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ECOLOGICAL VALIDITY OF NEUROPSYCHOLOGICAL ASSESSMENT IN SEVERE TRAUMATIC BRAIN INJURY

by

Stefanie L. Griffin

A DISSERTATION

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Major: Psychology

Under the Supervision of Professor William D. Spaulding

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GRADUATE COLLEGE
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ECOLOGICAL VALIDITY OF NEUROPSYCHOLOGICAL ASSESSMENT IN SEVERE TRAUMATIC BRAIN INJURY

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University of Nebraska, 2001

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The measures currently used in neuropsychological assessment were validated for diagnostic purposes (i.e., locus-of-lesion location); however, neuropsychologists are increasingly being asked to answer questions about everyday vocational functioning (e.g., return to work) and functional competence (e.g., ability to live alone/handle own finances). While an increasing number of studies have recently attempted to investigate questions about the ecological validity of neuropsychological tests, numerous methodological problems, such as poor choice of predictor and outcome variables, have prevented a clear understanding of the relationships between neuropsychological performance and everyday functioning. The present study was designed to assess the utility of a battery of commonly used neuropsychological measures which tap a broad range of cognitive skills in predicting functional competence and vocational functioning in a sample of 25 individuals with severe traumatic brain injury (TBI). A secondary goal of this study was to investigate the relative utility of neuropsychological measures when compared with other well-described predictors of outcome, including demographic,

biomedical, and emotional variables. Results indicated that participants were severely impaired, performing at approximately one to two standard deviations below the mean on most measures of neuropsychological, vocational, and functional performance. Analyses revealed that neuropsychological measures were generally poor predictors of vocational functioning, and that they did not provide significantly greater predictive utility than demographic variables such as prior occupational level. In contrast, neuropsychological measures of arithmetic and attention/speed of information processing accounted for approximately 46% of the variance in measures of overall functional competence, and provided a greater degree of predictive utility than demographic, emotional, or biomedical variables. Limitations of the study include small sample size and homogeneity of injury severity and suggest that these findings may be applicable to only a severe TBI sample. The findings highlight the need for future research investigating the relationship between neuropsychological performance and clinically useful outcome variables in different patient populations.

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The purpose of neuropsychological assessment is threefold (Miller, 1992): to answer diagnostic questions, to measure changes in cognitive functioning, and to provide information concerning the impact of cognitive impairment on an individual. Historically, neuropsychological evaluations were primarily employed for the detection and localization of injury/diseases of the brain (Hart & Hayden, 1986; Heaton & Pendleton, 1981; Heinrichs, 1990), thus addressing mainly diagnostic questions. In keeping with this focus, the tests currently in use by clinical neuropsychologists were developed and validated for their ability to detect specific lesions in the brain (Hart & Hayden, 1986). However, as more sophisticated methods of detecting brain injury have developed (i.e., CT, MRI, PET, SPECT scans), neuroimaging has taken the place of neuropsychological assessment as a primary tool for "locus-of-lesion" (Hart & Hayden, 1986, p. 23) detection. Further, technological advances in the field of medicine have allowed for decreased mortality following neurologic insult (i.e., traumatic brain injury, stroke, etc.), so that increasing numbers of individuals are surviving with lingering cognitive deficits (Guilmette & Kastner, 1998). While neuropsychological assessment remains useful as a tool for understanding the behavioral consequences of brain injury, the relatively recent development of neuroimaging techniques and other medical technologies has encouraged neuropsychologists to play new roles in patient care. Neuropsychological assessment may still be employed as an instrument in a larger diagnostic evaluation; however, its limitations for diagnostic purposes are clear (Miller, 1992).

Contemporary clinical neuropsychologists are increasingly asked to go beyond diagnostic statements to make predictions about patients' everyday functional abilities,

including strengths and weaknesses for vocational rehabilitation, deterioration in functioning from premorbid levels, and prediction of rehabilitation potential (Acker, 1986; Heinrichs, 1990). Clinical neuropsychologists are also asked to make specific statements regarding a patient's ability to drive, return to work, or handle his/her own legal, financial, and medical decisions. In attempts to respond to these types of referrals, clinical neuropsychologists often rely on tests which were not originally designed to address such questions (Hart & Hayden, 1986).

Paradigm shift in neuropsychology

Echoing concerns by many, Heinrichs (1990) has argued that "neuropsychological assessment, as it is currently practiced with batteries of tests focused on neurodiagnosis, is not well equipped to fulfill its expanding role" (p. 171). Since the early-1980's, the number of studies designed to evaluate the ecological validity of neuropsychological tests has increased (Hart & Hayden, 1986). The term "ecological validity" refers to the accuracy with which a neuropsychological measure can predict an individual's current capabilities in everyday life (Heinrichs, 1990). The increased interest in the concept of ecological validity is reflected in increased numbers of review articles (e.g., Acker, 1986), as well as the development of newer, more "ecologically valid" assessment tools (e.g., The Rivermead Behavioural Memory Test; Wilson, Cockburn, & Baddeley, 1985). Further, increasing numbers of researchers are focusing on neuropsychological prediction of everyday functioning in areas such as vocational performance (i.e., Bowman, 1996; Heinrichs, 1989; Newnan, Heaton, & Lehman, 1978; Ryan, Sautter, Capps, Meneese, & Barth, 1992), driving ability (i.e., Fox, Bowden, Bashford, & Smith, 1997; Golper, Rau, &

Marshall, 1980) activities of daily living (e.g., eating, dressing, hygiene; Denes, Semenza, Stoppa, & Lis, 1982; Williams, 1967), and handling of personal affairs (i.e., Marson, Cody, Ingram, & Harrell, 1995).

Some authors have denied the necessity of demonstrating empirical support for the use of neuropsychological measures in making predictions about patients' functional capacities. For example, Heaton and Pendleton (1981) recommended a strategy which relies on the belief that neuropsychological tests are face valid (in other words, the assumption that they accurately predict the abilities that they appear to assess). In citing the disadvantages of utilizing neuropsychological tests to make decisions regarding competency, Moye (1996) noted that "because of the tradition within neuropsychology, some evaluators may be reluctant to make inferences about the meaning of test scores for competency questions without empirical support for such inferences" (p. 31); despite his statement, this author strongly recommends using neuropsychological measures to evaluate competence.

Other authors have recommended against using currently available neuropsychological measures (i.e., Heinrichs, 1990; Rothke, 1992), suggesting the need to develop entirely new batteries of tests for the purpose of predicting everyday functioning. For example, Rothke (1992) has suggested that neuropsychologists develop instruments which include observations of patients performing a wide variety of "real-world" activities (e.g., remembering a list of grocery items, paying a bill, reading a sign). However, assessment of a full range of functional capacities would prove to be overly time and labor intensive if a battery of neuropsychological tests could be shown to reliably predict

performance on these same tasks.

Neuropsychologists' predictions about patient functioning are often based on clinical judgments rather than empirical results (Dodrill & Clemmons, 1984). For example, Williams (1998) notes that despite the fact that no study has examined the relationship between motor skills (e.g., Finger Tapping test) and the ability to perform assembly line work, clinicians persist in the belief that these skills are related. A significant body of research has suggested that even when attempting to answer more simple diagnostic questions, clinicians are prone to errors in judgment which result from attempts at combining large amounts of complex information using simple, linear models of information processing (Brehmer, 1980). Further, clinicians are also prone to judgment errors which result from the use of a variety of faulty heuristics (Chapman & Chapman, 1967, 1969; Dawes, 1986; Wedding & Faust, 1989). Neuropsychological prediction of everyday functioning is expected to be very susceptible to judgment error, as this task requires the integration of a wide range of data from measures which are not even validated for predictive purposes. It is thus evident that the challenge of validating neuropsychological measures for predictive purposes is a particularly important one.

Ecological Validity

While a growing body of literature is attempting to meet this challenge, methodological inconsistencies in the existing studies have resulted in varying conclusions regarding the ecological validity of neuropsychological assessment. Common methodological problems include the use of self-report measures to assess everyday functioning, inconsistent choice of neuropsychological measures, and failure to employ the

flexible battery approaches most often used by clinical neuropsychologists (Faust, 1991). Such problems make it difficult to apply empirical findings to the practice of clinical neuropsychology.

Review studies by Dodrill and Clemmons (1984), Baird, Adams, Ausman, and Diaz (1985), and Shelton and Parsons (1987) have concluded that only limited relationships exist between neuropsychological test performance and everyday functioning. Based on a brief review of the literature prior to 1991, Faust (1991) concluded that "current research does not support the proposition that neuropsychological tests or assessment methods permit accurate description of current functioning, nor prediction of future functioning" (p. 211). On the other hand, review studies by Heaton, Chelune, and Lehman (1978) and McSweeney, Grant, Heaton, Prigatano, and Adams (1985) have concluded that stronger relationships do exist between neuropsychological performance and everyday abilities.

Clearly, the American Psychological Association, in conjunction with other organizations, has stipulated that "when a test is to be used for a purpose for which it has not been previously validated, or for which there is no supported claim for validity, the user is responsible for providing evidence of validity" (Standard 6.3, AERA, APA & NCME, 1985). In order to maintain credibility in the field of clinical neuropsychology, and avoid violation of ethical guidelines for psychological testing, efforts to establish the ecological validity of neuropsychological measures must continue.

Impairments in vocational functioning and functional competence (i.e., ability to make medical decisions, utilize community resources, make appropriate safety decisions,

and handle financial decisions) are among the most debilitating impairments observed in neuropsychological practice. Neuropsychologists are often faced with making determinations about a person's ability to perform these major life activities. In concluding that an individual is incapable of performing a specific activity (i.e., returning to work, living alone), a neuropsychologist is effecting significant change in the quality of that person's life, and is potentially stripping that individual of basic human rights. Thus, it is imperative that such conclusions be solidly grounded in empirical data. In this review of empirical investigations of the ecological validity of neuropsychological assessment in the areas of vocational functioning and functional competency, an attempt will be made to draw general conclusions and highlight methodological problems.

Neuropsychological prediction of vocational functioning

Research has demonstrated that a only small percentage of individuals with a history of severe traumatic brain injury (TBI) return to the same employment held prior to injury (Bowman, 1996), while published estimates of return to work of any kind following TBI range from 15%-76% (Ben-Yishay, Silver, Piasetsky, & Rattok, 1987). Many individuals with a history of traumatic brain injury are unable to return to work even after participation in intensive vocational rehabilitation (Ryan et al., 1992). Attempts at predicting vocational functioning following head injury have potential utility in guiding individuals toward the appropriate utilization of rehabilitation resources (Ryan et al., 1992). Referral questions related to vocational functioning are common in neuropsychology: a 1990 survey of clinical neuropsychologists revealed that vocationally-related questions were second in frequency (Guilmette & Kastner, 1998). Specific

questions asked of neuropsychologists include whether a given patient is able to return to work, and if so, what skills can be drawn upon to assist with employment. As such, the neuropsychological evaluation is often characterized as an assessment of an individual's strengths and weaknesses for future vocational functioning (Ryan et al., 1992).

Investigators have attempted to describe the variety of variables related to vocational outcome after TBI. In most studies, vocational outcome is defined as employment status (i.e., employed/unemployed), with far fewer studies focusing on more complex aspects of vocational performance. Numerous investigators have included non-cognitive variables, including demographic and biomedical characteristics, in attempts to predict outcome after TBI. Demographic variables which have consistently been shown to be associated with return to work following TBI include age at time of injury (Bruckner & Randle, 1972; Brooks, McKinlay, Symington, Beattie, & Campsie, 1987; Dikmen, Temkin, Machamer et al. 1994; Sander, Kreutzer, Rosenthal, Delmonico, & Young, 1996) education (Rimel, Giordani, Barth, Boll, & Jane, 1981), and preinjury job level, stability, and income (Dikmen et al., 1994; MacKenzie, Shapiro, Smith et al., 1987; Rimel et al., 1981). Research has shown that individuals over the age of 40 (Sander, Kreutzer, & Fernandez, 1997) or 50 (Dikmen et al., 1994; Rothweiler, Temkin, & Dikmen, 1998) at the time of their head injuries are less likely to return to employment than younger individuals. Further, individuals with less than a high school education are less likely to return to work following TBI (Dikmen et al., 1994), as are individuals with unstable work history prior to injury (Dikmen et al., 1994). In addition, severity of injury frequently emerges as the most robust predictor of return to work following TBI (Dacey, Dikmen,

Temkin et al., 1991; Dikmen et al., 1994; MacKenzie et al., 1987; Sander et al., 1996). As might be expected, individuals with more severe head injuries have been consistently shown to have a lower likelihood of returning to employment after injury.

Not surprisingly, research has also suggested that impairments in cognitive, emotional, and behavioral functioning are significant impediments to vocational functioning following traumatic brain injury (Ben-Yishay et al., 1987, Dikmen, Machamer, Savoie, & Temkin, 1996). Cognitive difficulties most often reported by patients and employers as impediments to return to work include slowed thinking, confusion, memory difficulties, communication difficulties, and diminished awareness of deficits (Sander et al., 1997). Others have reported that cognitive problems, such as impairments in reasoning and concentration, as well as psychosocial problems, such as decreased initiation, social isolation, and lack of responsibility, contribute to vocational difficulties (McMahon & Shaw, 1998). Studies have generally consistently found that performance on measures of attention, verbal learning, verbal memory, and visuoconstructional skills is lower in unemployed individuals following brain injury (Brooks et al., 1987; Ip, Dornan, & Schentag, 1995). Relationships have also been found between verbal aptitude and psychomotor dexterity and the likelihood of gaining employment following head injury rehabilitation (Ezrachi, Ben-Yishay, Kay, Diller, & Rattock, 1991).

Crepeau and Scherzer (1993) performed a meta-analysis of studies published between 1967 and 1990, which investigated cognitive impairments as indicators of work status. While the authors' intention was not specifically to review the ecological validity of neuropsychological measures, their meta-analysis included only studies that utilized

neuropsychological tests as predictor variables. Overall, the authors found that measures of global cognitive functioning (i.e., intelligence measures, the Halstead Impairment Index, Raven's Progressive Matrices) correlated moderately well with work status, $r = 0.33$, as did measures of language and communication ability, $r = 0.30$, and measures of visuospatial ability $r = 0.27$. Overall, measures of executive functioning and cognitive flexibility (i.e., Wisconsin Card Sorting Test, Dual Task, Trail Making Test, Part B, Tinker Toy Test) consistently demonstrated the highest correlations with work status, $r = .49$. However, one frequently used measure of executive functioning (i.e., Category Test), was shown to be unrelated to work status. Crepeau and Scherzer noted that methods of assessing cognitive functioning varied widely throughout the literature, and reported that this heterogeneity of methodology created problems for the meta-analysis. This was especially apparent in the assessment of attention and memory. Reported correlations between measures of attention/concentration (i.e., WAIS Digit Symbol subtest, Paced Auditory Serial Addition Test, McGill Picture Anomalies Test) and vocational functioning averaged 0.21, with widely ranging estimates, depending on the measure used (i.e., studies using the WAIS Digit Symbol test reported correlations ranging from 0.55 to 0.76). Further, the authors reported that they could not compute an overall r for measures of memory, because the heterogeneity of reports was so extreme. For example, studies reported correlations ranging from 0.00 to 0.58, depending on the type of memory measure used.

In a review of studies addressing the utility of neuropsychological measures in predicting vocational functioning, Guilmette and Kastner (1998) reached the following

conclusions: the severity of cognitive dysfunction is inversely related to the likelihood of successful employment; neuropsychological assessment is better at determining who will do poorly than who will do well in a job setting; measures of mental speed, memory, and conceptual ability have demonstrated consistent relationships to work functioning, in general, while measures of numerical and verbal abilities have demonstrated consistent relationships to success at clerical, managerial and professional occupations, and measures of visual-motor speed and perceptual functioning have demonstrated consistent relationships to success at jobs which require constructional skills; and measures of psychological/psychosocial functioning account for a significant additional portion of variance in vocational functioning. These authors recommended that research in the field would benefit from utilization of a consistent battery of neuropsychological measures for study. They further suggested that neuropsychological batteries be normed on specific occupational subgroups.

Overall, research suggests that the strength of the relationship between neuropsychological test performance and employment status is low to moderate (Williams, 1998). In studies assessing the relationship between vocational status and neuropsychological test performance, measures of speed of information processing (i.e., WAIS-R Digit Symbol subtest, Paced Auditory Serial Addition Test), verbal memory (WMS-R Logical Memory subtest), and executive functioning/cognitive flexibility (i.e., Trail Making Test, Part B, WCST) most consistently emerge as predictors.

Increasingly, investigators have combined demographic and biomedical variables with neuropsychological and emotional measures in attempts to optimize prediction of

vocational outcome. Heaton et al. (1978) evaluated the use of a battery of neuropsychological tests, including the Wechsler Adult Intelligence Scale (WAIS), subtests of the Halstead-Reitan Neuropsychological Battery (HRNB), the Peabody Individual Achievement Test, the Story Memory Test, and the Wechsler Memory Scale (WMS) Figure Memory subtest, as well as Minnesota Multiphasic Personality Inventory (MMPI) subtests, in predicting vocational functioning (i.e., patient's self-report of employment status). When neuropsychological variables alone were submitted to discriminant function analysis, they correctly classified fewer subjects with respect to employment status (74.2%) than when neuropsychological variables were combined with MMPI variables (83.7%). Individual neuropsychological measures which most contributed to classification included the WAIS Performance subtests and the HRNB subtests. Heaton and colleagues concluded that, while the results of their analyses are useful for determining which individuals were at highest risk for unemployment following head injury, their analyses did not adequately account for the impact of specific impairments on employment status.

Ryan et al. (1992) investigated the utility of a battery of neuropsychological measures (i.e., WAIS-R, subtests of the HRNB, and others) and measures of emotional functioning in predicting patient referral for vocational evaluation, recommendation for vocational training, and final vocational classification or recommendation. Discriminant function analysis revealed a 77-78% hit rate in classifying subjects according to whether they received a vocational evaluation, with predictor variables including reading comprehension, immediate and delayed non-contextual verbal memory, aphasic errors, and

level of depression.

Bowman (1996) examined the utility of neuropsychological variables (i.e., selected subtests of the WAIS-R, WMS, and HRNB) as compared to demographic variables (i.e., age, sex, race, education), biomedical variables (i.e., length of coma, length of PTA, neuroimaging evidence) and emotional variables (i.e., psychosocial adjustment) in predicting vocational functioning following head injury. When combined with demographic, biomedical, and emotional variables, neuropsychological variables accounted for 21% of the variance in vocational functioning, as assessed by a nine-point scale including qualitative and quantitative aspects of functioning; demographic factors accounted for 27% of the variance. The individual neuropsychological variables which contributed most to the regression equation included Performance IQ, Digit Span, Picture Completion, Block Design, Digit Symbol, Trail Making Test Part B, and the Wechsler Memory Score. Combining all of the best predictors from each variable subtype, Bowman developed a final regression equation, accounting for 34% of the variance in vocational functioning, including the Block Design subtest, the Wechsler Memory Score, age at injury, sex, months to latest vocational functioning, vocational functioning at the time of testing, MMPI raw K score, and use of rehabilitation. Further discriminant function analysis revealed that this regression equation correctly classified 75% of unemployed subjects and 66% of employed subjects. Bowman concluded that neuropsychological variables are relatively better predictors of vocational functioning than emotional and biomedical variables, but noted that they are generally similar in utility to demographic variables.

Just as neuropsychological variables can provide predictive utility in making statements about return to work following neurological insult, studies have shown that demographic and severity of injury variables alone can correctly classify up to 68% of individuals in terms of employment status (Sander et al., 1996). If such variables, which take less time to collect than a battery of neuropsychological measures does to perform, can make relatively accurate predictions about vocational status, neuropsychological assessment must provide evidence of a stronger functional role for itself. The role for neuropsychology may involve predicting specific aspects of vocational performance (as opposed to vocational status). However, the utility of neuropsychological measures in predicting specific job skills has not been adequately studied.

In order to study such variables, it is important to understand which job skills are key to maintenance of productive employment. Research suggests that a major cause of job termination is poor coworker and supervisor relations (McMahon & Shaw, 1998). Other important job skills which are often addressed in vocational rehabilitation programs include "work behaviors (skill proficiency, work rate, work quality, work endurance); work values; work interests; learning style; and motivation" (McMahon & Shaw, 1998, p. 371). McMahon and Shaw (1998) have recommended a set of referral questions for use by vocational rehabilitation specialists referring clients for neuropsychological evaluation These include:

> Please comment upon...proficiency, rate, quality, and endurance...work adaptive behaviors (e.g., concentration and attention to task, capacity to get along with coworkers, response to authority, punctuality, attendance, grooming,

> hygiene)...learning style, with specific impressions regarding the type of training (e.g., formal academic or on-the job) which may be possible...self-awareness of cognitive strengths and deficits, and response to feedback or correction... areas of strength .... what level of supervision is required to perform the targeted job with proficiency... (p. 383).

These recommendations clearly indicate that neuropsychologists are expected to answer questions which are far more complex than whether or not an individual can return to work. It thus becomes evident that research needs to address the ability of neuropsychological measures to predict specific aspects of vocational functioning, including attitude toward work, interpersonal relationships, ability to work independently, and ability to complete specific task demands.

A small number of studies have investigated neuropsychological prediction of vocational performance as opposed to vocational status. One early study (Newnan et al., 1978) investigated the relationship between neuropsychological performance and vocational functioning in a number of different types of jobs, using individuals without neurological injury. They found that individuals who worked in clerical, administrative, and professional jobs scored higher on measures of verbal, numerical, and clerical skills, while those with jobs requiring motor and perceptual skills scored higher on measures of spatial relations. Butler, Anderson, Furst, Namerow, and Satz (1989) utilized work quality and work quantity ratings made by supervisors in simulated work settings, and found that only the WMS Visual Reproduction subtest and the Wisconsin Card Sorting Test (WCST) were significantly correlated with these ratings. Kibby, Schmitter-Edgecombe, and Long

(1998) examined the utility of the WCST and the California Verbal Learning Test (CVLT) in predicting job performance in TBI patients. Subjects were rated in terms of employment status as well as their current job performance (based on self-report and relative report). These authors found that the CVLT was a significant predictor of performance on the job, while both the WCST and the CVLT predicted the employment status of participants. Clearly, more studies of this sort are needed with larger batteries of neuropsychological measures.

This review highlights a number of methodological problems in studies investigating neuropsychological prediction of vocational functioning. One major limitation includes the use of inconsistent and/or limited outcome measures. The large majority of studies use employment status as an outcome variable, while failing to investigate more complex features of vocational functioning, (i.e., see discussion above). Thus, neuropsychologists are still at a loss to explain how performance on specific tests relates to specific aspects of job performance. Further, even within studies using employment status as an outcome variable, the criteria for defining employment status vary from part-time to full-time employment (Guilmette & Kastner, 1998; Sander et al., 1996). While available research suggests that neuropsychological measures provide some predictive utility in making statements about an individual's ability to work following injury, there is no empirical evidence to aid clinical neuropsychologists in answering referral questions about what types of employment an individual might best perform, or whether an individual will be successful in returning to previously held employment.