of overall impairment, rather than a malingerer's profile.

inant function. Each subject's score on this discriminant function indicated whether they most resembled patients or malingerers.

Of the 25 CBDI items, 11 demonstrated incremental validity in the stepwise discriminant analysis. Variables dropped out if they made no significant contribution to R2 beyond items already accepted. These 11 "best discriminators" appear in Table 3.

The last column in Table 3 shows the standardized beta-weights (positive or negative) of each variable on the discriminant function. These beta-weights are not entirely positive or entirely negative. All CBDI scores are pathology-high with means of 50 and *SD*s of 10 on the patient sample. The fact that the beta-weights in Table 3 were both positive and negative suggests that the discriminant analysis utilized an intelligent multivariate profile not simply classifying the most pathological cases as malingerers.

Analysis of the Discriminant Function

Hit rates. The critical feature of the analysis is how well the discriminate function distinguishes malingerers from actual patients. Both sensitivity (the percentage of correctly identified malingerers) and the specificity (the percent of correctly identified non-malingerers) are needed to judge the merit of a diagnostic technique (Kraemer, 1992). This sensitivity-specificity analysis appears in Table 4.

To estimate hit rates, the SPSS subprogram DISCRIMINANT calculated a discriminant function score for every malingerer and brain-damaged patient. This discriminant function score was the weighted sum of the significant predictors, fo example, +0.38 * (*z* Picture Completion) –0.35 * (*z* Trails B) . . . and so forth. Then DISCRIMINANT assigned each case to the most likely group to determine if the calculated assignment was correct.

In the 75% discovery sample, 98.67% of the cases were correctly identified. Sensitivity (correctly identified malingerers) was 91% and specificity (correctly identified brain-damaged patients) was 100%. Accuracy in the discovery can be inflated by chance when "correlation maximizing procedures have been used [such as] stepwise discriminant analysis" (Willson & Reynolds, 1982, p. 137). Stepwise analysis, like other automated selection

TABLE 4
Sensitivity and Specificity for the Discriminant Function

Actual Group	Predicted Group					
	Discovery Sample 75% (N = 225)		Hold Back[a] 25% (Random N = 74)		Jackknifed Count (N = 299)	
	Patient	Malingerer	Patient	Malingerer	Patient	Malingerer
Patients (n = 251)	191, 100.0% specificity	0, 0% false −	59, 98.3% specificity	1, 1.7% false −	247, 98.0% specificity	4, 2.0% false −
Malingering Students (n = 48)	3, 8.8% false +	31, 91.2% sensitivity	3, 21% false +	11, 78.6% sensitivity	5, 10.4% false +	43, 89.6% sensitivity

[a]The hold back analysis was done in two steps. First, a discriminant analysis was done on 75% of the sample chosen by a random number. Then the resulting discriminate function was applied to the fresh cases.

algorithms, can detect random "noise variables" as significant (Derksen & Keselman, 1992; Flack & Chang, 1987) even though they would be useless predictors in a new sample.

To determine how much of the accuracy of the CBDI resulted from capitalization on chance, sensitivity and specificity were calculated for the cross-validation (hold back) subsample. In addition to the hold back sample, jackknifed accuracy estimates were calculated. Jackknifed classification utilized the whole sample (N = 299), correcting the discovery sample's potentially optimistic accuracy estimates by using classification functions based on all cases except the one being classified (Dixon, 1992; Lachenbruch & Micky, 1968). The cross-validation[4] and jackknifed results appear in Table 4. Compared with the discovery sample, specificity remained above 98% accuracy in classifying brain-damaged patients correctly. Sensitivity in detecting malingerers decreased from 91.2% to 89.6% in the jackknifed count, and 78.6% in the hold back sample. These diminished sensitivities are high enough to be clinically useful in the absence of other detecting methods with better sensitivity and specificity.

Is there a malingering profile? Figure 1 compellingly demonstrates that malingerers score worse than legitimate patients on 22 of 25 CBDI items. The discriminant analysis revealed a differentiated profile for malingering, one with both positive and negative beta-weights. Does this complex profile actually add anything beyond the simple observation that grossly pathological scores indicate malingering?

To answer this question, a jackknifed discriminant analysis was implemented first with 25 items and then again with only one predictor, the GDI25 total impairment score. The GDI25 score has been previously demonstrated as the best single estimate of overall performance on the CBDI (Lambert & Engum, 1990). The sensitivity of the multivariate profile version was higher than that of the multivariate version (90% to 77%), but this difference was not significant[5] with 48 malingering cases [$\chi^2(1) = 2.7$, $p = .10$, NS]. The specificity of the multivariate profile version was higher as well (98% to 88%), and this difference was significant [$\chi^2(1) = 20$, $p < .00001$]. This significant difference suggests that there are profile

[4]The 95% confidence interval for 11 correct out of 14 is 57% to 100%.

[5]The effect size of this nonsignificant difference was Cohen's (1988) $W = .237$. The power of this χ^2 with $N = 48$ was only 38%; if there were a real result with $W = .237$ there would be a 62% chance of a B error (missing a real result).

differences between patients and malingerers beyond the obvious fact that the malingerers had a more pathological total score than the brain-damaged patients.

Post-study interviews were carried out with the two "most successful" malingerers, winners of the top two financial rewards ($50.00, $40.00) to learn what strategies they employed. The most successful subject stated that he simply forgot to feign brain-damage. The second best malingerer stated that he tried to respond normally.

DISCUSSION

The results of this study suggest that a timed quantitative test administered by computer can discriminate malingering pseudo-patients from patients whose impairment is genuine. There are four reasons to support this conclusion: (a) the ability of individual items to discriminate malingerers from brain-damaged patients; (b) the subtlety of CBDI scores, such as overall reaction time, four quadrant reaction times, variance, error scores, and "hidden" items (of which the potential malingerer would not be aware); (c) the misleading face-validity of certain CBDI items, inviting malingerers to identify themselves by markedly poor performances; and (d) a discriminant function with both positive and negative beta-weights.

There were highly significant differences between brain-damaged patients and malingerers on subtle aspects of task response on the CBDI. For example, on VRDR, a simple choice reaction time task, brain-damaged patients averaged approximately 0.57 seconds while malingerers averaged 1.24 seconds. Normal controls in the study by Engum, Lambert, and Scott (1990) responded in approximately 0.41 seconds. Instead of delaying their responses an average of 0.16 seconds, malingerers produced response latencies averaging 0.83 seconds. Malingerers grossly exaggerated their response latencies when attempting to feign brain-damage. The small confidence intervals around the item means (Figure 1) suggest that a malingerer would have to be very precise to deceive the CBDI.

Second, the complexity of many of the CBDI tasks makes what we believe to be impossible demands on the malingerer, such as manipulating seven variables simultaneously on the VRDR (overall response latency, response latencies in each of the four visual quadrants, an overall variance, and an error score). Merely being familiar with the test does not enable the malingerer to "get the right scores." In addition, between-item variance (scatter) based on 25 items was one of the most sensitive variables discriminating brain-injured patients from malingerers. We posit that response consistency is very difficult for a malingerer to fake. Malingerers' inability to control multiple response measures, some with tolerances as fine as 0.20 seconds, resulted in their detection.

Third, CBDI items have a face validity that might mislead malingerers. For example, Visual Scanning 3 yielded surprisingly high response latencies for the normal controls (right = 5.7 seconds; left = 6.1 seconds) and for the brain-damaged patients (right = 12.0 seconds; left = 12.5 seconds). Malingerers, unaware of the test norms, had mean response latencies more closely resembling normal controls than brain-damaged patients.

Finally, the discriminant function included both negative and positive beta-weights. Evidently individuals feigning brain-damage were impaired on some tasks and not impaired enough on others. Utilizing a weighted sum of 11-item scores enhanced the ability to discriminate malingerers from brain-damaged patients. While the discriminant function would be complicated to calculate by hand, it could be calculated easily by a spreadsheet or the software used to administer and score the CBDI.

The present research has limitations. First, the malingerers were undergraduate psychology students. Malingering studies are needed with different populations. The ideal sample would be difficult to identify, since malingerers seeking financial compensation or evading

criminal responsibility are not going admit that they are malingering. One of the authors (ESE) has clinically identified real malingerers with both the CBDI and other psychometric evidence, but not in numbers adequate for statistical comparisons.

Second, the sophistication of subjects, instructed to malinger but not taught how, may be lower than that of real malingerers. Research in progress teaches subjects the signs of brain-damage. If in future research *informed* subjects can be detected, subjects could be given feedback on CBDI items to determine if it is possible under ideal conditions to control multiple quantitative scores on a timed computer-administered test.

Because of the possibility of coaching, the CBDI is a qualification level "C" test according to the Standards for Educational and Psychological Testing. Only those individuals with advanced graduate degrees in psychology and advanced training in psychological assessment may utilize the CBDI. Detailed information about the CBDI must not be disseminated to the general public. In this way, even if coaching is possible, the CBDI can be maintained as a highly effective detection methodology for foiling the best efforts of disingenuous pseudo-patients.

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