Cognitive Behavioral Driver's Inventory

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One of the most difficult and vexing decisions facing the Rehabilitation Team involves the judgment regarding the brain injured individual's capacity to safety operate a motor vehicle (see Mittlemann and Greenfield, 1977). The cognitive impairments, emotional disturbances, and personality changes which are sometimes permanent sequelae to brain injury frequently outweigh any physical limitations which might impact upon the driving decision. For instance, Shore, Gurgold, and Robbins (I 980) found that 90% of a physically impaired group diagnosed as spinal cord injury, congenital disability, or muscular dystrophy, were relicensed following training in a Handicapped Driver's Education Program. Yet, only 50% of the neurologically impaired patients carrying diagnoses of cerebral vascular accident (CVA), cerebral palsy, or closed head injury, achieved relicensing after training. Attentional deficits, slowed reaction time, freedom from distractibility, disinhibition, impulsivity, and reduced information processing, are only the most obvious sequelae of neurological injury. Excessive concrete reasoning, poor judgment in problem solving, and impaired executive function are also frequently noted. These deficits may particularly affect the initiation, planning, and carrying out of activities plus the capacity to evaluate the results and consequences of one's actions.

In addition, one's ability to drive safely may be adversely affected by memory deficits, reduced endurance, perplexity, impaired generation ability, reduced tolerance for stress and pressure, and poor sequencing skills. Visual and perceptual impairments emanating from brain injury include spatial disorientation, poor depth perception, poor figure ground discrimination, hemi-inattention, reduced visual scanning, impaired attention to detail, and inability to differentiate essential from nonessential details. Bardach (1971), for instance, noted that the perceptual deficits secondary to right CVA were far more disabling than the language deficits secondary to left CVA when attempting to train stroke patients in a driver education program. Traumatically induced affective disturbances which typically impair one's driving ability may include emotional lability, increased anger at minor obstacles and frustrations, decreased impulse control, emotional incongruities, apathy, flattened affect, agitation, acting-out behavior, and reduced insight. Golper, Rau, and Marshall (1980) suggested that it was not just the perceptual deficits but also the affective and personality changes incident to right CVA which made those patients so dangerous and unreliable in operating a motor vehicle. Such patients were notoriously poor in their own self-appraisals, in their self-evaluations of their ability to safely operate a motor vehicle, and in their overall emotional control.

In order to operationalize the driving task, Michon (1979) posited a three level hierarchic structure which entailed a strategic level, a tactical level, and an operational level. In this hierarchical structure, the highest or strategic level includes such driving decisions as choice of route; time of day to undertake a trip; planning a sequence of trips or stops; and evaluating general risks of traffic, conditions of traffic density, and climate; all decisions usually made prior to commencing an excursion. Usually, individuals with acquired brain lesions suffer from poor planning, poor judgment impulsivity, and impaired insight; factors, it seems, which would adversely influence strategic decision-making. Unfortunately, van Zomeren, Brouwer, and Minderhoud (1987), in a review of the literature, concluded that no studies had been conducted which evaluated the strategic performance of brain injured individuals in the driving task.

Michon's second, or tactical, level encompasses behaviors and decisions made while in traffic; for example, adapting one's speed when entering a residential area, switching on headlights when rain reduces visibility, deciding when to pass another vehicle, approaching street crossings at an appropriate speed, and adjusting actual driving to environmental conditions such as traffic density, visibility and weather. Though difficult to evaluate in a purely objective fashion, most investigators note major impairments at the tactical level in their brain damaged individuals. Impulsivity, as attributed to disinhibition or reduced cognitive control; poor judgment as derived from poor estimation of risks and inadequate adaptation of speed to traffic conditions; and inability to shift behaviors according to the changing demands of the situation seem to be the primary impairments at the tactical level, (Shore, 1980; Quigley and DeLisa, 1983; and Hopewell, 1985).

The third and lowest level, the operational level, addresses whether brain injured individuals show impairments in basic driving skills. These skills encompass attention and concentration, visual scanning of traffic and environment spatial perception and orientation, tracking, speed in acting, and appropriateness of response when more complex actions must be undertaken. At the operational level, Postma and de Rijk (1985) noted poor coordination in the lower extremities of brain injured patients leading to difficulty in subtle control of the brake and the accelerator. In addition, these same researchers noted that some brain injured individuals were able to adequately judge traffic when riding a bicycle but not when driving a car. In their view, the "pictures were coming too fast for the neurologically impaired individual to process while driving. Essentially, the brain injured individual was unable to process the multiple and complex information as rapidly and smoothly as was necessary for the safe operation of a motor vehicle.

At least five groups of researchers have attempted to assess operational tactical skills as related to driving performance. Sivak, Olson, Kewman, Won, and Henson (1981) used a variety of perceptual and cognitive tasks to evaluate brain injured individuals. In addition, they used both closed course driving and open road driving to further enhance their decision making. Unfortunately, these authors neglected to evaluate the very important features of sustained attention, concentration, rapid decision making including reaction time, cognitive control, and ability to shift attention from one task to another. Jones, Giddens, and Croft (1983) used simple visual acuity tests, basic reaction time, and a preview tracking task in addition to on-road tests to facilitate decision making. These authors apparently did not emphasize perceptual skills in terms of visual scanning, visual-motor coordination, visual sequencing, or perceptual organization. Their measure of attention only entailed standard accelerator to brake reaction times. Unfortunately, attention is a much more complex process entailing freedom from distractibility, capacity to monitor relevant and salient stimuli, stimulus selectivity, and capacity to shift attention from one task to the other. Sivak, Hill, Henson, Butler, Silber, and Olson (1984) actually attempted to modify perceptual deficits through the use of simple paper and pencil exercises. While their results clearly demonstrate that the degree of improvement in driving performance was directly related to the degree of improvement of perceptual skills as reflected in these paper and pencil exercises, the authors failed to work with some of the most important components of the driving task, specifically attention, concentration, and cognitive control.

In the most recent study involving victims of head injury, vanZomeren et al (1988) noted that only one of nine head injured patients was completely free of complaints which might impact upon safe driving. The other patients complained of poor concentration, forgetfulness, intolerance to bustle, and general slowness in behavior. Despite those difficulties, van Zomeren et al found that neuropsychological tests of memory, visual perception and search, attention, and motor functions were not statistically significantly different from those scores obtained by matched controls. Even a measure of lateral position control, the ability to steer a straight course while driving, was not statistically different for the two groups. However, all subjects underwent a test for advanced drivers which consisted of a one-hour drive in the subject's own car in the company of an observer using an extensive rating system covering numerous categories of traffic actions, including vehicle maneuvering. Five of the nine brain injured patients were classified as insufficient in driving while none of the controls received this classification. An analysis of efforts in categories entitled Traffic Actions and Perception and Insight did not differentiate between groups. However, statements by the observer suggested that the errors made by the head injured patients were more serious from the viewpoint of traffic safety. In judging driving fitness, van Zomeren et al concluded that the quality of efforts was more essential to the decision than the quantity. It should be noted, however, that the head injured subjects had been injured between 1973 and 1981 and that the mean interval between injury and inclusion in the present study was six and a half years with a minimum of three years. Since these subjects had been treated in rehabilitation centers with all of the latest techniques for cognitive rehabilitation, it should not be surprising that nonsignificant differences were noted between the rehabilitated relatively independent head injured patients and their matched controls.

The most sophisticated and comprehensive driver evaluation and training procedures for brain injured individuals were undertaken by Kewman, Seigerinan, Kintner, Chu, Henson, and Reeder (1985). The authors' laboratory exercises included tasks of visual-motor tracking, divided attention, and ability to shift attention from one task to another. The most unique aspect of their evaluation and training program included the use of a small electric powered vehicle, an AMIGO, equipped with automatic transmission, power steering, dual brake controls, and hand controls, hemi-peddle controls, and steering knob if necessary. Using the modified AMIGO wheelchair, the brain injured individual was provided eight two-hour driving sessions on seven driving related exercises including: 1) straightaways; 2) an S curve; 3) a figure eight; 4) a serpentine; 5) a serpentine with special visual monitoring, designed as a divided attention task; 6) a serpentine with special auditory monitoring, designed as a divided attention task; and7) a serpentine with both the visual and auditory monitoring tasks combined. The results indicated that the AMIGO Program that included the specific driving related exercises resulted in improved on-the-road driving when compared to the AMIGO control condition without specific training exercises. Interestingly, the brain injured experimental group still scored significantly lower than a non-brain injured reference group on all driving tasks ($p < .05$). Clearly, this study is the most sophisticated, and in our opinion, the most effective driver's evaluation and training program that we have reviewed. The program involves both operational and tactical levels of the driving task. However, most inpatient acute rehabilitation programs have neither the equipment nor the space in which to conduct such an evaluation and training program.

The present battery, entitled the Cognitive-Behavior Driver's Inventory (CBDI), was designed with the recognition that standard methods of appraisal or evolution are either ineffective or too sophisticated and expensive for practical usage. Knowing the patient's diagnosis or pathology typically does not yield predictions about the patient's ability to drive. In fact, two patients with rather similar injuries may differ greatly in their ability to safely operate a motor vehicle. Even loss of brain mass is not deemed to be an exact predictor of driving skills. One would not argue that the neurosurgeon's estimate of tissue loss should be used to predict which patients can drive safely (e.g., patients with a seven percent or more loss cannot drive; patients with six percent or less may). Even neuropsychological tests which can detect gross organic impairment or provide useful catalogs of patients' impairments and abilities do not seem to assess driver potential. Persons with physical disabilities such as paralysis, spasticity, or muscular atrophy can be evaluated and retrained in a relatively straightforward fashion (see Kent et al, 1979). It is much more difficult to decide which brain injured patients have the global intellectual, attention, emotional, and perceptual skills to drive.

With these factors in mind, the authors have constructed an operational battery that is easy to administer and which assesses the requisite skills for safe operation of a motor vehicle. The present battery was designed to elicit those operational behaviors which most closely resemble the sustained attention, cognitive control, and perceptual quickness crucial to the driving task. In addition to the paper and pencil tasks, an Atari microcomputer was used to present quickly changing multiple stimuli under conditions of complexity and distraction, the very problems that make otherwise capable brain injured patients unsafe drivers. Finally, a road test conducted by a trained driving instructor was administered to assess operational, tactical and, to some degree, strategic skills in vivo. The CBDI has been designed to achieve high internal reliability and excellent predictive validity. Performance on the CBDI has been and continues to be, validated against independent evaluations of actual driving skill by a certified driving instructor and trainer. Such validation, by its nature, also includes assessments of the tactical and strategic skills involved in driving. The present study seeks to outline the features of the CBDI, the criteria that have been used to make decisions about driving safety, a report of internal reliability, and brief estimates of test validity based on patients' actual ability to operate a motor vehicle as independently evaluated by a driving instructor.

Procedure

Subjects

The 94 subjects were exclusively neurologically impaired individuals referred to the Patricia Neal Rehabilitation Center of Fort Sanders Regional Medical Center for comprehensive rehabilitation. Whenever a particular patient's fitness to operate a motor vehicle was in issue due to cognitive, perceptual, physical, behavioral, or emotional factors, a staff member would initiate a referral to the driver's Evaluation Program through the appropriate physiatrist. The physiatrist would then make a dual referral to the Psychology and Occupational Therapy Departments. Other patients were directly referred to the Driver's Evaluation Program by independent medical practitioners in the community specializing in neurology, neurosurgery, physiatry, or psychiatry when there was a question as to a particular patient's driving ability.

The primary diagnoses of patients referred to the Driver's Evaluation Program included right cerebral vascular accident (RCVA), left cerebral vascular accident (LCVA), and traumatic head injury (THI) in which there was at least some period of coma following injury and in which there were demonstrable deficits in function as per the Ranchos Scale (Level VIII or below). A fourth category designated Other Neurological Disorders (Other) included those patients suffering from neoplasm, both intrinsic and extrinsic; infections of the brain, including meningitis and viral encephalitis; demyelinating diseases, including multiple sclerosis; Parkinson's Disease; and other systemic disorders in which central nervous system involvement might be expected, such as Guillain Barre Syndrome, lupus erythematosus, and myasthenia gravis. A fifth category included selected spinal cord injured patients (SCI), primarily paraplegics without known brain damage. For purposes of the following analysis, patients were grouped into one of the five following categories, namely: 1) Right cerebral vascular accident (32); 2) Left cerebral vascular accident (25); 3) Traumatic brain injury (20); 4) Other neurological disorders (11); and 5) Spinal cord injury (6). All patients, prior to undertaking the CBDI, sign an Authorization Form allowing the evaluators to forward the results not only to the referring physician, but also to the Tennessee State Department of Safety.

Equipment and Materials

The administration of the CBDI included both computerized and standardized psychometric tasks, to be described below. The computerized items were presented on the Atari 800 computer with an AMDEK Color- I Monitor, an Atari 1050 Disk Drive, and Wico Command Control Joysticks. The computerized software was adapted from Bracy's Cognitive Rehabilitation Programs (BCRP) for brain injured and stroke patients marketed through Psychological Software Services, Inc. (PSS). Standardized psychometric tests included the Picture Completion and Digit Symbol subtests from the WAIS-R (1982) and the Trail Making Tests from the Halstead-Reitan Neuropsychological Test Battery (Reitan, 1955). The visual tests administered with the Keystone Driver Vision

Telabinocular are described below. On-road driver's evaluations were conducted in a specially adapted 1986 Oldsmobile Cutlass equipped with dual brakes and controls.

Composition of Test Battery

In order to test the components necessary for the safe operation of a motor vehicle, tasks were administered in Psychology which addressed attention, concentration, reaction time, rapid decision making, visual scanning, visual alertness, attention to detail, ability to shift attention from one task to another, stimulus discrimination/response differentiation, visual-motor coordination, and visual sequencing (see Exhibit 1). In addition, tests of visual acuity, color blindness, visual fields, and brake reaction time were administered in Occupational Therapy prior to undertaking the road test. The tasks administered were as follows.

Visual Reaction Differential Response (Bracy, 1982)

Adopted from the Bracy Cognitive Rehabilitation Program (BCRP) Foundations I Package, this task measures attention, concentration, and reaction time. The program bisects the monitor's screen into halves by a vertical line. A small dark square appears on the screen, positioned randomly and with variable intertrial delay. The patient responds by pushing the joystick toward the side of the screen on which the square is presented. The results include comprehensive overall reaction time in seconds (VRISPEED), variance (VRIVARIA), errors including premature responses (VRINERRS), and individual response latencies in each of the four visual quadrants (VRIQ1SPD, VRIQ2SPD, VRIQ3SPD, VRIQ4SPD). Criterion scores for comprehensive overall reaction time are less than 0.60 seconds with a variance of less than 500, fewer than two (2) errors, and quadrant response latencies each less than 0.60 seconds.

Visual Reaction Differential Response Reversed (Bracy, 1982)

The task is derived from BCRP Foundations I Package and is essentially identical to Visual Reaction Differential Response but for one key difference. The joystick is turned 180 degrees and the patient responds not by pushing the joystick towards the side of the screen on which the square is displayed but rather by pushing the joystick in the opposite direction. As such, the task again measures attention, concentration, reaction time, and in addition, requires dynamic cognitive processing and simple decision making. During the time the individual performs the task, a radio is playing in the background to provide auditory distracters. The results include comprehensive overall reaction time in seconds (VRIRSPED), variance (VRIRVARI), errors including premature responses (VRIRNER), and individual response latencies in each of the four visual quadrants (VRIRQ1SP, VRIRQ2SP, VRIRQ3SP, VRIRQ4SP). Cutoff scores for overall reaction time are 0.65 seconds with a variance less than 600, fewer than three errors, and response latencies in each of the individual quadrants of less than 0.65 seconds.

Visual Discrimination Differential Response II (Bracy, 1982)

Derived from BCRP Foundations 1, this is a discrimination task in which the individual must fixate on the central of three large, colored squares on the screen. When the color of either the peripheral squares matches the color of the central square, the subject must move the joystick to that side indicating recognition of the match. Three trials are administered on this task which assesses rapid decision making and stimulus discrimination/response differentiation. The subject is expected to perform at better than 85 percent for the number correct versus the number of possible matches (VDDRPTCR) while producing no more than two false positives per trial (VDDR2NVY'R).

Visual Scanning III (Bracy, 1985)

Derived from BCRP Foundations II, Visual Scanning III is a most complex task which assesses one's ability to shift attention from one stimulus set to another and then back again. Two columns of alphabet characters are displayed, one on each side of the screen. Commencing on the left side, a character group is highlighted by a cursor. The patient must find the character group on the right that matches it and move the matching cursor to it using arrow keys on the computer. After entering the answer through the press of the space bar, the same procedure is then repeated with the patient having to obtain the target from the right side column while being required to move the response cursor in the left side column. The alternation continues for twenty trials, consuming approximately five (5) minutes. The subject is expected to correctly target at least 90 percent of the items (VSCAN3KR, VSCANRR3) while solving each presentation in less than ten (10) seconds (VSCAN3LT, VSCANRT3).

Wechsler Adult Intelligence Scale-Revised Picture Completion Subtest (Wechsler, 1981)

This subtest of the WAIS-R consists of twenty drawings, each omitting an important element. The subject's task is to discover what is missing in each picture within a twenty-second time limit. As such, the task requires concentration, visual alertness, visual scanning, attention to detail, and ability to differentiate essential from nonessential details. The criterion for successful completion of the Picture Completion subtest is an expected raw score of thirteen (13) (PICTCOMP).

Wechsler Adult Intelligence Scale-Revised Digit Symbol Subtest (Wechsler, 1981)

The key to the Digit Symbol subtest from the WAIS-R consists of boxes containing the numbers one through nine with a symbol below each number. The individual is required to write the symbols in boxes that contain a number in the upper part and an empty space in the lower part. Total score is the number completed within a ninety second time limit (DIGTTRAN). The Digit Symbol subtest taps visual-motor coordination, fine motor speed, speed of mental operation, visual short-term memory, and visual incidental learning. The expected raw score for successful completion of the Digit Symbol subtest is 39 items.

Trail Making Tests (Reitan, 1955)

The Trail Making Test consist of two parts. Part A consists of twenty-five circles distributed across an 8 1/2" X 11 " sheet of white paper and numbered one to twenty-five. The subjects must connect the circles in order commencing at number one. Part B also consists of twenty-five circles; thirteen of which are numbered one to thirteen and the remainder lettered A to L. The individual must connect the circles alternating between numbers and letters, e.g., 1-A-2-B-3-C-, etc.. The time in seconds to finish each part is the salient variable (TRAILATM, TRAILBTM). As such, the test assesses simple and complex sequencing as well as visual scanning and visual-motor coordination. Successful completion of Trails A is expected in less than 60 seconds while completion of Trails B is expected in less than 120 seconds.

Brake Reaction Test

This is a simple task to determine an individual's reaction time for movement from the accelerator to the brake. The individual is given twenty trials at random intervals. Ten trials occur while the individual is looking at lighted dials mimicking a dashboard. The other ten trials are presented while the individual is looking straight ahead and responding to auditory stimuli. The latter ten trials also evaluate an individual's proprioceptive input. An overall average is calculated (BRAKERTM). The patient is expected to produce average brake reaction latencies of less than 0.60 seconds.

Keystone Driver Vision Test

This test utilizes a Keystone Driver Vision Telabinocular, which is a stereoscopic instrument specifically designed for the vision testing of driver license applicants. The instrument is equipped with double type, + 5.00 D prism lenses corrected for chromatic and spherical aberrations. It utilizes opaque stereograms as test targets. Targets are illuminated from the front by a lamp built into the Telabinocular. The cardholder for targets is permanently set for the equivalence of a twenty-foot testing distance, to eliminate any possibility of error in setting the test positions. The test includes far point vertical balance, far point lateral balance, right eye far point, left eye far point, both eyes far point, color vision-test for severe color deficiency, and color vision-test for mild color deficiency. The subject is expected to pass all visual tests except those for color blindness. If the subject is color blind, it is noted on the assessment form and serves as the basis for not administering Visual Discrimination Differential Response II which is dependent upon color discrimination.

Keystone Periometer Field of Vision

While fixing one's vision on a fixation point, the patient is presented stimuli to determine the ability to detect objects that are approximately 90 degrees to either side of the line of vision. The test is particularly sensitive to homonymous hemianopsia and quadrantanopsia as well as to tunnel vision and other visual field problems caused by neurological injuries. A field of vision that is more restricted than 65 degrees is judged to be dangerous for the safe operation of a motor vehicle and serves as a basis for failure (LPERIOMT, RPERIOMT).

Following completion of the above off-road tests, consideration is given to whether the patient should undertake the on-road test. If the results of the CBDI fall clearly outside the stated criterion, the assessment is terminated and it is recommended that the patient not be allowed to operate a motor vehicle. In many cases, it is recommended that a follow-up driver's evaluation be conducted in six months to one year. If the results are borderline, both the psychologist and the occupational therapist in charge of the program discuss the advisability of undertaking an on-road examination with primary consideration given to the patient's safety and to the probability of an accident. For those patients who achieve the criterion, on-road examinations are promptly administered. In the on-road evaluation, the patient is assessed based on control operations such as locking doors, buckling seatbelts, minor adjustment, checking emergency brake, using turn signals, using the shift selector, starting the car, and using the horn. With regard to attitudinal variables, subjective evaluations are made by the driver's evaluator regarding hostility, confusion, inattention to detail, distractibility, impulsivity, inability to self-correct, difficulty in following directions, poor judgment, inadequate problem solving, reaction under pressure, awareness of traffic conditions, safety awareness, and ability to find one's way around a designated circuit (see Exhibits 2 and 3). In addition, notations are made of the adaptive equipment necessary including hand controls, left foot accelerator, steering devices, and other necessary equipment. The test drive typically commences in a nondemanding area where basic driving skills can be evaluated. When satisfactory, the test drive gradually progresses to more demanding situations so that further assessment of the patient's ability to drive safely can be undertaken.

Assessment Recommendations

Assuming successful completion of all of the driving components, the patient is given a Pass rating and instructed to proceed to the department of Safety of the State of Tennessee for formaldrivingevalua6on. It should be noted that our recommendations have been advisory only and have no legal standing. Upon completion of the examination, a letter is generated to the Department of Safety stating the patient's performance and our recommendation for driving. Formal driver's evaluation, conducted at the option of the State of Tennessee, is then undertaken. It is our judgment the CBDI is much more demanding than the State Driver's Test, thereby, minimizing false acceptances; that is, passing individuals who cannot safely operate a motor vehicle.

Results

Preface

Data analysis had three primary goals: 1) examining item scores; 2) assessing the CBDI's reliability; and 3) inspecting the preliminary data on validity. All analyses were conducted with SPSS-PC+ version 2.0.

Descriptive Statistics

Table 1 shows descriptive statistics for the 27 variables of the CBDI. Of the 94 patients tested, 79 had complete protocols with no missing data. Despite some data points being unavoidably missing (e.g., VDDRPTCR, a color discrimination task which could not be completed by color blind patients), the overall rate of missing data was about one percent (1%).

Eliminating Outliers

An initial psychometric data problem was the presence of a few seriously out-of-range scores for those patients failing to respond coherently to a particular task. For example, VRIRSPED (VRDR Reversed average time) is approximately normally

Table 1

Descriptive statistics on Cognitive-Behavioral Driver's Inventory items: summary scores for 94 brain injured patients.

Item	Mean	Std Dev	Skew-ness	Std Err Skew	Min	Max2	N	Variable Level
BRAKERTM	.56	.10	1.49	.25	.26	1.00	90	Brake pedal reaction time
LPERIOMT	73.87	10.48	-2.42	.26	18	90	89	Periometer degrees, left
RPERIOMT	75.52	10.45	-2.10	.25	30	86	90	Periometer degrees, right
TRAILATM	59.17	29.06	.92	.25	20	120	94	Trails A completion time
TRAILBTM	165.60	87.17	A8	.25	45	300	94	Trails B completion time
VDDR2NWR	6.19	4.09	1.16	.26	1.00	20.00	86	VDDR2, match squares, N errors
VDDRPTCR	83.37	13.99	-1.06	.26	43.00	100.00	86	VDDR2, match squares, % correct
VSCAN3KR	16.30	6.77	-1.91	.25	.00	20.00	94	Vis scan III Match cols left, N correct
VSCAN3LT	13.61	8.72	.99	.25	3.02	30.00	94	Vis scan III Match cols left, time
VSCANRR3	16.41	6.86	-1.88	.25	.00	20.00	94	Vis scan III Match cols right, N correct
VSCANRT3	13.14	8.79	1.03	.25	3.00	30.00	94	Vis scan III Match cols right, time
VRINERRS	1.95	2.64	1.77	.25	.00	10.00	94	VRDR JStick toward square errors
VRIQLSPD	.59	.23	2.35	.25	.34	1.50	94	VRDR JStick toward QI time
VRIQ2SPD	.62	.23	1.93	.25	.33	1.50	94	VRDR JStick toward QII time
VRIQ3SPD	.59	.22	2.04	.25	.33	1.50	94	VRDR JStick toward QIII time
VRIQ4SPD	.62	.27	2.10	.25	.35	1.50	94	VRDR JStick toward QIV time
VRISPEED	.61	.23	2.02	.25	.34	1.50	94	VRDR JStick toward square ave time
VRIVARIA	736.50	1810.16	3.73	.25	20.00	10000	94	VRDR JStick toward square variance
VRIRNERR	3.46	4.24	2.09	.25	.00	20.00	94	VRDR Rev JStick away N errors
VRIRQLSP	.79	.29	1.11	.25	.37	1.50	94	VRDR Rev JStick away QI time
VRIRQ2SP	.80	.30	1.05	.25	.38	1.50	94	VRDR Rev JStick away QII time
VRIRQ3SP	.77	.27	1.08	.25	.33	1.50	94	VRDR Rev JStick away QIII time
VRIRQ4SP	.78	.29	1.16	.25	.43	1.50	94	VRDR Rev JStick away QIV time
VRIRSPED	.78	.27	.96	.25	.38	1.50	94	VRDR Rev JStick away ave time
VRIRVARI	1181.21	2121.16	2.93	.25	38.00	10000	94	VRDR Rev JStick away variance
DIGTRRAN	33.11	16.34	.16	.25	0	72	94	WAIS Digit Symbol N correct
PICTCOMP	12.97	4.54	-.98	.25	0	20	94	WAIS Picture completion N correct

distributed with a mean of 0.78 seconds and standard deviation of 0.27 seconds. If a patient were totally baffled by the task, the score in seconds could be an extremely large number, even infinite if the patient never responded. A few such large numbers could be statistically highly influential, even though they do not reflect behaviorally meaningful differences between patients (i.e., there is no difference between VRIRSPED response latencies of 10 seconds and 20 seconds - both scores are fatally large).

To resolve this problem, maximum scores were established (e.g., 1.50 seconds for VRIRSPED), after which the task was no longer scored beyond the maximum. This procedure is analogous to the common and accepted practice of discontinuing a test after a patient misses a specified number of items. The cut-off values (maximum) for all variables are in Table 1, with rounded values revealing examiner set maxima.

Before cut-off scores were set, some variables had skews as high as 10. After cut-offs were set, all skews were within ±4.00. These corrected data were deemed acceptable for further statistical analysis.

Calculating Standardized Variable Scores

Common scale standardized scores were computed from the multiple predictor variables so that relative performance could be compared over a number of measures. Raw scores were converted to standard scores with a mean of 50.0 and a standard deviation of 10.0. Six variables' directions were reversed so that all low standard scores indicate good performance while high standard scores represent excessive errors or excessive time to completion of the task.

Computed data

When standard scores were calculated, all missing items (0.31 missing items per patient) were replaced with the mean score (50.0) so that patients with one or two missing items could still be used in the study (when standard scores appear, mean replacement may have occurred, but raw scores always reflect exact data without replacement).

A new variable entitled SCATTER was derived from the patient's other standard scores. Traditionally, organic impairment causes larger than normal variability among a patient's scores. For example, if one patient's WAIS-R scores are all between 9 and 11 and another patient's scores are scattered between 3 and 15, the patient with the larger variance is more likely to be organic (Lezak, 1983), even though both may have equivalent intelligence quotients. To obtain an index of scatter, the average deviation of each patient's scores relative to the patient's overall mean score was calculated. The patient's standard deviation (i.e., the deviation of variable scores from the patient's overall mean score) was calculated and then multiplied by 0.674 to produce *average deviation*, the amount by which a patient's standard scale scores differ from his or her overall mean standard score.

Patients' scatter scores (SCATTER) ranged from a minimum of 1.40 to a maximum of 11.20, with a mean of 4.69. SCATTER was then also standardized (with a mean of 50 and standard deviation of 10) to produce ZSCATTER.

Measuring a Patient's Global Performance

A patient's global performance was defined as the average of the standardized item scores. Thus a patient with a total score of 50.00 was exactly average for this sample; a patient scoring 55 would have more impairment than average, while a patient scoring 45 would have performed better than average (see Table 6).

Reliability

Overall Scale Reliability

The internal consistency reliability (Cronbach's *alpha)* is a standard measure of whether the items of a test all measure the same thing. This measure was chosen since test-retest reliability was judged

Table 2

Cronbach's alpha for the Cognitive-Behavioral Driver's Inventory items for 94 brain injured patients.

Scale	definition	Cronbach's alpha	standardized item alpha	ave interitem correlation
Total	All 28 items	.949 (.945)	.949 (.945)	r = .40 (.39)
Best 25	25 items $r_{it} > .4$	*.955 (.951)*	*.955 (.951)*	r = .46 (.44)
Best 21	21 items $r_{it} > .5$	.957 (.952)	.957 (.952)	r = .52 (.50)
Best 16	16 items $r_{it} > .6$	.955 (.951)	.955 (.951)	r = .57 (.56)
Best 11	11 items $r_{it} > .7$	.947 (.942)	.947 (.942)	r = .62 (.62)

Notes:

[1] r_{it} is the item-total correlation, which is higher for items with high internal consistency.

[2] "Best 25" means the 25 items with the best r_{it}, i.e. those with r_{it} equal to or greater than 0.30.

[3] Chronbach's alpha (internal consistency reliability) goes up when better items are used but it goes down as a test gets shorter.

[4] Coefficients in parenthesis concern 79 patients with no missing items or calculated items (scatter). The 94 patients had less than 1% missing items; the grand mean (50.0) was substituted for missings.

Table 3
Cognitive-Behavioral Driver's Inventory items[1] ranked[2] by item-total correlation (internal consistency reliability) for -Q4 brain injured patients.

Variable	mean	Std dev	*N*	r (item, total)	Variable label
ZBRAKERT	50.0426	9.7979	94	.1082	Brake pedal reaction time
ZVRINERR	50.0851	9.9932	94	.2602	VRDR JStick toward square error
ZRPERIOM	50.0532	9.7863	94	.3641	Periometer degrees, right
ZLPERIOM	49.9894	9.7842	94	.4264	Periometer degrees, left
ZVDDR2NW	50.0426	9.5646	94	.4744	VDDR2, match squares, N errors
ZVRIRNER	50.0745	9.9604	94	.4786	VRDR Rev JStick away N errors
ZVRIVARI	50.0213	9.9935	94	.4820	VRDR JStick toward square variance
ZVRIRVAR	50.0426	10.0332	94	.5326	VRDR Rev JStick away variance
ZVSCANRR	50.1064	9.9542	94	.5744	Vis scan III Match cols right, N correct
ZVSCAN3K	50.1596	9.8596	94	.5771	Vis scan III Match cols left, N correct
ZVRIQ4SP	50.0319	9.9973	94	.5938	VRDR JStick toward square QIV time
ZVDDRPTC	50.0106	9.5754	94	.5950	VDDR2, match squares, % correct
ZPICTCOM	50.0745	10.0635	94	.6617	WAIS Picture completion N correct
ZVRIRQ2S	49.9255	10.0132	94	.6618	VRDR Rev JStick away QII time
ZVRIQ2SP	49.9894	10.0166	94	.6815	VRDR JStick toward square QII time
ZVSCANRT	49.8830	9.9869	94	6872	Vis scan III Match cols right, time
ZTRAILBT	49.9362	9.9004	94	.6963	Trails B completion time
ZVSCAN3L	50.0426	10.0941	94	.7075	Vis scan III Match cols left, time
ZVRIRQ4S	50.0106	9.9564	94	.7237	VRDR Rev JStick away QIV time
ZVRIQ3SP	49.9894	10.0166	94	.7398	VRDR JStick toward square QIII
ZVRIQISP	50.0319	10.0370	94	.7400	VRDR JStick toward square QI time
ZTRAILAT	50.0000	9.9871	94	.7588	Trails A completion time
ZVRIRQLS	50.0532	9.9422	94	.7653	VRDR Rev JStick away QI time
ZVRIRQ3S	50.0000	9.9234	94	.7722	VRDR Rev JStick away QIIItime
ZDIGTTRA	49.9787	9.9849	94	.7725	WAIS Digit symbol N correct
ZVRISPEE	50.0000	10.0397	94	.7838	VRDR JStick toward square ave time
ZSCATRER	50.0000	10.0000	94	.8202	Std [50,10] ave deviation across items
ZVRIRSPE	49.9787	10.0075	94	.8217	VRDR Rev JStick away ave time

Notes:

[1] The correlation of an item with all other items in the whole scale is higher for reliable items.
[2] The top items with the worst item-total correlations are the least reliable because they have the weakest relationship with overall driving disability.
[3] 79 patients had no missing items in a sample of 94 patients with less than 1 % missing overall.

inappropriate for studying the impairment of patients recovering from fairly recent brain injuries. The results of this analysis indicate that the CBDI is extremely reliable. Table 2 shows the details of Cronbach's *alpha* for the CBDI. Overall *alpha* was 0.949 for all 27 items plus SCATTER. When weaker test items were eliminated because low part-whole correlations suggested that they measured something other than driving ability, alpha increased very slightly to 0.955 for 16 variables. To make sure that recalculated scores (SCATTER and missing replacements) were not inflating alpha, reliabilities were calculated without any recalculated scores. These *alphas*, in parentheses, were slightly lower. Calculated scores thus were found to inflate the overall reliability coefficient only slightly. Cronbach's alpha and standardized alpha were essentially identical, indicating that standardizing the variables allowed each variable to make an equal contribution to total test variance.

The average correlation of each variable correlated with every other was r = 0.40, indicating that the variables were generally closely related to each other. Hence, a patient scoring low on one variable also scored low on others, the hallmark of a reliable test with high internal consistency.

Variable Reliability

Even though the overall reliability appears excellent it is still possible for certain variables to be candidates for removal from the battery because they measure something other than those cognitive-

Table 4

Relationship between Cognitive-Behavioral Driver's Inventory items and the Psychologist's pass-fail[1] decision for 94 brain injured patients.

Variable	mean pass	mean fail	Std dev pass	Std dev fail	univ Sig	multi Sig [2]	Variable label
			Items making a unique contribution				
ZVDDRPTC	44.4	*55.1*	*5.0*	9.9	.0001	*.0009*	VDDR2, match squares, % correct
ZSCATTER	43.2	56.2	5.6	9.0	.0001	*.0014*	Std [50,10] ave deviation across items
ZDIGTI'RA	43.3	56.1	7.5	7.9	.0001	*.0018*	WAIS Digit symbol N correct
ZRPERIOM	45.8	54.0	4.0	11.7	.0001	*.0059*	Periometer degrees, right
			Items distinguishing passes and fails				
ZLPERIOM	45.8	53.8	5.3	11.3	.0001	*p>.05*	Periometer degrees left
ZPICTCOM	44.6	*55.1*	6.5	10.1	.0001	*p>.05*	WAIS Picture completion N correct
ZTRAILAT	43.8	55.7	4.9	10.1	.0001	*p>.05*	Trails A completion time
ZTRAILBT	43.6	55.8	6.2	9.1	.0001	*p>.05*	Trails B completion time
ZVRIQLSP	45.2	54.5	3.9	11.8	.0001	*p>.05*	VRDR JStick toward square QI time
ZVRIQ2SP	44.4	*55.1*	3.7	11.2	.0001	*p>.05*	VRDR JStick toward square QII time
ZVRIQ3SP	44.6	*55.0*	3.8	11.3	.0001	*p>.05*	VRDR JStick toward square QIII time
ZVRIQ4SP	45.6	*54.1*	6.7	10.8	.0001	*p>.05*	VRDR JStick toward square QIV time
ZVRIRNER	45.9	53.9	4.4	12.0	.0001	*p>.05*	VRDR Rev JStick away N errors
ZVRIRQLS	44.2	55.4	5.3	10.2	.0001	*p>.05*	VRDR Rev JStick away QI time
ZVRIRQ2S	44.3	*55.1*	5.8	10.3	.0001	*p>.05*	VRDR Rev JStick away QII time
ZVRIRQ3S	44.5	*55.0*	6.1	10.1	.0001	*p>.05*	VRDR Rev JStick away QIII time
ZVRIRQ4S	44.6	*55.0*	5.8	10.4	.0001	*p>.05*	VRDR Rev JStick away QIV time
ZVRIRSPE	43.5	56.0	*5.1*	9.7	.0001	*p>.05*	VRDR Rev JStick away ave time
ZVRIRVAR	45.7	*54.0*	2.2	12.5	.0001	*p>.05*	VRDR Rev JStick away variance
ZVRISPEE	44.6	*55.0*	4.0	11.3	.0001	*p>.05*	VRDR JStick toward square ave time
ZVSCAN3K	45.8	54.1	1.3	12.4	.0001	*p>.05*	Vis scan III match cols left, N correct
ZVSCAN3L	43.6	55.9	3.7	*10.5*	.0001	*p>.05*	Vis scan III match cols left, time
ZVSCANRR	45.7	54.2	1.8	12.4	.0001	*p>.05*	Vis scan III match cols right, N correct
ZVSCANRT	43.7	55.6	3.7	*10.5*	.0001	*p>.05*	Vis scan III match cols right, time
ZVDDR2NW	47.0	52.8	7.4	10.6	.003	*p>.05*	VDDR2, match squares, N errors
ZVRIVARI	47.1	52.7	4.3	12.7	.0058	*p>.05*	VRDR JStick toward square variance
ZVRINERR	47.3	52.7	6.1	12.0	.0086	*p>.05*	VRDR JStick toward square error
			Items not distinguishing passes and fails				
ZBRAKERT	49.7	50.4	12.1	7.2	.74	*p>.05*	Brake pedal reaction time

Notes: [1] Pass meant that the psychologist (E.E.) approved the patients taking the state's driving test.
[2]Univariate significance refers to a simple two group oneway ANOVA; multivariate significance refers to nonredundant differences found in a stepwise discriminant including all items.
[3]Translation: Number of errors made when pushing the joystick toward a square appearing on the screen.
Number correct, variance over time, and time of response in seconds were generally measured also.

behavioral skills related to driving. The part-whole correlations in Table 3 indicate the psychometric worth of each variable. The corrected part-whole correlations in Table 3 indicate each variable's correlation with the total score on the test. Excellent variables such as ZVRIRSPE (VRDR Reversed average time) have high part-whole correlations indicating that they measure the quintessence of what the overall CBDI measures. Weaker variables, such as ZBRAKERT (Brake Pedal Reaction Time) or ZRPERIDM (Right Periometer) seem to be measuring something other than driving skill. For example, the variable ZVRIRSPE provides a very good estimate of total CBDI score (r = 0.8217), while ZBRAKERT is not nearly as good an indicator (r = 0. 1082).

Another indicator of variable quality is whether or not it is related to the psychologist's overall judgment of the patient's fitness to drive. If there were measures for which failing patients performed significantly better than passing patients, the worth of such measures would obviously be of questionable utility in making such judgments. To address this question, a discriminant analysis was performed, results of which appear in Table 4. All items without exception had better means for those who passed validity of ZBRAKERT, it was not significantly related to the psychologist's opinion, and its part-whole correlation with the entire battery was extremely low (r = 0. 1082).

Validity

Psychologist's Pass-Fail Decisions and Driving Performance

While a definitive assessment of the CBDI's validity for screening brain-injured drivers awaits completion of a study now in progress, some preliminary evidence is presently available. One form of evidence appears in Table 5, which shows the relationship between the psychologist's pass-fail decision and the outcome of on-road driving test. Of the 44 patients whom the psychologist determined passed the CBDI, 42 (95.5%) passed the actual on-road driving test. This result, along with the finding that CBDI total score is significantly better for patients who pass the road test, suggests that there is significant and meaningful connection between the psychologist's clinical judgment, the CBDI, and the patient's ability to pass an actual road test. Though preliminary, these findings enhance the apparent criterion related validity of the CBDI.

Total Score, Diagnosis and the Road Test

Total scores for patients appear in Table 6 as a function of diagnosis, results of the actual road test and the psychologist's (ESE) opinion as to whether the patient was cognitively and behaviorally capable of driving safely.

Diagnosis: There was no relationship between diagnosis and overall performance [F (1,92) = 1.1, $p > 0.05$]. Apparently overall performance was influenced by degree of cognitive and behavioral impairment, rather than by the exact site of the injury or the diagnosis. This result is not surprising since the overall score reflects a broadly multifaceted performance requiring total cerebral organization of multiple cognitive capacities rather than a narrowly defined and localized task dependent on a single brain structure or zone.

Road test and clinical recommendation: Patients who passed the actual road test had better overall scores than patients who failed or who were not allowed to take the road test [F(1,92), $p < 0.0001$]. This result is evidence, admittedly incomplete, that the CBDI actually measures those cognitive-behavioral abilities that are requisite to passing a road test and safely driving a motor vehicle. Patients who were approved to take the road test obtained an overall standard score of 45.1 while patients who were not approved obtained a standard score 54.6; a difference that was highly significant [F (1,92) = 112.5, $p < 0.0001$].

Table 5
Crosstab tables showing the psychologist's pass-fail decision and results of an actual road test for 94 brain injured patients

Table of patient counts [1]

Actual Road Test / DRIVPOTN	Count	Pass	Fail	No Road Test	Row Total
Examiner pass		42	2	0	44 47.8%
Examiner fail		0	6	42	48 52.2%
	Column Total	42 45.7%	8 8.7%	42 45.7%	92 100.0%

Table of adjusted standardized residual z's [2]

Adj Res	Pass	Fail	No Road Test
Pass	9.2	-1.4	-8.4
Fail	-9.2	1.4	8.4

Notes:

[1] "Counts" refer to the ordinary crosstab count of patients by two variables.
[2] Chi-square (2)=86, p=.0001 for the overall table, Cramer's V=0.97, i.e. there was a strong contingency between the examiner's decision and the results of the actual road test.
[3] "Adjusted standardized residuals" are z scores (mean=0, s.d.=1.0) for each cell in a crosstab table. A cell with a significant z>|+1.96| is one which contributes significantly to the significant overall chi-square.

Discussion

Based upon the obtained results it appears that the CBDI serves as a highly reliable test of the brain injured individual's ability to safely operate a motor vehicle. It is reliable in the sense that the vast majority of the variables intercorrelate with each other to produce a scale of significant internal consistency. The CBDI is also reliable in the sense that those individuals for whom a "pass" decision was made by the psychologist performed better significantly than those for whom a "fail" decision was made on 27 of the 28 variables which were investigated. Consistent with traditional intelligence theory (Spearman, 1904), there appears to be some general or "g" factor for driving which all of the variables apparently measure and which are directly correlated with the psychologist's judgment about the individual's capacity to safely drive. This "g" factor appears to include those cognitive processes which are postulated to exist at Michon's (1979) operational level; e.g., attention, concentration, visual scanning, visual alertness, spatial perception, visual/motor coordination, and ability to shift attention from one task to another. Consistent with the postulated hierarchical structure, an individual incapable of performing appropriately at the operational level is not expected to perform appropriately at the tactical or strategical levels which require such higher level executive functions as estimation of risk, adaptation to changing demands of the situation, judgment, insight, and overall planning ability. This theory is consistent with traditional Lurian Neuropsychological Theory which postulates interdependent but hierarchical functional units of cognition (Luria, 1973).

The new variable entitled SCATTER is, based upon our knowledge, one of the first attempts to actually quantify the frequently noted qualitative observations of brain injured individuals' inconsistency in task performance. The variable is unique in the sense that it measures average deviation, that is, the amount that a patient's average standard score differed from his or her own mean standard score; an intra-individual comparison. Interestingly, SCATMR was one of the most highly ranked items with regard to part-whole reliability (r = 0.8202) and, in addition, was one of the four variables that made a unique contribution to the psychologist's pass-fail judgment. It should be noted

Table 6

Total [1] score on Cognitive-behavioral Driver's Inventory and psychologist's recommendation, outcome of road test, and neurological diagnosis.

Variable	Group	*N*	Mean	Std dev	95% confidence intervals for mean	F	p(alpha)
Psychologists Recommendation	Pass	45	45.1	2.63	44.3 to 45.8		
	Fail	49	54.6	5.48	53.0 to 56.1		
	Total	94	50.0	6.45	48.7 to 51.3	112.5	.0001
Actual Road Test 2	Pass	42	44.8	2.52	44.0 to 45.6		
	Fail	8	52.5	6.09	47.4 to 57.6		
	No test	42	54.8	5.43	53.1 to 56.5		
	Total	92	50.0	6.52	48.7 to 51.4	54.9	.0001
Diagnosis	Left CVA	25	50.1	6.80	47.3 to 52.9		
	Right CVA	32	51.4	6.21	49.2 to 53.6		
	Traumatic	20	49.6	7.26	46.2 to 53.0		
	Spinal cord	6	45.7	5.10	40.3 to 51.1		
	Other	11	48.9	4.96	45.6 to 53.2		
	Total	94	50.0	6.45	48.7 to 51.3	1.1	>.05

Notes: [1]Total scores were the sum of the means of each standard [50,10] item score on all 28 items.
[2]According to a post-hoc Scheffe test, the pass group differs from the other two (p<.05), which do not differ from each other (p>.05).

that this statistic was not available to the psychologist at the time of decision but was, in fact, only calculated after the data were compiled. Therefore, it appears that the psychologist was at least indirectly and subliminally attending to the SCATTER in the protocol when making the pass-fail judgment. The effectiveness of the SCATTER variable in predicting driving ability is inconsistent with the qualitative observations of van Zomeren et al (1988) who noted that it is the type and timing of errors as opposed to the number of errors which rendered brain injured individuals unfit to drive. Further attempts at quantifying SCATTER or intra-individual inconsistency may be crucial in enabling rehabilitation professionals to make a number of judgments regarding brain injured individual's capacity to perform a variety of tasks independently; e.g., handling power tools, handling firearms, returning to the work place, making financial decisions, or living without supervision.

Another interesting aspect of the results was with regard to the variable BRAKERTM (Brake Reaction Time). Though facially, this is a task which one expects would be closely related to driving ability, the analysis suggests instead that it does not correlate highly with the ultimate decision of the psychologist nor does it correlate highly with the other variables in the battery. Evidently, impairment in driving skill as defined by the CBDI is measured best by complex attentional and stressful perceptual tasks such as VRIRSPED (Visual Reaction Differential Reaction Reversed Average Time) rather than by simple tasks like depressing a brake pedal rapidly. In fact, a brief inspection of Table 3 suggests that such items as visual scanning (periometer degrees), number of errors made on a particular task, and even overall variance only minimally contribute to the ultimate pass-fail decision. Seemingly, reaction times, sequencing, visual-motor coordination, and ability to shift attention from one task to another better measure dynamic ability as related to driving skill, a conclusion that is in line with Michon (1979) and with van Zomeren, et al (1988).

The CBDI was constructed primarily by two neuropsychologists and an occupational therapist all with experience in working with brain injured individuals. From that perspective, each of the contributors had certain concepts or ideas about the relevant variables necessary for the safe operation of a motor vehicle. Fortunately, these concepts regarding the cognitive-behavioral skills for safe driving were largely confirmed by the analysis. As we became more comfortable with the reliability of the instrument and the appropriateness of the cut-off (expected) scores, it became apparent that the battery could be applied almost mechanically. In the evolution of our ability to appropriately interpret the results, we discovered that we could turn the testing procedures over to a technician. The technician would administer the CBDI and then report results to the psychologist who could then mechanically make his judgment. Of the 44 individuals whom the psychologist passed, 42 were ultimately judged capable of safely operating a motor vehicle in a semi-blind but independent road test. Of the 48 subjects who failed, only six were allowed to take the road test. All six of those individuals failed the road test. This is a desirable result in light of our stated goal of controlling and minimizing false acceptances, while not protecting as well against the possibility of false rejections.

The CBDI appears reliable and apparently valid enough (though validation studies are still underway) that even for the practitioner with minimal knowledge of neuropsychology, administration of this battery can lead to appropriate and accurate judgments of one's capacity to safely drive. Interestingly, the psychologist's judgments regarding patient's ability to drive were consistent across the five diagnostic categories and did not in any way prejudice one diagnostic category in favor of another. Based on our sample, there did not appear to be any significant difference in the pass-fail judgment between the four major cognitively impaired groups (excluding spinal cord injuries), suggesting that these measures of cognitive and behavioral status are independent of diagnosis. This is further evidence that the CBDI measures skills directly related to driving and not to some disability peculiar to a particular diagnosis.

At the present time, we are in the process of conducting further validity studies in which all patients who take the CBDI are later provided with a road test. The driving evaluator is blind to the psychologist's judgment and has no prior knowledge of the patient's performance on the CBDI. Obviously, for safety reasons, the driving tasks begin with very simple requirements away from traffic. Only as the patient demonstrates his or her capacity to safely operate a motor vehicle in increasingly complex situations is the road test continued to completion. In this way, patients who are grossly unable to complete the road test will do so without having to face any dangerous maneuvers that would threaten the safety of the patient or the road test examiner. In comparison with the comprehensive training and evaluation procedures undertaken by Kewman, et al (1985) which included the use of the modified AMIGO wheelchair, the present battery serves as a useful, inexpensive, highly reliable, and apparently valid estimate of safe driving techniques and operations. Yet, we still do not recommend that the driving decision be made solely upon the results of the CBDI. We still strongly recommend that a road test be administered for all persons for whom a driving decision must be made. At this time, the CBDI appears to serve as an appropriate instrument for disqualifying severely impaired patients from driving. As more validation is accomplished, it may be possible to make fairly good predictions based solely upon CBDI results without the need of a road test. We invite professionals involved in this very difficult decision making to adopt the CBDI and provide the investigators with the results so that we may enhance the reliability and validity of the battery. The results can be sent to the primary author at Lakeshore System Svcs., Center for Outpatient Rehabilitation, 8373 Kingston Pike, Knoxville, TN 327919.

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EXHIBIT I

COGNITIVE BEHAVIORAL DRIVER'S INVENTORY

Eric S. Engum, PhD, JD   Thomas M. Pendergrass, RN, PhD
Laura Cron, OTR

Name: Diagnosis: Date:
Age: Physician:

RAW SCORES   EXPECTED SCORES   SUMMARY:

BREAK REACTION SCORES:
Time:______

KEYSTONE DRIVER VISION TEST:
Pass_____   Fail_____
Problem Areas:____________________________

PERIMETER TEST SCORES:

	Raw	Expected
Right	_____	65-90
Left	_____	65-90

WAIS-R PICTURE COMPLETION:
_______________   13 +/- 3

WAIS-R DIGIT SYMBOL:
_______________   39 +/- 6

TRAIL MAKING TEST:

		Raw	Expected
Test A:	Time:	______	60 seconds
	Errors:	_____	
Test B:	Time:	______	120 seconds
	Errors:	_____	

VISUAL REACTION DIFFERENTIAL RESPONSE:

Mean:			<0.60	
Variance:			<500	
Errors:			<2	
Quadrants:	I.	II.	I. <0.60	II. <0.60
	III.	IV.	III. <0.60	IV. <0.60

VISUAL REACTION DIFFERENTIAL RESPONSE-REV WITH DISTRACTORS:

Mean:			<0.65	
Variance:			<600	
Errors:			<2	
Quadrants:	I.	II.	I. <0.65	II. <0.65
	III.	IV.	III. <0.65	IV. <0.65

VISUAL DISCRIMINATION DIFFERENTIAL RESPONSE II:

Correct/Possible	Errors	Correct/Possible	Errors
Trial 1	______		
Trial 2	______		
Trial 3	______		
AVERAGE		85% to 100%	<6

VISUAL SCANNING III:

Time:_____	No. Correct:	Time:	No. Correct:
Right:_____	_________	10 seconds	90%
Left:_____	_________	10 seconds	90%

Pass_____   Fail_____

____________________________   ____________________________

Eric S. Engum, PhD., J.D.
Director, Clinical Psychology

Laura Cron, OTR
Driving Program Evaluator

EXHIBIT 2

COGNITIVE BEHAVIORAL DRIVER'S INVENTORY

Eric S. Engum, PhD, JD
Thomas M. Pendergrass, RN, PhD
Laura Cron, OTR

Name: Diagnosis: Date:
Age: Physician:

Previous Driving Experience: Yes_____ No______

Transfers:

Test Drive:
Miscellaneous Control Operations

	Pass	Fail	Comments
door/locks	_____	_____	
seat/seat belt	_____	_____	
mirror adjustment	_____	_____	
emergency brake	_____	_____	
turn signal	_____	_____	
shift selector	_____	_____	
ignition	_____	_____	
horn			

Attitude:

	Problem
hostility	____________
confusion	____________
inattention to detail	____________
distractability	____________
impulsivity	____________
inability to self correct	____________
difficulty following directions	____________
poor judgement	____________
inadequate problem solving	____________
awareness of traffic conditions	____________
safety awareness	____________

Adaptive Equipment Used:

hand controls __________ left foot accelerator_________
steering device_________ other____________________

Recommendations from Test Drive:

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Therapist