The Estimation of Premorbid Intelligence: a Comparison of Approaches.

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THE ESTIMATION OF PREMORBID INTELLIGENCE:
A COMPARISON OF APPROACHES

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ABSTRACT

Early methods to estimate premorbid intelligence focused on the use of the WAIS or WAIS-R IQ scores or selected WAIS or WAIS-R subtests. It was expected that performance on such tests would remain stable after a brain injury. As further research showed this belief was not valid, researchers turned to the use of other tests of current ability, one being a measure of reading ability known as the National Adult Reading Test (NART).

A second approach focused on the relationship found between certain demographic variables and intelligence. More recently, researchers have employed an approach that combined present abilities performance and demographic predictors in regression equations. Vanderploeg and Schinka (1995) used a combination of present ability as measured by the WAIS-R with certain demographic characteristics. Friedberg and Gouvier (1996) developed linear regression equations to estimate WAIS-R IQs using estimated Barona IQ (Barona, Reynolds, & Chastain, 1984) combined with error score on the NART.

The present study compared the equations of Vanderploeg and Schinka (1995) with those of Friedberg and Gouvier (1996) using normal subjects and brain-injured individuals. Both sets of predictor equations found significant differences for the estimated IQ scores of the two groups.
with the control group having higher estimated scores than the head-injured group.

Secondly, both sets of predictor equations noted a significantly greater difference between the estimated and obtained IQ scores for the CHI group than for the control group. This finding suggested that the obtained IQ scores were significantly decreased from premorbid levels, suggesting clinical utility for the equations as measures of premorbid intelligence.

Finally, a comparison of the two sets of equations using a hierarchical regression pointed to the Vanderploeg and Schinka equations as better predictors of premorbid intelligence as they accounted for more of the variance than the Friedberg and Gouvier equations. However, this may be partly due to the fact that the predictor equations were derived from the same data as the criterion variable. This would suggest the need for further research using predictors that are independent of the data used in the criterion.
INTRODUCTION

After an individual has suffered a brain injury because of trauma, a stroke, or any number of other reasons, it may be necessary to do an assessment to measure his or her current level of functioning for clinical, legal, or research purposes (Lezak, 1983). However, if premorbid testing is not available for a comparison, it is difficult to determine the level of deterioration or if, in fact, there has been any deterioration at all in certain areas of competence. Normative data can be used to convey the individual's relative standing to an appropriate reference group, but it is not particularly useful in determining if there has been a decline in the absolute level of ability (Reitan & Davison, 1974). To further complicate matters, there are individuals who, for a variety of reasons, may not match well with any of the published reference groups for certain psychological tests.

Therefore, some measure of premorbid functioning would be of great value in presenting a more accurate estimate of where the patient stood before the injury and thus permit better comparison with the current situation. A comparison of current performance with data from cognitive test batteries administered prior to the neurological disorder would be ideal. But beyond school or military records, such information is usually not available, so one must then turn to estimates of premorbid functioning to provide the appropriate information (Vanderploeg & Schinka, 1995).
It has long been recognized that establishing an estimated level of premorbid intellectual functioning would be a difficult endeavor to undertake (Yates, 1956; Wechsler, 1958). Demographic variables such as age, sex, race, education and occupation had previously been identified as being of potential use in estimating premorbid intelligence. However, when subjective estimates are derived from this information, they are often unreliable because the estimates are still made primarily on clinical judgment, past experience with similar populations, and intuition (Golden, 1978; Golden, Zillmer, & Spiers, 1992; Gregory, 1987). A need arose for more objective measures to estimate premorbid intelligence and research efforts have been directed towards using the demographic information in such a manner (Eppinger, Craig, Adams, & Parsons, 1987).

Approaches to the determination of premorbid levels of function have primarily focused on measures attempting to predict WAIS or WAIS-R intelligence quotients. Three distinct types of predictor variables have been examined in the research. The first type of variable focuses on estimates based on measures of current ability. The second type examines estimates based on demographic information. The third type attempts an amalgamation of both current ability and demographic information (Vanderploeg & Schinka, 1995). The discussion will review the research looking at each type of predictor.
Estimation Procedures Based on Current Performance

The area of prediction of premorbid functioning has been researched since 1944 when Wechsler first presented his concept of the Wechsler-Bellevue "Deterioration Index" (Wechsler, 1944). The idea behind this concept was that certain measured subtests of intellectual functioning were unaffected by the normal aging process (known as "hold" subtests) while others showed a typical age-related decline (known as "don't hold" subtests). When the "hold-don't hold" difference exceeded what would be normally exhibited, organic impairment would be suspected.

The publication of the Wechsler Adult Intelligence Scale (Wechsler, 1955) led to the introduction of the "Deterioration Quotient" as a tool for diagnosing brain damage (Wechsler, 1958). This reflected modification in composition and definition of the "hold" and "don't hold" subtests from the 1944 formulation. Wechsler postulated that WAIS Vocabulary, Information, Picture Completion, and Object Assembly subtest scores were minimally affected by the effects of aging and brain impairment. Conversely, Digit Span, Similarities, Block Design, and Digit Symbol comprised the "don't hold" tests that were influenced by damage sustained by the brain. A score reflecting the estimated premorbid level of intellectual functioning was then derived by contrasting performance on the "hold" subtests with the performance on the "don't hold" subtests. Specific scores
were statistically determined to be used in comparison to identify "possible deterioration" and "definite deterioration".

Several authors subsequently suggested modification to this approach. Yates (1956) proposed using only WAIS Vocabulary scores while McFie (1975) suggested using the average of Vocabulary and Picture Completion scores, or the higher of these two subtests, if one is substantially lower, as the best estimate of premorbid functioning.

However, it appears brain damage can adversely affect the WAIS "hold" measures (Russell, 1972), with different types of injury differentially affecting some measures more than others (McFie, 1969). Further, subsequent literature reviews have cast doubts on the validity of using "hold" and "don't hold" subtests as an aid in diagnosing organic cerebral pathology (eg. Matarazzo, 1972; Klesges, Wilkening, & Golden, 1981; Vogt & Heaton, 1977). Studies have shown that the "hold"-"don't hold" method has been unable to differentiate patients with organic impairment from those with psychiatric symptomatology (Crookes, 1961; Bersoff, 1970). Revised ratios of the deterioration quotient that have had success in identifying brain-damaged subjects within one group have failed to discriminate brain-damaged subjects in another similarly constituted group (Watson, 1972).

Klesges et al. (1981) discussed reasons to doubt the stability of Wechsler's four "hold" tests when brain damage is sustained. The authors
concluded that the approach was probably a "simplistic and inaccurate approach to assessment of premorbid status" (p. 34). Klesges and Troster (1987) further stressed that there is a tacit but rather clear assumption behind the "hold-don't hold" approach that the brain is assumed to be equipotential for function and that brain damage is expressed in a unitary manner regardless of the localization or acuteness of the injury. This assumption is inconsistent with more contemporary empirically-based theories of brain-behavior relationships (Golden, 1979). In actuality, the assumption was considered somewhat questionable even when the "Deterioration Quotient" was a new topic. Allen (1948), for example, found in a study of brain-damaged patients that Object Assembly was among the three most seriously impaired of all the subtests, suggesting that its classification as a "hold" test, and thus as an index of premorbid functioning, was incorrect.

Lezak (1983) noted that the Wechsler Vocabulary subtest is the "hold" test most commonly used to estimate premorbid intellectual functioning. In fact, due to the nature of the test, it has long been assumed that Vocabulary is the single best measure of premorbid functioning (Zimmerman & Woo-San, 1973). Research, however, has consistently shown that current Vocabulary performance of neurological patients is significantly lower than that of healthy subjects and of non-neurological patients.
Unfortunately, most of the early studies failed to control for the influence of demographic factors that are known to impact vocabulary skills, such as age and education level (Matarazzo, 1972).

Vogt and Heaton (1977) found WAIS Vocabulary subtest performance of neuropsychologically impaired subjects was significantly lower than that of unimpaired subjects. However, this difference may have been due to a significant difference in the level of education for the two groups. Russell (1972) also found similar differences using the WAIS Vocabulary subtest in an age-matched hospitalized patient group. However, these results may have been further skewed because the brain-damaged group also included congenitally brain-damaged patients.

In studies that controlled for the possible effects of age and education, WAIS FSIQ estimated from WAIS Vocabulary scale scores for patients diagnosed with dementia of the Alzheimer's type (DAT) were found to be significantly lower than that of similar controls (Hart, Smith, & Swash, 1986). Similar results were reported for other neurological disorders, such as multi-infarct dementia (MID), alcoholic dementia, Huntington's disease, and Korsakoff's disease (Crawford, Parker, & Besson, 1988). These results seemed to indicate that vocabulary skills do not remain stable after a traumatic injury. It also appears that the role of such variables as cultural environment and education on vocabulary skills confound interpretation and
make it difficult to confidently or consistently use performance on this subtest for estimating premorbid functioning (Klesges et al., 1981).

It has also been suggested that the WAIS Picture Completion subtest correlates highly with the construct of general intelligence (Zimmerman & Woo-San, 1973) and would be a good predictor of premorbid intelligence if it were impervious to the effects of brain damage. However, Reitan (1959) found significant differences between brain damaged and normal individuals on this subtest. McFie (1975) noted that performance on Picture Completion may be sensitive to secondary area occipital and left parieto-occipital lesions.

Finally, the WAIS Information subtest is clearly sensitive to educational and environment variables and, like the Vocabulary subtest, is not always an adequate reflection of the optimal functioning of which a client is capable. Reitan (1959) found Information scores to be significantly different between a brain-damaged and a normal population. This decrease, in turn, accompanied a general decline in intellectual performance noted on other subtests as well.

A second often highly used measure of current ability has been word reading ability which has also been advocated as an indicator of premorbid functioning. Nelson and McKenna (1975) found that word-reading ability and general intelligence level were significantly correlated in a group of
normal adults. Through the use of the Schonell Graded Word Reading Test (SGWRT; Schonell, 1942), the authors were compared dementia patients with normal controls. Although, as expected, mean WAIS scale scores were significantly lower in the dementia group, no significant difference was found for reading performance between the groups. Since mean reading scores for the demented and control groups were almost identical it was argued that single-word reading may be retained virtually intact until the degree of dementia becomes quite severe. This finding implies that word-reading ability may be a useful indicator of the premorbid level of intellectual functioning of the demented patient. From the data, a regression equation was developed which could predict Full Scale IQ from the number of words correctly read on the SGWRT. The limitation to this use of the SGWRT as a means of estimating levels of intelligence was that it could not differentiate between the higher levels of intelligence because its ceiling level was equivalent to a Full Scale IQ of only 115. Nelson and O'Connell (1978) noted that the SGWRT was designed to measure the reading attainment in children from the most elementary levels so the easier words on the test were much too simple to provide any discrimination between literate adults. There also were not enough difficult words at the upper end of the test to provide adequate discrimination between adults groups with higher levels of literacy skills.
According to the authors, the usefulness of a word-reading test in the estimation of the premorbid intelligence level of a dementing patient relies upon that test providing a measure of previous familiarity with the words, rather than a measure of current cognitive ability to analyze a complex visual stimulus and, from this analysis, to synthesize the correct oral response (Nelson & O'Connell, 1978). Further, the use of “irregular” words—those which are spelled in such atypical ways that application of common rules of phonetic interpretation would result in incorrect reading—would maximize the importance of previous familiarity with the word. Thus, such words would be a more sensitive indicator of the premorbid intellectual status of a dementing patient than the words on the SGWRT. This led to the development of the National Adult Reading Test (NART) (Nelson, 1982). The NART consists of 50 irregular words listed in order of increasing difficulty, which are read aloud by the subject (see Appendix A).

Several studies using NART error scores as predictor variables have shown NART performance to be relatively resistant to various neurologic and psychiatric conditions (Crawford, 1989; Vanderploeg, 1994). However, some studies have reported significant differences between demented and control subjects on NART predicted IQ scores (Hart, Smith, & Swash, 1986; Stebbins, Wilson, Gilley, Bernard, & Fox, 1990), particularly in the populations of moderately to severely demented subjects. Unfortunately,
the NART score could also underestimate IQ in patients with only mild dementia when language deficits are present (Stebbins, et al., 1990).

Research has also found that the various forms of the NART adequately predict Verbal IQ scores, but tend to be poor predictors of Performance IQ (Vanderploeg, 1994). This could be expected since NART performance accounts for approximately twice the amount of WAIS Verbal IQ variance (60%) as Performance IQ variance (32%) (Nelson, 1982).

The publication of the revised version of the WAIS in 1981 introduced questions of the usefulness of the NART as a means to estimate WAIS-R IQ scales. Sharpe and O’Carroll (1991) developed regression equations to estimate WAIS-R FSIQ and VIQ from NART error score, using methodology similar to that used to develop the original WAIS equation. They found that NART performance was highly correlated with WAIS-R FSIQ at a correlation of .77, a figure similar to that of Nelson and O’Connell’s. This appears to show high correlations between NART performance and measures of general intellectual ability. These regression equations accounted for 59% of the variance in WAIS-R FSIQ and 65% of the variance of WAIS-R VIQ. When cross-validated with a group of elderly dementia patients, no significant differences were shown in the number of NART errors for either demented or non-impaired subjects. NART-estimated IQs, however, were significantly higher than obtained IQs for the demented
group. The authors concluded that the ability to correctly pronounce irregular words remains relatively unimpaired in dementia, making the NART a useful tool in estimating WAIS-R scores.

Ryan and Paolo (1992) used the NART to estimate WAIS-R IQs in a sample of normal elderly by cross validating regression equations on a sample of neurologically impaired subjects who had been diagnosed with brain damage or dysfunction. The study revealed significant overestimation of the actual WAIS-R IQs by the NART estimated IQs. The results, however, were consistent with previous research and showed that the NART-estimated IQs appeared to adequately demonstrate intellectual deterioration in a brain-damaged sample.

NART performance has been shown to be useful in estimating premorbid IQ in both non-impaired individuals and brain-damaged patients but the majority of studies have focused on demented patients. Crawford, Parker, and Besson (1988) investigated the usefulness of the NART in a comparison of matched, healthy control subjects with those suffering from a wide variety of organic conditions including Korsakoff's psychosis, alcoholic dementia, Alzheimer's disease, multi-infarct dementia, Huntington's disease, and closed head injury. No significant difference was found in NART performance between control subjects and the various impaired groups except for the Korsakoff and Huntington's groups. However, the
NART estimate was significantly higher than that provided by the Vocabulary subtest of the WAIS. The authors also noted that an opportunity existed to research the usefulness of the NART in estimating scores on the WAIS-R in a variety of populations.

In conclusion, the current abilities approach has shown promise as a means to estimate premorbid IQ. Research has shown that the use of the NART has especially shown promise as a useful predictor. However, limitations to this approach, such as the test's low ceiling and the possible effects severe language deficits might have on performance, have made it necessary to explore other methods to estimate premorbid intelligence.

Demographic Variable-Based Estimation Procedures

Demographic variables have been found to have a reasonably strong relationship with intelligence. Since demographic characteristics are usually unchanged even if an individual suffers a neurological disorder, they constitute potentially useful estimators of premorbid ability (Vanderploeg & Schinka, 1995). Current IQ test performance is oftentimes examined for consistency with educational and occupational history data obtained during the clinical interview (Matarazzo, 1972). Early attempts to estimate premorbid IQ from demographic attributes involved classifying subjects into one of four educational categories based on number of years of education (Fogel, 1964; Ladd, 1964). WAIS FSIQs of hospitalized non-neurological
patients were used as premorbid IQ calibration values for the education-matched neurologically impaired subjects. These studies failed to control for the influence of age and socio-economic status variables but showed that demographic information, such as educational attainment, could be useful in estimating premorbid IQ.

Using data from the respective tests' standardization samples, regression equation using demographic variables as predictors have been developed for both the WAIS (Wilson, Rosenbaum, Brown, Rourke, & Whitman, 1978) and the WAIS-R (Barona, Reynolds, & Chastain, 1984). Wilson et al. (1978) used multiple regression techniques to explore the relationship between demographic variables and current intelligence in a more systematic and objective manner. The authors reasoned that adult onset neurological dysfunction should have little effect on demographic status. Therefore, the accuracy of regression equations to estimate IQs would be limited only by the correlation between IQ and demographic variables. WAIS FSIQ, VIQ, and PIQ scores were regressed in a stepwise procedure on five demographic variables (age, sex, race, education, and occupation) as predictors using the WAIS standardization sample as a subject pool.

Educational attainment was found to be the single best predictor of IQ for each of the WAIS scales, although the remaining demographic
variables significantly improved predictive accuracy at subsequent steps of the analysis. The WAIS regression equation accounted for 53%, 42%, and 54% of the variance in actual VIQ, PIQ, and FSIQ scores respectively.

Wilson, Rosenbaum, and Brown (1979) compared the ability of the demographic method of estimating premorbid IQ with the present-abilities method (WAIS “hold tests”) in the classification of brain-impaired and nonimpaired subjects. Each method was then used as the premorbid estimate of WAIS FSIQ in the Wechsler (1958) Deterioration Quotient. The equation using the demographic variables as the estimator of premorbid IQ was found to be more accurate than that using the present-abilities method in case classification by 73% to 62%, respectively.

A cross-validation study by Klesges, Sanchez, and Stanton (1981) examined the correlation between demographically-estimated IQ and obtained WAIS IQ in two neurologically unimpaired clinical samples. Highly significant correlations of estimated and obtained IQ were found in both groups but the proportion of FSIQ variances accounted for was lower than expected. The authors also found that the demographic equations significantly overestimated FSIQ in both samples and encouraged the use of the educational correction presented by Wilson et al. (1978) to compensate for the increase in mean education level from the time the standardization data was collected up until the regression equations were produced.
In a subsequent study, Klesges, Fisher, Vasey, and Pheley (1985) compared the original Wilson et al. (1978) formula with the one the authors derived using the educational correction. Significant overestimation of WAIS IQs using the original formula was reported for both the brain-impaired and normal groups. The authors also found the significant overestimation when the educationally adjusted formula was used. These results were consistent across FSIQ, VIQ, and PIQ measurements and led the authors to assert that the Wilson et al. (1978) formulas should be restricted to research purposes.

Bolter, Gouver, Veneklasen, and Long (1982) evaluated the utility of the Wilson et al. (1978) FSIQ formula for head-injured patients. The Halstead Reitan Battery and the WAIS were administered in serial evaluations to two groups of closed head-injury patients. The "recovered" group had impaired neuropsychological test performance at the first testing and normal neuropsychological test performance at the second. The "non-recovered" group had impaired neuropsychological test performance at both evaluations. These two groups were compared with a control group of pseudoneurological patients (individuals evaluated for suspected neurological dysfunction but with normal medical diagnostic results). IQ scores obtained at the time of the second evaluation for the patients in the recovered group were deemed reasonable estimates of premorbid
intelligence. Educationally adjusted and non-adjusted IQ estimates were correlated with the measured IQ at final testing for all three groups of patients.

Correlations between estimated and obtained IQs were at .68 for the recovered and non-recovered groups and .73 for the controls when the estimates were not adjusted for education. Little improvement in predictive ability was noted when the educationally adjusted formula was used. The overall predictive accuracy of the formulas to correctly classify the individual into a group was examined. At the time of the second evaluation, the rate of correct classification for the two groups of head injury patients was only about 50%, with greater accuracy for the non-adjusted than the adjusted equation.

A follow-up study by Gouvier, Bolter, Veneklasen, and Long (1983) examined the same issues with the same patients, but reported on the comparisons between predicted and obtained VIQ and PIQ instead of FSIQ. Overall, the accuracy of Performance IQ estimates tended to be greater than that of the Verbal IQ estimates for both the impaired and non-impaired subjects but both were sufficiently low to lead the authors to discourage the clinical use of the equations in their present form. Even the use of the Wilson et al. (1978) educational adjustment did not make a significant difference for prediction.
It has been found that intellectual recovery over the years following a head injury typically is associated with recovery on neuropsychological tests (Klonoff, Low, & Clark, 1977). In a similar vein, the previous two studies introduced the use of “recovered groups” as an interesting option to the use of regression equations as predictors of premorbid IQ. Bolter et al. (1982) concluded that, although some intellectual impairment might persist in those patients whose neuropsychological test performance had returned to the normal range, IQ scores obtained after “recovery” would appear to be a reasonable estimate of premorbid intelligence. In fact, the authors postulated that estimates of actual IQs using the Wilson et al. (1978) formulas would be more accurate for the recovered patients than for the non-recovered. The accuracy was expected to be at a level comparable to the accuracy of prediction for the controls. Results were disappointing, however, and the slightly greater classification accuracy observed among control patients suggests that the use of recovered neuropsychological test performance may not be a valid criterion for a successful recovery.

Karzmark, Heaton, Grant, and Matthews (1985) conducted a cross-validation study that included a large sample of healthy, unimpaired individuals in order to provide a group that would eliminate the possibility of intellectual deterioration as a measured artifact. Mean estimated FSIQ corresponded closely with mean obtained FSIQ (110.9 versus 112.8). The
accuracy of the Wilson et al. (1978) formula was relatively stable across different levels of age, education, and occupation but not across different intellectual levels. The formula was less accurate in the high and low ranges, again pointing out the limitations of this method.

The introduction of the WAIS-R (WAIS-R; Wechsler, 1981) necessitated an update of the Wilson et al. (1978) formula to compensate for changes to the test in the revision. Changes in content and renorming procedures led to IQ scores that averaged approximately seven points lower than those generated by the WAIS. Barona et al. (1984) used a methodology similar to that of Wilson et al. (1978) to develop demographic regression equations for the estimation of premorbid WAIS-R IQ by using the WAIS-R standardization sample. The five predictor variables used in the original WAIS regression equations (age, sex, race, education, and occupation) were used again along with variables for urban/rural residence and geographical region.

In the derived equations, the most powerful predictors of IQ were education, race, and occupation. However, in the final equations, all of the variables contributed significantly to the explained variance in estimating premorbid intelligence. The disappointment was that the WAIS-R regression equations appeared to have less predictive power than had those for the WAIS; with the total variance accounted for being only 38%, 24%, and
36% for VIQ, PIQ, and FSIQ, respectively. Despite the use of more current norms, the Barona et al. (1984) equations accounted for less IQ variance and had larger standard errors of measurement than had the Wilson et al. (1978) equations, lending question as to the clinical utility of the equations.

The Wilson et al. (1978) and Barona et al. (1984) formulas were compared by Sweet, Moberg, and Tovian (1990). For both psychiatric and brain-damaged patients, the Barona et al. (1984) estimates were more accurate than were the original Wilson et al. (1978) estimates. However, the Wilson et al. (1978) estimates were also calculated after they were corrected in the manner suggested by Karzmark et al. (1985) which led to an eight point reduction of all scores in order to increase their accuracy as predictors of WAIS-R IQs. The corrected equations equaled or exceeded the accuracy of the Barona et al. (1984) formulas. Significant overestimation of the WAIS-R IQ scales was a result of all three methods. The poor results led the authors of the study to conclude that even though the demographic method of estimating premorbid intellectual ability is more accurate than “hold-don’t hold” deterioration ratios, use of the formulas with individual patients is still not recommended.

Barona and Chastain (1986) attempted to improve the accuracy of demographic estimation of intelligence by eliminating two subgroups from the standardization sample and developing regression equations for the
remaining subjects. Subjects 16 to 19 years of age were eliminated because their occupation was classified as head of household whenever they were not employed in full-time occupations. This was misleading and may have resulted in inaccurate estimates of premorbid IQ since, at their young age, their intellectual development had not had time to fully develop. The second deleted group consisted of races other than black and white. Due to the low representation of “other” races in the standardization sample, coding them for inclusion in the analysis might have inflated error variance. The same predictor variables used in the Barona et al. (1984) equations were again employed. The total portion of the variance accounted for by these equations was 47%, 28%, and 43% of VIQ, PIQ, and FSIQ scores respectively which represented a small improvement over the Barona et al. (1984) equations. Paolo and Ryan (1992) subsequently compared the Barona et al. (1984) and Barona and Chastain (1986) equations in estimating premorbid IQ for elderly adults. Though both sets of equations were able to adequately estimate FSIQ, neither was found to be an accurate estimator or PIQ. Further, only the Barona et al. (1984) equation was an adequate estimator of VIQ. Overall, it appeared that the Barona et al. (1984) equations were seen as slightly better in estimating WAIS-R IQs.

Cross-validation studies of the WAIS and WAIS-R regression formulas have also been researched but have come up with mixed results.
overall (Vanderploeg, 1994). At the group level these regression equations have been found to do an adequate job of predicting mean IQ scores. However, at the individual level, the equations have a tendency to predict IQ scores outside of the actual IQ category of subjects more than half the time. As might be expected, the equations are most accurate in predicting IQ scores when these scores fall in the average range. The equations tend to underestimate high IQ scores and overestimate low IQ scores (Vanderploeg & Schinka, 1995).

**Combined Predictor Estimation Procedures**

Crawford, Stewart, Parker, Besson, & Cochrane (1989) used a combination of present abilities performance and demographic predictors in regression equations. They surmised that (a) variance unique to the two sets of measures (NART and demographic variables) might better relate to intellectual ability and, thus, together account for more IQ score variance, and (b) demographic variables may moderate the relationship between NART and IQ. The demographic variables included in this study were age, gender, education, and occupation. With the exception of education, each variable contributed significant predictive power above and beyond the NART in stepwise regression equations for WAIS FSIQ, VIQ and PIQ. Combined regression equations accounted for significantly more variance than either set of predictor variables independently (78%, 39%, 73% of the
variance in WAIS VIQ, PIQ, and FSIQ, respectively). While cross-validation and construct validity studies (Crawford, Nelson, Blackhorse, Cochrane, & Allan, 1990; Crawford, Besson, Parker, & Stewart, 1990) have revealed moderate shrinkage in the size of the regression correlations, the results suggest that the combined estimation method has considerable potential for estimating premorbid IQ.

Two more recent studies using the combined estimation method have been noted. Vanderploeg and Schinka (1995) used an approach of prediction which combined present ability as measured by the WAIS-R with certain demographic characteristics. The subjects were the 1,880 individuals of the WAIS-R standardization sample. In that the previous research in the field had pointed out that any WAIS-R subtest may be impaired following brain injury, the authors made the point that none of the subtests were determined a priori to be "hold" measures. Using the stepwise method of selection of predictor variables, analyses were conducted for each of the 11 WAIS-R subtests combined, in turn, with all of the considered demographic variables to predict Verbal, Performance, and Full Scale IQ scores. Thirty-three analyses were therefore generated. The demographic predictor variables were entered into the regression equation if they produced a significant change in $R^2$ which also resulted in an increase of at least 1% in the explained variance of the dependent variable (see Appendix B).
The derived equations accounted for more variance in actual IQ scores than either current ability or demographic variables independently. Initial and cross-validation studies demonstrated the stability of the approach and the derived equations. In all cases, equations combining a WAIS-R subtest with demographic variables accounted for more variance than the parallel Barona et al. (1984) demographic equation did. A number of the equations doubled the amount of IQ variance accounted for compared to the Barona et al. (1984) equations. The equations were also able to account for more variance in actual IQ than previously developed NART/demographic WAIS IQ regression equations (Crawford, Nelson, et al., 1990). For most of the regression equations generated in the study, 50% or more of the standardization sample obtained predicted scores within a +/- 6 to 7 point range of their actual IQ scores. It was noted that regression to the mean did not appear to be a significant problem with the equations. In significant contrast to the Barona et al. (1984) regression equations, these derived equations were able to identify potential ranges from lows of 60 to highs of 146. The authors believed that the availability of all 33 regression equations would allow future investigators the potential opportunity to empirically examine which equation would be the most effective predictor for a particular clinical situation. The authors concluded that, until that time, previous research can aid the clinician in individual cases.
Vanderploeg and Schinka (1995) caution that clinical samples need to be utilized to determine which equations provide the best estimates in various clinical situations. Another point of concern was that the method used was susceptible to the problems associated with both the "hold" and the demographic approach. The most problematic was that some measures of current ability may not "hold" in instances of brain injury or psychopathology while others may.

A series of studies developed by Friedberg and Gouver (1996) also used a combined demographic and present abilities approach to develop equations to estimate premorbid intelligence. Linear regression equations were developed to estimate WAIS-R IQs using estimated Barona IQ (Barona et al., 1984) plus error score on the NART as predictors. The equations were cross-validated on a clinical sample of severe closed head injury patients.

First, the study found that NART performance was a valid present abilities measure for the estimation of current intelligence in a non-injured American population, and a stable indicator of estimated premorbid IQs in patients with severe head injuries. Mean NART error scores and estimated NART IQs were the same for closed head injury (CHI) patients and matched controls while mean obtained WAIS-R IQs were significantly lower for the CHI group.
Regression equations to estimate WAIS-R IQs were then developed by combining a stable measure of performance (the NART error score) with the Barona et al. (1984) demographic estimation of WAIS-R IQs. This resulted in impressive figures for the amount of variance accounted for as the NART-Barona regression equations accounted for 76%, 57%, and 74% of VIQ, PIQ, and FSIQ variance, respectively. In the cross validation sample, the correlations between obtained WAIS-R IQs and the NART-Barona estimated IQs ranged from .76 to .87. The authors therefore concluded that for WAIS-R FSIQ and VIQ estimates, the combined NART-Barona equation showed a smaller discrepancy between estimated and obtained IQs than either the Barona et al. (1984) or the Ryan and Paolo (1992) equations previously used.

The Present Study

The last two studies discussed here (Vanderploeg & Schinka, 1995; Friedberg & Gouvier, 1996) both hold exciting promise in finding equations to provide reliable estimations of premorbid IQ. Both studies were able to generate equations combining the present abilities and demographic methods as estimators. It would seem that if both the present abilities method and the demographic estimation method each account for a significant amount of non-overlapping variance in measuring premorbid IQ, it could be reasonably expected that the combination of the present abilities
and demographic variables in regression equations would be useful as a means to provide a more accurate estimate of premorbid IQ (Bolter et al., 1982; Stebbins et al., 1990).

It appears that the next step would be to assess the validity of such an equation for a variety of clinical populations. Though both the Vanderploeg and Schinka (1995) and Friedberg and Gouvier (1996) equations show promise, the Friedberg and Gouvier equations have been used effectively to assess a clinical population of CHI patients, while Vanderploeg and Schinka have expressed reservations about the utility of their own equations. This study therefore compared the two sets of equations with clinical populations of head injured patients along with a comparison to normal subjects in order to find which set is a more accurate predictor of premorbid intelligence.

Thus, this study was begun with the expectation that obtained WAIS-R IQs would be significantly lower for CHI patients than for a group of matched unimpaired controls while the estimated premorbid IQs should be approximately equal for the two groups. There was also an expectation that the discrepancy between obtained WAIS-R IQs and the estimated premorbid IQs would be significantly greater for CHI patients than for matched, unimpaired controls. Finally, in a comparison of the two different sets of regression equations, one expected that the Friedberg and Gouvier equations would be more accurate estimators of premorbid functioning than
the Vanderploeg and Schinka equations. This assumption was made because of the unknown ability of WAIS-R subtests to consistently hold for various types of brain injury when used as measures of current ability. Since one could not know the true premorbid IQ of the members of the CHI group, the equations were run on the unimpaired subjects only. Scores on the WAIS-R and NART were available to provide a measure of concurrent validity.

Given the background of previous research in this area, the following hypotheses are presented for this study:

Hypothesis 1: Obtained WAIS-R IQs would be significantly different between the CHI (closed-head injury) group and the control group but the estimated premorbid IQs, as measured by the Friedberg and Gouvier and the Vanderploeg and Schinka equations, for the two groups would be approximately equal.

Hypothesis 2: The discrepancy between obtained WAIS-R IQs and estimated premorbid IQs would be significantly greater in the experimental group than in the control group for both sets of predictor equations.

Hypothesis 3: The Friedberg and Gouvier equations would be a more accurate estimator of premorbid IQ than the Vanderploeg and Schinka equations for an unimpaired population.
METHODS

Subjects

The total sample included 128 subjects who were physically capable of completing the required tasks. The sample size was derived according to the formula set forth by Cohen (1992) who stated that to detect a “medium effect size” difference between two sample means at the .05 level, an N of 64 is needed for each group. Cohen characterized a medium effect size as one likely to be visible “to the naked eye of a careful observer”. The author provided the definition that in effect-size surveys, a medium effect size approximates the average size of observed effects in various fields.

The clinical sample consisted of 64 individuals who had suffered a CHI (closed-head injury) and were recruited from within the San Bernardino/Riverside area of southern California. Most had been inpatients at the testing site, a local medical center’s rehabilitation department, and were contacted by phone to request their participation in the study. Others were recruited from various community programs providing services for those who had suffered a CHI or through an advertisement placed in the medical center’s community newsletter. All members of the clinical sample had suffered a severe closed head injury within the past three years. The definition of a severe head injury that was used in this study was proposed by Russell and Smith (1961) and identified such an injury as one that
results in a period of post-traumatic amnesia (PTA) for greater than 24 hours. The authors defined PTA as a period of coma followed by confusion with the end point being the recovery of continuous memory. The sample excluded subjects who reported a history of drug and/or alcohol dependence as defined by DSM-IV (APA, 1994) criteria or those who were known to have neurological disorders premorbidly. This information was gleaned during an interview with the subject at point of contact.

The non-clinical population consisted of 64 individuals recruited through advertisements in the medical center’s employee newsletter and community newsletter. Subjects were also recruited from the family and friends of members of the CHI group as a matched control. The control group consisted only of subjects with no history of head injury, neurological impairment, drug and/or alcohol dependence, or psychological impairment likely to affect intellectual functioning. These individuals were recruited as a matching control group for the CHI group and were matched as closely as possible on the five major demographic categories (age, sex, race, education, occupation).

A summary of the demographic characteristics of the two groups appears in Table 1. A series of t-tests found no significant differences between the CHI and control groups on any of the five demographic variables used in this study.
Table 1

Demographic Characteristics of the Subject Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
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<th>p</th>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>33.77</td>
<td>13.53</td>
<td>-0.21</td>
<td>ns</td>
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<td>Education</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>CHI</td>
<td>64</td>
<td>13.14</td>
<td>1.68</td>
<td>-0.27</td>
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<td>13.22</td>
<td>1.60</td>
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<tr>
<td>Occupation (1-6) Vanderploeg &amp; Schinka (1995)</td>
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<tr>
<td>CHI</td>
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<td>1.91</td>
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<td>ns</td>
</tr>
<tr>
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<td>3.66</td>
<td>1.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupation (1-6) Barona et al. (1984)</td>
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<td></td>
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<td>1.68</td>
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<td></td>
</tr>
<tr>
<td>Sex (1-2)*</td>
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<td></td>
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<td></td>
</tr>
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<td>1.47</td>
<td>0.50</td>
<td>-0.18</td>
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<td>1.48</td>
<td>0.50</td>
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<td></td>
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<td>Race (0-1)**</td>
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<td>CHI</td>
<td>64</td>
<td>0.84</td>
<td>0.37</td>
<td>0.24</td>
<td>ns</td>
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<tr>
<td>Control</td>
<td>64</td>
<td>0.83</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*--variable coded; numerically translates as such
CHI: males-34, females-30
Control: males-33, females-31

**--variable coded; numerically translates as such
CHI: whites-54, non-whites-10
Controls: whites-53, non-whites-11
Materials

Non-clinical subjects were first administered an informal screening questionnaire (see Appendix C). The purpose of the questionnaire was to assess the presence of any factors which could possibly affect intellectual functioning and, in turn, performance on the tests to be administered. Exclusionary criteria consisted of factors such as history of head injury, neurological disorder, or alcohol/drug dependence.

All of the subjects included in the study were administered both the WAIS-R and the NART as experimental measures. The Wechsler Adult Intelligence Scale-Revised (WAIS-R) is an individually administered inventory of intellectual functioning consisting of eleven subtests broken down as six measuring verbal skills and five measuring performance skills. In the standardization study, the scale was found to have very high reliability across tested age groups with average coefficients of .97, .93, and .97 for Verbal, Performance, and Full Scale IQs respectively. The scale was administered and scored in the standard way outlined in the manual (Wechsler, 1981).

The National Adult Reading Test (NART) is an individually administered single word reading test consisting of 50 words listed in order of difficulty (see Appendix A). The validation study for this test (Nelson and O'Connell, 1978) compared the performance of subjects with bilateral
cortical atrophy with normal subjects. Though the demented group had a significantly lower WAIS FSIQ than the control group, NART score differences between the groups was not significant. This suggested resistance of the NART to the effects of the dementing process and as a useful estimator of premorbid intellectual functioning. The NART word list was administered in the manner outlined by the authors.

Procedures

Each subject was administered both the WAIS-R and the NART in individual sessions. Demographic information relevant to the study was also recorded. Of note is that the information gathered is based on prior level of functioning in order to have a more accurate picture of premorbid functioning (Barona et al, 1984). Prior to the testing session, the subject was informed of the purpose of the study and asked to provide consent for the study (see Appendices D and E). The control subjects were then given the screening questionnaires prior to test administration. Subjects who met the participation criteria were then administered the tests, with half of the subjects in each group given either the WAIS-R or the NART first.

Data Analyses

Several data analyses were used to measure the differences between the groups in relation to the hypotheses set forth for the study. The analyses were set up for each hypothesis in the manner described below.
Hypothesis 1 proposed that there would be a significant difference on obtained WAIS-R IQs when comparing the CHI and control groups, but that there would not be a difference for the estimated premorbid IQs. The scores on the obtained IQs were compared by using three t-tests, one for each measure of the WAIS-R (VIQ, PIQ, FSIQ).

To test for differences between estimated IQ scores, a series of t-tests were performed comparing the CHI and control groups on each of the two sets of predictor equations. The comparison using the Friedberg and Gouvier (1996) equations was fairly straightforward as three t-tests were set up to compare the two groups on estimated IQ.

However, due to the number of predictor equations set forth by Vanderploeg and Schinka (1995), the comparisons using these equations were somewhat more complicated. These authors proposed a total of 33 predictor equations, each equation using one of the eleven WAIS-R subtests to predict a score on one of the three WAIS-R scales. Comparisons of estimated IQ scores were made using each of the 33 equations. Since such a large number of comparisons could inflate the p level and show a significant difference where there might not be one, a second method was explored. In that Vanderploeg and Schinka (1995) proposed equations using each of the subtests of the WAIS-R, the scores from the equations using the subtests for each particular scale were combined to come up with an average estimated
score for each scale. Thus, the scores from the six predictor equations for VIQ which used VIQ subtests were combined and averaged for one VIQ score. Similarly, the five PIQ scores from predictor equations using PIQ subtests were combined and averaged for one PIQ score. All eleven predictor equations for FSIQ were also combined and averaged for one FSIQ score. The derived scores for each group were then also compared through the use of three t-tests.

Hypothesis 2 proposed that the difference between obtained WAIS-R IQs and estimated IQs would be significantly greater for the CHI subjects than for those of the control group. To test this, discrepancy scores (D-scores) were calculated comparing estimated and obtained IQ scores on each of the three WAIS-R scales for the CHI and control groups. Subsequently, a series of t-tests was performed to assess for significance in the difference between the scores.

Hypothesis 3 proposed that the Friedberg and Gouvier equations would be more accurate predictors of premorbid IQ than would the Vanderploeg and Schinka equations. This conclusion was drawn due to the Vanderploeg and Schinka’s equations reliance on WAIS-R subtests. As it has been discussed here previously, the WAIS-R subtests are not known to be a consistent measure of current ability and may, therefore, not be able to reliably gauge an individual’s premorbid ability after a head injury. The
comparisons of the two set of predictor equations focused on the unimpaired
control group only since it would not be reasonably possible to know the
actual premorbid IQ of an individual after they have suffered a closed head
injury.

In order to test the relative effectiveness of each set of equations as a
predictor of premorbid intelligence, a direct comparison was set up between
the Friedberg and Gouvier equations and those of Vanderploeg and Schinka.
In that Vanderploeg and Schinka proposed 33 total equations to estimate
each of the three IQ measures (VIQ, PIQ, and FSIQ), it was decided that the
"averaged" predictor score for each dependent measure would be calculated
first as the best measure for the scale. The scores of this one particular
equation would then be directly compared in a regression equation to the
corresponding Friedberg and Gouvier scores from the equation for the
particular WAIS-R scale.

The two corresponding sets of scores were compared for VIQ, PIQ, and
FSIQ through the use of a hierarchical regression analysis. In this step, the
scores for each predictor equation were entered into the regression both as
the first and second variable. The purpose of this step was to find how much
of the variance they could account for on their own when entered in the first
step and how much of the variance they could account for on top of what the
other score could provide when entered as the second step. With this
information, one could directly note which equation was the best predictor for the particular scale.
RESULTS

Regression equations predicting premorbid intelligence developed by Vanderploeg and Schinka (1995) and Friedberg and Gouvier (1996) were compared using a group of individuals with a diagnosis of CHI and a normal control group. The results of the statistical analyses are described here for each of the hypotheses set forth in this study.

Hypothesis 1

Hypothesis 1 proposed that there would be a significant difference in observed WAIS-R IQ scores between the CHI group and the control group. The mean differences between the two groups on the three measures were 9.72 points for VIQ, 12.64 points for PIQ, and 11.94 points for FSIQ with the CHI group having a lower score on all three measures. Results of independent t-tests confirmed hypothesis 1 for the WAIS-R VIQ (t(126)=4.78, p<.001), PIQ (t(126)=5.34, p<.001, and FSIQ (t(126)=5.44, p<.001) scales. Thus, as would be expected due to impairment in the CHI group, their scores on each of the scales was lower than that of the control group. Means and standard deviations for each of the three measures can be found in Table 2.

Hypothesis 1 also expected that the estimated IQ scores using the two sets of predictor equations for the CHI and control groups would be approximately equal. The results here, however, did not lend support to the
Table 2

Obtained WAIS-R IQs for the Experimental (CHI) and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WAIS-R VIQ</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHI</td>
<td>64</td>
<td>91.63</td>
<td>12.04</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>101.34</td>
<td>10.94</td>
</tr>
<tr>
<td><strong>WAIS-R PIQ</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHI</td>
<td>64</td>
<td>92.92</td>
<td>15.68</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>105.56</td>
<td>10.61</td>
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<tr>
<td><strong>WAIS-R FSIQ</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHI</td>
<td>64</td>
<td>91.56</td>
<td>13.53</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>103.50</td>
<td>11.17</td>
</tr>
</tbody>
</table>
hypothesis as both the Friedberg and Gouvier (1996) equations and the Vanderploeg and Schinka (1995) equations found significant differences between the CHI and control groups for estimated IQ scores.

Independent t-tests were subsequently run on each set of predictor equations comparing the estimated IQ scores. All three of the Friedberg and Gouvier (1996) equations found significant differences between the CHI and control groups for estimated IQ, with the control group having higher predicted scores on each scale. The mean differences were 6.38 points for the estimated VIQ \( t(126)=3.75, p<.001 \), 5.56 points for the estimated PIQ \( t(126)=4.01, p<.001 \) and 6.47 points for the estimated FSIQ \( t(126)=4.02, p<.001 \). Means and standard deviations can be found in Table 3. Since it is not possible to know the true premorbid IQ of an individual with a CHI, the difference between the actual and predicted IQ of the control group sample was examined. The difference between the two scores was significant for both the estimated VIQ and the estimated FSIQ as the Friedberg and Gouvier equation had a tendency to overestimate both of these scores but not the PIQ. The difference between the estimated VIQ and the actual VIQ was 3.47 points \( t(63)=3.14, p>.005 \). The difference between the estimated FSIQ and the actual FSIQ was 2.47 points \( t(63)=2.27, p>.05 \).

Subsequently, the 33 predictor formulas developed by Vanderploeg and Schinka (1995) were analyzed to see if any of them would produce
Table 3

Estimated WAIS-R IQs using the Friedberg & Gouvier (1996) Equations

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated VIQ</strong></td>
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<td></td>
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<tr>
<td>CHI</td>
<td>64</td>
<td>98.44</td>
<td>10.05</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>104.81</td>
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<td><strong>Estimated PIQ</strong></td>
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<tr>
<td>CHI</td>
<td>64</td>
<td>100.54</td>
<td>8.25</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>106.10</td>
<td>7.40</td>
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<tr>
<td><strong>Estimated FSIQ</strong></td>
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<td></td>
<td></td>
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<tr>
<td>CHI</td>
<td>64</td>
<td>99.51</td>
<td>9.93</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>105.98</td>
<td>8.99</td>
</tr>
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</table>
similar estimated IQ scores for the CHI and control groups. Independent t-tests were run on each of the formulas and 31 of the 33 formulas were found to produce significantly different estimated IQ's between the CHI and control groups. The two formulas that did not find a significant difference were an estimator for VIQ using the Object Assembly subtest and an estimator for PIQ using the Digit Span subtest. The Object Assembly equation found a mean difference on VIQ of 2.47 points (t(126)=1.66, ns). The Digit Span equation found a mean difference between the groups of 2.36 points (t(126)=1.89, ns). The other 31 predictor formulas all found significant differences between the estimated IQ scores of the CHI and control groups with the scores of the control groups being significantly higher on every occasion. Means, standard deviations, and results of the t-tests can be found in Table 4.

As discussed previously, the Vanderploeg and Schinka (1995) predictor equations were looked at in a second way. In that the authors developed 33 predictor equations which could be used to estimate premorbid IQ, one would be concerned that doing 33 t-tests on those equations would have the effect of inflating the p level and, in turn, showing significance by chance alone. Therefore, average scores were calculated for estimated VIQ, PIQ, and FSIQ using the predictor equations for the subtests found on the particular scale. The estimated VIQ score was derived by combining the
Table 4
Estimated WAIS-R IQs using Vanderploeg and Schinka (1995) Equations

<table>
<thead>
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<th>Controls</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>VIQ (Information)</td>
<td>94.53</td>
<td>9.83</td>
<td>103.39</td>
</tr>
<tr>
<td>VIQ (Digit Span)</td>
<td>100.80</td>
<td>9.07</td>
<td>104.29</td>
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<td>VIQ (Vocabulary)</td>
<td>96.14</td>
<td>10.18</td>
<td>103.97</td>
</tr>
<tr>
<td>VIQ (Arithmetic)</td>
<td>99.12</td>
<td>9.86</td>
<td>103.12</td>
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<td>VIQ (Comprehension)</td>
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<td>VIQ (Similarities)</td>
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<td>VIQ (Picture Comp)</td>
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<td>105.99</td>
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<td>9.89</td>
<td>105.34</td>
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<td>106.47</td>
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<td>FSIQ (Digit Symbol)</td>
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<td>105.26</td>
</tr>
</tbody>
</table>

*--p=n.s.; comparison found no difference between obtained and actual IQs
scores from the six verbal subtest regression formulas and finding an average. Then, the estimated PIQ score was derived by combining the scores from the five performance subtest regression formulas and finding an average. Finally, the estimated FSIQ score was derived by combining the eleven regression formulas and finding an average.

However, all three of these average scores found significantly different estimated IQ scores when comparing the CHI and control groups. The averaged VIQ estimator score found a mean difference of 5.71 points between the two groups ($t(126)=4.08, p<.001$). The averaged PIQ estimator score found a mean difference of 6.33 points between the groups ($t(126)=4.46, p<.001$). Finally, the averaged FSIQ estimator score found a mean difference of 5.33 points between the groups ($t(126)=4.03, p<.001$). For each equation, the estimated IQ score of the control group was significantly higher than that of the CHI group. Means and standard deviations can be found in Table 5. Once again, the predicted and actual IQ scores for the control group were examined. The $t$-tests found significant differences only between the predicted and actual scores for VIQ. The predicted VIQ was measured 2.25 points higher than the actual IQ ($t(63)=3.55, p>.001$). It appears that the Vanderploeg and Schinka equations overestimated the VIQ for this group of controls. The differences between predicted and actual scores for PIQ and FSIQ were not significant.
Table 5

Estimated IQs using the averaged* Vanderploeg and Schinka (1995) Equations

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<th>N</th>
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<th>SD</th>
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<td></td>
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<tr>
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<td>64</td>
<td>97.89</td>
<td>8.15</td>
</tr>
<tr>
<td>Controls</td>
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<td></td>
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<td>98.80</td>
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<tr>
<td>Controls</td>
<td>64</td>
<td>105.13</td>
<td>6.77</td>
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<tr>
<td><strong>Estimated FSIQ</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CHI</td>
<td>64</td>
<td>99.18</td>
<td>7.91</td>
</tr>
<tr>
<td>Controls</td>
<td>64</td>
<td>104.52</td>
<td>7.05</td>
</tr>
</tbody>
</table>

*--estimated IQs derived from average of scores of corresponding scales on the WAIS-R (VIQ is average of the six Verbal scales; PIQ is average of the five Performance scales; FSIQ is average of all 11 scales)
Hypothesis 2

Hypothesis 2 proposed that the discrepancy between obtained WAIS-R IQs and estimated IQs would be significantly greater in the experimental group than in the control group. To test for the significance, discrepancy scores (D-scores) were calculated and compared for the CHI and control groups. Statistical analyses found that this hypothesis was broadly supported by both sets of predictor equations, as there was significantly more discrepancy between the estimated and obtained WAIS-R IQs for the CHI group than for the control group.

For the Friedberg and Gouvier equations, all three equations found significant discrepancy scores between estimated and obtained IQ scores. The mean VIQ D-score was -6.82 (SD=8.22) for the CHI group and -3.47 (SD=8.86) for the control group ($t(126)=2.22, p<.05$). The mean PIQ D-score was -7.62 (SD=13.23) for the CHI group and -0.54 (SD=8.80) for the control group ($t(126)=3.57, p<.001$). For FSIQ, the mean D-score was -7.95 (SD=10.15) for the CHI group and -2.48 (SD=8.71) for the control group ($t(126)=3.27, p<.001$).

Similarly, the averaged Vanderploeg and Schinka equations also produced significant discrepancy scores between estimated and obtained IQ scores for both groups. The mean VIQ D-score was -6.26 (SD=5.49) for the CHI group and -2.25 (SD=4.91) for the control group ($t(126)=4.29, p<.001$).
The mean PIQ D-score was -5.37 (SD=7.68) for the CHI group and 0.43 (SD=5.45) for the control group ($t(126)=5.37, p<.001$). Lastly, the mean FSIQ D-score was -7.62 (SD=7.47) for the CHI group and -1.02 (SD=6.25) for the control group ($t(126)=5.43, p<.001$). Means, standard deviations and the results of t-tests for the discrepancy scores can be found on Table 6.

It appears that both sets of equations generated a significantly greater discrepancy between the estimated and obtained IQ scores for the CHI group than for the control group. These discrepancies suggest that the obtained WAIS-R IQs were significantly decreased from premorbid levels after the closed head injury and therefore that the predictor equations do have clinical utility as measures of premorbid intelligence.

**Hypothesis 3**

The final hypothesis proposed that when examining the two sets of predictor equations, the Friedberg and Gouvier (1996) equations would be better predictors of premorbid IQ than would the Vanderploeg and Schinka (1995) equations. This was expected since the Vanderploeg and Schinka equations were derived from WAIS-R subtests which are known not to be strong “hold” measures that could provide a solid measure of prior ability following a severe head injury.

Regression equations were computed to identify which set of predictor equations are better estimators of premorbid intelligence. Since one cannot
Table 6

Discrepancies between Obtained and Estimated WAIS-R IQs

<table>
<thead>
<tr>
<th></th>
<th>CHI</th>
<th>Controls</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean  SD</td>
<td>Mean  SD</td>
<td></td>
</tr>
<tr>
<td>Friedberg &amp; Gouvier (1996)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated VIQ</td>
<td>-6.82 8.22</td>
<td>-3.47 8.86</td>
<td>-3.35*</td>
</tr>
<tr>
<td>Estimated PIQ</td>
<td>-7.62 13.23</td>
<td>0.54 8.80</td>
<td>-3.57**</td>
</tr>
<tr>
<td>Estimated FSIQ</td>
<td>-7.95 10.15</td>
<td>-2.48 8.71</td>
<td>-3.27**</td>
</tr>
</tbody>
</table>

Vanderploeg & Schinka (1995)

<table>
<thead>
<tr>
<th></th>
<th>CHI</th>
<th>Controls</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean  SD</td>
<td>Mean  SD</td>
<td></td>
</tr>
<tr>
<td>Estimated VIQ</td>
<td>-6.26 5.49</td>
<td>-2.25 5.07</td>
<td>-4.29**</td>
</tr>
<tr>
<td>Estimated PIQ</td>
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<td>0.43 5.45</td>
<td>-5.37**</td>
</tr>
<tr>
<td>Estimated FSIQ</td>
<td>-7.62 7.47</td>
<td>-1.02 6.25</td>
<td>-5.43**</td>
</tr>
</tbody>
</table>

for independent t-test comparisons between the CHI and control groups for each predictor equation: *p<.05; **p<.001.
know the true premorbid IQ of an individual after they have suffered a CHI, the equations were compared using only the data from the unimpaired controls.

The Friedberg and Gouvier (1996) equations were first put through multiple regression analyses to find the amount of variance they could account for. All three equations were found to account for a significant amount of variance of the IQ scores. The VIQ equation was found to have an $R^2=0.39$ ($F(1, 62)=39.59, p<.001$), the PIQ equation was found to have an $R^2=0.33$ ($F(1, 62)=30.20, p<.001$), and the FSIQ equation was found to have an $R^2=0.42$ ($F(1, 62)=44.30, p<.001$). $R^2$, standard errors, and beta weights can be found on Table 7.

Finding the appropriate Vanderploeg and Schinka (1995) equations to use for the comparison was somewhat difficult. One possible solution would have been to find the regression equation for each scale which would explain the most variance. However, it would be an inappropriate and unfair comparison to pick out the best equation from a group of equations and then put it in a direct comparison with one particular equation. Therefore, it was decided to use the “averaged” Vanderploeg and Schinka equations for the comparison.

All three of the “averaged” Vanderploeg and Schinka (1995) equations accounted for a significant amount of variance of the IQ scores. The
Table 7

Regression Summary Table for Friedberg & Gouvier (1996) Equations*

<table>
<thead>
<tr>
<th></th>
<th>R²</th>
<th>SE</th>
<th>beta</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>Estimated VIQ</td>
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<td>8.62</td>
<td>.62</td>
<td>39.59</td>
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</tr>
<tr>
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<td>8.77</td>
<td>.57</td>
<td>30.21</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Estimated FSIQ</td>
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<td>8.60</td>
<td>.65</td>
<td>44.30</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

---Friedberg and Gouvier equations used in the study were generated as:

Estimated VIQ=69.2886 + 0.5020 (BaronaVIQ) - 0.8749 (NART errors)
Estimated PIQ=79.5881 + 0.3993 (Barona PIQ) - 0.7638 (NART errors)
Estimated FSIQ=75.3933 + 0.4577 (Barona FSIQ) - 0.8880 (NART errors)
"averaged" VIQ equation was found to have an $R^2=.83$ ($F(1,62)=297.77$, $p>.001$). The "averaged" PIQ equation was found to have an $R^2=.80$ ($F(1,62)=252.22, p>.001$). The "averaged" FSIQ equation was found to have an $R^2=.74$ ($F(1,62)=175.83, p>.001$). $R^2$, standard errors, and beta weights can be found in Table 8.

The final step was to compare the three Friedberg and Gouvier (1996) equations with the three "averaged" Vanderploeg and Schinka (1995) equations to see which were able to account for the greatest amount of variance. In order to compare the incremental validity of the two sets of equations, separate hierarchical regressions were done for VIQ, PIQ, and FSIQ scores. Each regression consisted of the scores of the corresponding Friedberg and Gouvier equation and Vanderploeg and Schinka equation alternately entered into the hierarchical regression as the first and second step of the analysis, with the comparison equation using the opposite entry sequence.

In the VIQ analysis, the scores from the Friedberg and Gouvier equation had an $R^2=.38$ when entered in the first step of the hierarchy. When the corresponding Vanderploeg and Schinka scores were entered second, the variance explained increased dramatically ($R^2=.84$). In comparison, when the Vanderploeg and Schinka scores was entered first, the $R^2=.83$. Entering the corresponding Friedberg and Gouvier scores, however,
Table 8

Regression Summary Table for "averaged" Vanderploeg and Schinka (1995) Equations

<table>
<thead>
<tr>
<th></th>
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<th>SE</th>
<th>beta</th>
<th>F</th>
<th>p</th>
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<tbody>
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<td>Estimated VIQ</td>
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<td>4.58</td>
<td>.91</td>
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<td>&lt;.0001</td>
</tr>
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<tr>
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<td>.86</td>
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had a very small effect on the amount of variance explained (R^2=0.84). In the PIQ analysis, the scores from the Friedberg and Gouvier equation had an R^2=0.33 when entered in the first step while the corresponding Vanderploeg and Schinka scores again dramatically increased the total amount of variance explained (R^2=0.81). In comparison, when the scores from the Vanderploeg and Schinka equation were entered first, the amount of variance explained was very high (R^2=0.80), leaving only a negligible amount for the scores from the corresponding Friedberg and Gouvier equation.

Finally, for the FSIQ analysis, the scores from the Friedberg and Gouvier equation had an R^2=0.41 when entered first and the corresponding Vanderploeg and Schinka scores again dramatically increased the total amount of variance explained when entered second (R^2=0.74). In comparison, when the Vanderploeg and Schinka scores were entered first in the analysis, the R^2=0.74, once again leaving only a negligible amount of variance for the scores from the corresponding Friedberg and Gouvier equation to explain. R^2, standard errors, and the results of t-tests for each of the hierarchical regressions can be found in Table 9.

For all three scales of the WAIS-R, it appears that the Vanderploeg and Schinka equation is able to explain a greater amount of the variance than the corresponding Friedberg and Gouvier equation. Moreover, only in the case of VIQ was the corresponding Friedberg and Gouvier equation able
Table 9

Regression Table of Comparisons for Friedberg & Gouvier (1996) and Vanderploeg & Schinka (1995) Equations

<table>
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<th>Order equation is entered</th>
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<td></td>
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<td>39.59</td>
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</tr>
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<td>2. Vanderploeg &amp; Schinka</td>
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<tr>
<td>1. Vanderploeg &amp; Schinka</td>
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<td>4.42</td>
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<td><strong>PIQ</strong></td>
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<td></td>
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<tr>
<td>1. Friedberg &amp; Gouvier</td>
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<td>8.77</td>
<td>30.21</td>
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<td>4.75</td>
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<td>2. Friedberg &amp; Gouvier</td>
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</table>

*--equations were unable to add significantly to the amount of variance explained
to add incremental validity and account for variance that was missed by the corresponding Vanderploeg and Schinka equation. The Friedberg and Gouvier equations, therefore, appear to have limited relevance in the process of estimating premorbid intelligence and do not appear to account for as much variance as the corresponding Vanderploeg and Schinka equations. Scatterplot graphs comparing each of the predictor equations with the actual IQ score for both the CHI and normal groups can be found in figures 1 to 6. Correlations of the actual IQ scores with the estimated scores using both the Friedberg and Gouvier equations and the Vanderploeg and Schinka equations can be found in Table 10.
Figure 1: Scatterplot of actual VIQ scores relative to predicted scores for CHI subjects.
Figure 3: Scatterplot of actual PIQ scores relative to predicted scores for CHI subjects.
Figure 4: Scatterplot of actual PIQ scores relative to predicted scores for normal subjects.
Figure 5: Scatterplot of actual FSIQ scores relative to predicted scores for CHI subjects.
Figure 6: Scatterplot of actual FSIQ scores relative to predicted scores for normal subjects.
Table 10

Correlations of estimated versus obtained IQ scores

<table>
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<tr>
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<th>Friedberg &amp; Gouvier equation</th>
<th>Vanderploeg &amp; Schinka equation</th>
</tr>
</thead>
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DISCUSSION

Clinicians have various methods for measuring an individual’s current level of functioning following a traumatic brain injury. However, since there is usually a scarcity of data on premorbid functioning available, the clinician may have difficulty in getting an accurate picture of the individual’s prior level of functioning. For many years, researchers have attempted to solve this problem by devising a valid and reliable method to estimate premorbid intelligence. Two approaches that have been studied intently highlight the use of demographic variables and measures of present abilities. Several authors have developed either demographic or present abilities equations that have been used to predict premorbid intelligence (e.g. Barona et al., 1984 and Ryan and Paolo, 1992, respectively). Most recently, attention has been turned towards the use of equations that combine both the demographic method and the present abilities method. Such a combination of variables has been proposed to be a more accurate estimator of premorbid IQ scores (Bolter et al., 1982; Stebbins et al., 1990).

This study was devised to test several of the equations that have been developed using both predictive methods. The first set of equations was developed by Vanderploeg and Schinka (1995) and used WAIS-R subtest scores as the current ability predictors plus demographic information. The second set of equations was developed by Friedberg and Gouvier (1996) and
used scores on the National Adult Reading Test (NART) as the measure of current ability and combined these scores with demographic information. The two sets of equations were compared using a group of CHI patients and a closely matched set of unimpaired controls matched to the demographics of age, gender, education, race, and occupation.

The first hypothesis proposed that the observed scores of the CHI and control groups would be significantly different on all three scales of the WAIS-R. The results were as expected with the control group having a significantly higher observed score on all three scales. The finding points out that individuals who have suffered CHIs do subsequently show a reduction in intellectual capabilities (Lezak, 1983) and the WAIS-R is sensitive to such intellectual changes.

The first hypothesis also proposed that the estimated IQ scores for the two groups would not be significantly different from each other. If the predictor equations are, indeed, valid predictors of premorbid intelligence, the scores for the two matched groups should not be statistically significant. The results, however, failed to support the hypothesis. The three Friedberg and Gouvier (1996) equations, in fact, all measured a significant difference for predicted IQ when comparing the CHI and control groups. In order to find out if the limitation was an overestimation of the estimated IQ for the control group, an examination of the difference between the actual and
predicted IQ of the control group was done. It found a significant difference between the two scores only for estimated VIQ. It appears that for estimated VIQ, the Friedberg and Gouvier equation tended to overestimate the actual IQ. However, no significant differences were found between the predicted and actual IQ scores for PIQ and FSIQ.

In examining the Vanderploeg and Schinka (1995) equations, similar results were found. First, 33 t-tests were performed to examine which of the predictor equations would produce similar estimated IQ scores for the CHI and control groups. Only two of the 33 formulas did not find significant differences between the groups. The other 31 equations all estimated the IQs of the control group higher than that of the CHI group.

When the “averaged” scores from the Vanderploeg and Schinka equations were tested, all three equations (for VIQ, PIQ, and FSIQ) found a significant difference between the estimated IQ score for the CHI and control groups. Once again, the predicted and actual IQ scores for the control group were examined. The t-test found a significant difference between the predicted and actual scores for VIQ with the predicted VIQ being significantly higher than the actual IQ. It appears that the Vanderploeg and Schinka equations overestimated the VIQ for this group of controls. The difference between predicted and actual scores for PIQ and FSIQ were not significant.
The second hypothesis proposed that the discrepancy between obtained WAIS-R IQs and estimated IQs would be significantly greater in the CHI group than in the control group. Both sets of equations supported this hypothesis and found significantly greater discrepancies between the estimated and obtained VIQ, PIQ, and FSIQ scores for the CHI than for the control group. The discrepancies suggest that the obtained WAIS-R IQs were significantly decreased from premorbid levels after the closed head injury and that the predictor equations do have clinical utility as a measure of premorbid intelligence.

The third hypothesis proposed that the Friedberg and Gouvier equations would be better predictors of premorbid intelligence than the Vanderploeg and Schinka (1995) equations because the Vanderploeg and Schinka equations were derived from WAIS-R subtests which are not known to be strong "hold" measures in measuring intelligence.

Regression equations were computed using only the data from the control group since it is not possible to know the true premorbid IQ of an individual after they have suffered a CHI. The three "averaged" Vanderploeg and Schinka equations were compared to the three corresponding Friedberg and Gouvier equations to find which respective equation accounted for the greater amount of variance for each of the three IQ scores.
For all three measures of intelligence, the Vanderploeg and Schinka equation was able to account for more variance than the corresponding Friedberg and Gouvier equation. Such a result might be due to the fact that when using the Vanderploeg and Schinka equation, both the independent and dependent variables are derived from the same WAIS-R standardization data. The two variables are found to share the variance as the predictor is derived from the same data as the criterion. For this reason, one would expect that the two would be highly correlated. It would seem a reasonable approach then to develop different measures of predictor variables to avoid the problem with shared variance.

Though the Vanderploeg and Schinka equations were able to account for a larger percent of the variance explained than did the Friedberg and Gouvier equations, both sets of equations found significant differences between the estimated IQ scores of a group of CHIs and a group of matched controls. Since this study did use a matched set of controls, it appears that test performance (for both the NART and the WAIS-R) is not stable after a CHI. Therefore, these equations may be better suited to research purposes and not as clinical instruments for predicting premorbid functioning.

Several other points should be considered in the context of this project when looking at possible shortcomings. The most serious might be the limitations that reduce the accuracy of the demographic formulas. Some of
the information that is entered into the formulas is not based on a
continuum but rather on distinct categories. When considering education, for
example, the same code is given to an individual who completed high school
by taking 12 years of special education and an individual who took advanced
classes but has not yet enrolled in college. Similarly, there could be
significant differences in age and occupation that would be coded as being
the same due to the variability within the category of the demographic
formula.

A second concern involves the time frame used for inclusion to the
CHI group. All subjects in this group suffered a head injury within a three
year period prior to testing but there was a fairly wide variance in time as
some patients had suffered their injury only a month prior to testing while
others had suffered their injury just about three years prior. Some research
(Mandleberg & Brooks, 1975) has found that intellectual functioning
improves with time since injury, and that WAIS IQ scores would return to
normal within three years. This tenet has not been universally accepted,
however. Others have noted that residual deficits can be present for a much
longer period of time after an injury (Drudge, Williams, Kessler, & Gomes,
1984). As an option, Bolter et al. (1982) proposed the use of "recovered"
groups, individuals who can be serially tested over time to chart their
neuropsychological progress and how that may affect their performance on
test measures. This would allow for a closer and more complete look at the recovery process and provide some insight into estimating IQ scores for the head-injured.

A concern during this study was the use of multiple t-tests as a way to compare means. In fact, comparing the 33 Vanderploeg and Schinka (1995) equations was difficult due to the concern that the number of t-tests would work to inflate the p level and give significant results where none may exist. In working with such a large number of equations, a more prudent course may have been to do the analysis using a multivariate analysis of variance (MANOVA) which would have been better able to lower the possibility of a Type I error due to multiple tests of correlated dependent variables (Tabachnick & Fidell, 1996). In the use of multiple regression equations, there are several forms that can be used in the analysis. In this study, the hierarchical regression method was chosen as it provides more control for the researcher as to the order of entry of the variables into the equation. Using a method, such as the stepwise regression method, draws caution since the empirical selection of predictors is likely to be highly sample specific and not generalizable to a variety of situations (Licht, 1995).

On a more general level, there does exist the question of why clinicians continue to measure IQ at all. Lezak (1988) stated that the concept of IQ is based on a questionable conceptual basis. She points out
that neuropsychological studies have been unable to identify specific neuroanatomic or neurophysiological correlates of IQ as they have been for other discrete mental abilities. She further states that IQ tests tend to be limited by the complex nature of their items and subtests which make it difficult to identify cognitive functions or neurobehavioral correlates clearly. Lezak concluded that an alternative does exist and it is to drop the "unitary phenomenon" of IQ and instead report findings based on a profile of scores. Therefore, even if the equations examined in this study could accurately estimate premorbid IQ, there remains the question as to if IQ is a useful concept and what knowing such a score could do for the individual.

Overall, the conclusions that can be drawn from this study are that one should be cautious when using either the Vanderploeg and Schinka (1995) or the Friedberg and Gouvier (1996) equations as predictors of premorbid intelligence. At this time, a good deal of research remains to be carried out with a wide variety of clinical populations including demented subjects, subjects with neurological impairments, and patients with psychiatric disorders. Until this additional research is done to further validate the formulas, they cannot be used with confidence in determining impairment due to cerebral dysfunction.
REFERENCES


### APPENDIX A

**WORD LIST OF THE NATIONAL ADULT READING TEST**

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<thead>
<tr>
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<td>PRELATE</td>
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APPENDIX B

REGRESSION EQUATIONS DEVELOPED BY VANDERPLOEG AND SCHINKA (1995)

VIQ (Information) = 3.71(Info) + 1.01(SES) + 57.11
VIQ (Digit Span) = 2.74(Dig Spn) + 2.28(SES) + 0.87(Age) + 52.19
VIQ (Vocabulary) = 3.96(Vocab) + 0.70(SES) + 57.49
VIQ (Arithmetic) = 3.26(Arith) + 1.52(SES) + 57.45
VIQ (Comprehension) = 3.45(Compre) + 1.17(SES) + 58.10
VIQ (Similarities) = 3.21(Simil) + 1.40(SES) + 0.95(Age) + 55.60
VIQ (Picture Completion) = 2.66(SES) + 2.10(Pic Com) + 1.40(Age) + 53.79
VIQ (Picture Arrangement) = 2.78(SES) + 1.94(Pic Arr) + 1.44(Age) + 54.47
VIQ (Block Design) = 2.61(SES) + 2.19(Blk Dsgn) + 1.50(Age) + 53.09
VIQ (Object Assembly) = 3.08(SES) + 1.67(Obj Asm) + 1.30(Age) + 55.11
VIQ (Digit Symbol) = 2.78(SES) + 1.64(Dig Sym) + 1.72(Age) - 3.75(Sex) + 61.69

PIQ (Information) = 2.55(Info) + 6.69(Race) + 0.77(SES) + 64.05
PIQ (Digit Span) = 1.85(Dig Spn) + 1.51(SES) + 8.59(Race) + 63.13
PIQ (Vocabulary) = 2.99(Vocab) + 5.84(Race) + 66.84
PIQ (Arithmetic) = 3.01(Arith) + 6.30(Race) + 1.56(Sex) + 63.77
PIQ (Comprehension) = 2.38(Compre) + 6.50(Race) + 0.87(SES) + 64.81
PIQ (Similarities) = 2.74(Simil) + 7.54(Race) + 68.57
PIQ (Picture Completion) = 3.51(PC) + 1.54(Age) + 0.93(SES) + 4.65(Race) + 49.97
PIQ (Picture Arrangement) = 3.18(PA) + 1.56(Age) + 1.09(SES) + 6.91(Race) + 50.02
PIQ (Block Design) = 4.00(Blk Dsgn) + 1.88(Age) + 0.79(SES) + 49.58
PIQ (Object Assembly) = 3.62(Obj Asm) + 1.69(Age) + 1.42(SES) + 48.89
PIQ (Digit Symbol) = 3.06(DS) + 2.24(Age) + 6.94(Race) + 4.15(Sex) + 0.88(SES) + 56.27

FSIQ (Information) = 3.55(Info) + 1.00(SES) + 58.70
FSIQ (Digit Span) = 2.56(Dig Spn) + 2.11(SES) + 59.39
FSIQ (Vocabulary) = 3.78(Vocab) + 0.70(SES) + 59.09
FSIQ (Arithmetic) = 3.28(Arith) + 1.39(SES) + 58.32
FSIQ (Comprehension) = 3.31(Compre) + 1.14(SES) + 59.60
FSIQ (Similarities) = 3.08(Simil) + 1.23(SES) + 0.84(Age) + 5.61(Race) + 53.60
FSIQ (Picture Completion) = 2.94(Pic Com) + 2.13(SES) + 1.62(Age) + 49.41
FSIQ (Picture Arrangement) = 2.61(PA) + 2.17(SES) + 1.56(Age) + 7.00(Race) + 46.60
FSIQ (Block Design) = 3.20(Blk Dsgn) + 2.00(SES) + 1.81(Age) + 47.62
FSIQ (Object Assembly) = 2.69(Obj Asm) + 2.58(SES) + 1.59(Age) + 48.61
FSIQ (Digit Symbol) = 2.21(SES) + 2.44(Dig Sym) + 2.16(Age) -
APPENDIX C

MEDICAL AND PSYCHOLOGICAL SCREENING FOR CONTROL
SUBJECTS
Subject #______________ Date ______________

1. Have you ever been hospitalized or received medical attention for an
infection involving the brain, spinal cord, or the nervous system?

2. Have you ever been treated for a stroke or had symptoms attributed to a
stroke or a transient ischemic attack (TIA)?

3. Have you ever been hospitalized or treated for a head injury of any type?

4. Have you ever been knocked unconscious? If yes, for how long?

5. Have you ever experienced a loss of awareness (for even a brief time)?

6. Have you ever experienced sudden uncontrollable body tremors, muscle
twitches, or convulsions?

7. Have you ever been diagnosed with a brain tumor or other malformation
of the brain?

8. Have you ever received treatment for any neurological or psychiatric
disorder?

9. Have you ever been under the care of a mental health professional for
personal difficulties?

10. Have you ever received treatment, either inpatient or outpatient, for
alcohol or drug abuse?

11. Have you ever been a regular user of alcohol or other drugs?

12. Do you have now, or have had in the past, any other medical or
psychological problems that have not been addressed here?
APPENDIX D

CONSENT FORM FOR HEAD-INJURED SUBJECTS

Participation in: The Estimation of Premorbid Intelligence

Dear Participant:

Purposes and Procedures

You are invited to participate in a research study because you have suffered a head injury in your recent history. Many times when a person suffers such an injury, it is difficult to know what types of abilities and deficits the person will have later on. Even though we can measure what someone's abilities are like after the injury, we cannot always know how the person functioned before the injury. This makes it difficult to know what the effects of the injury are which makes it hard, in turn, to plan for future treatment and activities. For this reason, this study has been put together.

The study will compare different types of statistical predictors that have been developed in order to see which ones are best to use when estimating someone's level of functioning prior to a head injury. Data will be collected from individuals like yourself to test these formulas. Data will also be collected from people who have not suffered head injuries to compare differences.

Your participation in this study will take approximately one and one-half to two hours. Participation in this study involves taking a test which will include answering some questions, doing some math, and putting together some puzzles along with some other tasks. This part of the test will take about one to one and a quarter hours. The second part of the study will consist of reading a list of 50 words. This part will take approximately 15 minutes.

Risks

The committee at Loma Linda University that reviews human studies (Institutional Review Board) has determined that participating in this study exposes you to minimal risk.

Some of the test questions you will be asked may seem difficult and this, in turn, may be frustrating for you. There is no need for significant concern. Most people could not answer all of the questions. It is only important that you try to do your best. If, after testing, you have concerns about your performance, you may ask the examiner or call the investigator (Peter A. Petito, MA) at (909) 824-4727.
Benefits
The potential benefit to you is giving you a better understanding of what your cognitive strengths and deficits are since your brain injury. This may allow you to make better plans for your future in regards to school, employment, etc. The benefits to humanity are finding information that will help identify strengths and deficits in those who have suffered a head injury and allow for the more efficient design of programs to help them.

Participants' Rights
Participation in this study is voluntary. Your decision to participate or stop at any time will not affect your present or future medical care.

Confidentiality
All information gathered in this study will be held in confidentiality. Any published document resulting from this study will not disclose your identity without your permission. Your name will be kept separate from test results and kept only to give you feedback on your performance. Testing will identify you only by a code number assigned specifically to you. Once you have received your feedback, any records containing your name or other identifying data will be destroyed.

Impartial Third Party Contact
If you wish to contact an impartial third party not associated with this study regarding any complaint you may have about the study, you may contact the Office of Patient Relations, Loma Linda University Medical Center, Loma Linda, CA 92354, phone (909) 558-4647 for information and assistance.

Informed Consent Statement
Before participating in this study you will have the opportunity to ask the examiner any question you may have. You may ask these questions either when you are contacted to make an appointment or when you come in for the testing session. Please take these opportunities to make sure all of your questions are answered.

I have read the contents of the consent form and understand that I will be given opportunities to have any questions answered to my satisfaction. I hereby give voluntary consent to participate in this study. My consent to participate does not waive my rights nor does it release the investigators, institution, or sponsors from their responsibilities. I may call Peter A. Petito, MA at (909) 824-4727 and ask for him if I have additional
questions or concerns. I have been given a copy of this consent letter for my
records.

If at this time, you are willing to be a subject in this study, please put
your name, phone number, and the best time to contact you on the sheet
attached to this form.

Thank you for your participation!

__________________________________________  ___________________________
Signature                                  Date
APPENDIX E

CONSENT FORM FOR VOLUNTEER SUBJECTS

Participation in: The Estimation of Premorbid Intelligence

Dear Participant:

Purposes and Procedures

You are invited to participate in a research study comparing people who have had head injuries with people who have not. Many times when a person suffers such an injury, it is difficult to know what types of abilities and deficits the person will have later on. Even though we can measure what someone's abilities are like after the injury, we cannot always know how the person functioned before the injury. This makes it difficult to know what the effects of the injury are which makes it hard, in turn, to plan for future treatment and activities. For this reason, this study has been put together.

The study will compare different types of statistical predictors that have been developed in order to see which ones are best to use when estimating someone's level of functioning prior to a head injury. Data will be collected from individuals like yourself to test these formulas. Data will also be collected from people who have suffered head injuries to compare differences.

Your participation in this study will take approximately one and one-half to two hours. Participation in this study involves taking a test which will include answering some questions, doing some math, and putting together some puzzles along with some other tasks. This part of the test will take about one to one and a quarter hours. The second part of the study will consist of reading a list of 50 words. This part will take approximately 15 minutes.

Risks

The committee at Loma Linda University that reviews human studies (Institutional Review Board) has determined that participating in this study exposes you to minimal risk.

Some of the test questions you will be asked may seem difficult and this, in turn, may be frustrating for you. There is no need for significant concern. Most people could not answer all of the questions. It is only important that you try to do your best. If, after testing, you have concerns about your performance, you may ask the examiner or call the investigator (Peter A. Petito, MA) at (909) 824-4727.
Benefits

The potential benefit to you is giving you a better understanding of what your cognitive strengths and deficits are like. This may allow you to make better plans for your future in regards to school, employment, etc. The benefits to humanity are finding information that will help identify strengths and deficits in those who have suffered a head injury and allow for the more efficient design of programs to help them.

Participants’ Rights

Participation in this study is voluntary. Your decision to participate or stop at any time will not affect your present or future medical care.

Confidentiality

All information gathered in this study will be held in confidentiality. Any published document resulting from this study will not disclose your identity without your permission. Your name will be kept separate from test results and kept only to give you feedback on your performance. Testing will identify you only by a code number assigned specifically to you. Once you have received your feedback, any records containing your name or other identifying data will be destroyed.

Impartial Third Party Contact

If you wish to contact an impartial third party not associated with this study regarding any complaint you may have about the study, you may contact the Office of Patient Relations, Loma Linda University Medical Center, Loma Linda, CA 92354, phone (909) 558-4647 for information and assistance.

Informed Consent Statement

Before participating in this study you will have the opportunity to ask the examiner any question you may have. You may ask these questions either when you are contacted to make an appointment or when you come in for the testing session. Please take these opportunities to make sure all of your questions are answered.

I have read the contents of the consent form and understand that I will be given opportunities to have any questions answered to my satisfaction. I hereby give voluntary consent to participate in this study. My consent to participate does not waive my rights nor does it release the investigators, institution, or sponsors from their responsibilities. I may call Peter A. Petito, MA at (909) 824-4727 and ask for him if I have additional
questions or concerns. I have been given a copy of this consent letter for my records.

If at this time, you are willing to be a subject in this study, please put your name, phone number, and the best time to contact you on the sheet attached to this form.

Thank you for your participation!

__________________________________________  ________________________
Signature                                      Date
VITA

Peter Anthony Petito was born in Philadelphia, Pennsylvania on April 29, 1963. He attended elementary school in Philadelphia before moving to Tucson, Arizona where he attended junior high and high school. He then went on to the University of Arizona where he majored in psychology and minored in sociology. He graduated in December of 1984 with a Bachelor of Science degree awarded with distinction.

He was accepted into the Clinical Psychology program at Louisiana State University and received his Master of Arts in December of 1987. After completing his on campus coursework, he did a one year clinical internship at the Jerry L. Pettis Veterans Administration Medical Center in Loma Linda, California. Upon completing his internship, he took a position with the Rehabilitation Psychology service at Loma Linda University Medical Center and has worked there while completing the requirements for his doctorate. He received his doctorate from Louisiana State University in December 1999.
DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: PETER ANTHONY PETITO

Major Field: PSYCHOLOGY

Title of Dissertation: THE ESTIMATION OF PREMORBID INTELLIGENCE: A COMPARISON OF APPROACHES

Approved:

[Signatures of Major Professor and Chairman, Dean of the Graduate School, and members of the examining committee]

EXAMINING COMMITTEE:

[Signatures of committee members]

Date of Examination:

JULY 22, 1999