HOW PERFORMANCE ON THE PASAT RELATE TO GLOBAL OUTCOME ON THE DISABILITY RATING SCALE FOLLOWING CLOSED-HEAD INJURY.

A Thesis

Presented to

The Faculty of the Department

Of Psychology

University of Houston

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

By

Lee A. Wiegand
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ABSTRACT

Objective: Care, treatment, and rehabilitation of individuals who have sustained a TBI are reliant on our understanding of the factors that predict common outcomes. Cognitive ability, as measured by neuropsychological testing, has proven to be an influential factor in predicting the global outcome of individuals that have sustained a head injury. The PASAT measures processing speed, working memory, and attention, which are cognitive abilities often associated with head injury. This study aimed to elucidate the differences between participants able to complete the PASAT and those who could not. Then the ability of PASAT performance to predict global outcome as measured by the DRS was determined when injury severity were taken into account. Finally, it aimed to determine the ability of PASAT performance to predict outcome when scores of participants unable to complete the PASAT were added to the statistical analysis through imputation.

Participants and Method: Data from 169 individuals with complicated mild, moderate, and severe closed head injuries who participated in CPHS approved, NIH funded research that involved the collection of DRS data and neuropsychological testing at six months post injury were used. Groups were created based on an individuals' ability or inability to complete the PASAT. Demographic, injury severity, and outcome variables were compared. Linear regression models were used to analyze the relationship between PASAT performance and outcome on the DRS at 6 months post injury. These data were analyzed controlling for severity of injury and demographic variables. Imputation methods, including mean substitution, the minimum score substitution, and regression

based substitution were used to further assess the relationship between PASAT performance and DRS scores.

Results: Ability to complete the PASAT was significantly related to global outcome as measured by the Disability Rating Scale. Performance on the PASAT accounted for 16.4% of the variance in DRS scores when pertinent demographic and injury severity measures were controlled for. Statistical imputation of PASAT data did not increase the amount of variance in DRS scores accounted for by PASAT performance, but 3 of 4 imputation techniques were able to increase the total models' predictive ability.

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INTRODUCTION

Morbidity due to Traumatic Brain Injury (TBI) is a major health problem in the United States. Individuals sustaining a TBI often sustain persistent impairment; require ongoing rehabilitation and mental health support related to community reintegration. Rehabilitation of individuals who have sustained a TBI is, to some degree, dependent on our understanding of the cognitive measures that are used to evaluate individuals with TBI and the relationship to global outcome. This study is designed to better understand how performance on a neuropsychological measure of attention/information processing speed, the Paced Auditory Addition Test (PASAT), at 6 months post injury relates to global outcome as measured by the Disability Rating Scale (DRS). The literature review will cover aspects of TBI including its definition, epidemiology, demographic variables related to outcome, acute care injury severity variables, and global outcome measures. This will be followed by a review of the relevant PASAT literature. Finally, the use of neuropsychological testing in post-acute stages, patient testability confound in research, treatment of missing data, and the use of test completion codes will be included.

Defining Traumatic Brain Injury

A Traumatic Brain Injury (TBI) is an alteration in brain function, or other evidence of brain pathology, caused by an external force (Menon et al., 2010). The term TBI generally refers to an injury to the brain, though the term head injury is often used synonymously. The term Acquired Brain Injury (ABI) is an umbrella term that encapsulates any insult to the brain that can occur which is not hereditary, congenital,

degenerative, or induced antepartum (Lezak at al., 2012). While all TBIs are considered ABIs, insults such as stroke and hypoxia which are ABIs are generally not considered to be TBIs. TBI is subdivided into closed head injury (CHI) and penetrating head injury (PHI). PHI is often differentiated as an insult in which an object penetrates the skull and dura mater. CHI often occurs as a result of acceleration-deceleration forces, blunt trauma, or both and can involve a depressed skull fracture in which there is no penetration of the dura mater.

TBI can occur on a broad continuum of severity, which can range from very mild transient injuries to catastrophic injuries resulting in death or severe disability (Iverson, 2005). TBI is frequently classified as mild, moderate, or severe; however, there are no universally accepted classification criteria for injury severity (Schultz & Rogers, 2011). The variables used to define severity of injury differ to some degree both across classification systems and as used in research (H.J. Hannay, personal communication, April 1st, 2014). In part, the variables used to designate a severity of injury category or to take severity of injury into account are dependent on what acute or more chronic variables are available to the clinician and researcher as well as the kinds of assessments that are done at the scene of the injury and thereafter such as behavioral, physical, physiological, neuro-anatomical and functional imaging. Acutely, these variables might include but not be limited to post resuscitation Glasgow Coma Scale (GCS) score, best day 1 or worst day 1 GCS score or best day 1 GCS motor score and associated pupillary reactivity; increased intracranial pressure (ICP), cerebral blood flow, computed tomography (CT) scan magnetic resonance imaging (MRI) under some conditions, cerebral blood flow measures (e.g., transcranial Doppler, xenon CT scan). Some of these

variables might only be available on more severely injured patients undergoing clinical monitoring in a Level 1 Trauma Center (Hannay, 1986).

Epidemiology of Traumatic Brain Injury

TBI is a leading cause of death and disability in the United States. In 2010, 2.5 million emergency department (ED) visits, hospitalizations, or deaths were associated with TBI. For individuals hospitalized after a TBI, almost half (43%) had a related disability one year after the injury (Selassie et al. 2008). The distribution of GCS scores among patients admitted to a hospital following TBI in the past 25 years suggests that approximately 80% of the patients had a mild (GCS 13-15), 10% moderate (GCS 9-12), and 10% severe (GCS 3-8) TBI (Krauset al., 2000). Over the course of 10 years (2001-2010), rates of TBI-related ED visits increased by 70%, hospitalization rates by 11%, while death rates decreased by 7% (Centers for Disease Control and Prevention, 2010). Improvements in acute care may be responsible for the noted decrease in TBI related mortality but the use of seatbelts and airbags along with the development of CT scans may have had the greatest effect on survival rates over the years. While TBIs occur across the age range, the highest incidence rates per 100,000 in 1994 were found in those aged 75 or more, then 15-24 and finally 0-4 years of age (Thurman et al. 2007). Males experience higher rates of TBI related ED visits, hospitalization, and morbidity; however, this finding is ameliorated over the years (Bruns & Hauser, 2003). While Bruns & Hauser report ratios of about 2:1 males to females, our research group usually finds about a 4:1 ratio. Lower socio-economic status, unemployment, lower educational levels, pre-existing alcohol and substance abuse and divorce as well as previous TBI appear to

increase the likelihood of a TBI (Naugle, 1990; Parry-Jones et al., 2006; Levin, Benton & Grossman, 1982)

Demographic Variables Related to Outcome

Demographic variables possibly related to outcome include age, sex, education and race/ethnicity. Older patients have worse functional outcomes following head injury even when matched for injury severity (Susman, et al., 2002). Female hormones, estrogen and progestin, may play a protective factor following acute neurological injury (Roof & Hall, 2000), though conflicting studies indicate that women have poorer outcomes when mechanism of injury is controlled (Kraus J et al., 2000). Studies have shown that ethnic minorities experience worse long-term functional outcomes including standard of living, engagement in leisure activities, and return to work or school even when matched for injury severity (Staudenmayer et al., 2007; Shafi et al., 2007; Rosenthal et al., 1996). Education was related to poorer outcome on Extended Glasgow Outcome Scale measures 10 years following initial injury (Ponsford et al., 2008). The IMPACT study, based on results from 8,000 individuals indicated that outcome following TBI is dependent on age, race, and to a lesser extent on education, but not on gender (Mushkudiani et al., 2007).

Acute Care Injury Severity Measures

Patients who have experienced a TBI may exhibit cognitive, motor, and sensory deficits along with other deficits as a result of their injury (Thurman et al. 1999). Damage may occur at the time of the initial injury or within the following days, making prediction of the level of deficit difficult based on admission characteristics. However,

multiple acute care variables do contribute to the prediction of outcome. In a study that included over 8,000 individuals with significant head injuries, the strongest predictors of mortality and poor outcome were age, GCS motor score, pupillary reactivity and CT scan characteristics (Steyerberg et al. 2008). Similar studies have indicated models based on pupillary response and CT scan characteristics, including presence of subarachnoid hemorrhage, ICP, and midline shift, have high predictive value in regards to outcome (Tasaki et al., 2009).

The GCS score is the most widely used rapid screening instrument for evaluating brain injury severity (Brain Trauma Foundation et al., 2000). A GCS score is a summation of factors that measure components of consciousness: Eye opening (1-4), verbal response (1-5) and motor response (1-6) (see Appendix A). GCS scores can range from 3-15, with 3 indicating a lack of eye, verbal, or motor response and a 15 generally indicating full consciousness (Teasdale & Jennett, 1974). The GCS has limitations which include possible lower admission scores due to sedation, anesthesia, or intubation. Alcohol intoxication, and medications administered in intensive care (e.g., etomidate, hydrocodone) may have large or additive effects on GCS performance. Physical limitations due to comorbid injury (not directly related to the brain insult) may affect motor scores or vocal production. (Lezak et al., 2012; Fischer et al., 2004). In order to reduce these aforementioned limitations, the best GCS score that the patient receives within the first 24 hours of admission is often used. It also has a documented relation to outcome following head injury. (Cifu et al., 1997) Mild head trauma is commonly associated with a best day one Glasgow coma scale (BD1 GCS) score of 13-15, moderate head trauma 9-12, and more severe head trauma 3-8 (Teasdale & Jennett, 1974) although

these are just guidelines for a division of GCS scores and do not necessarily typify the status of all individuals.

Pupillary reactivity is a measure of how quickly a pupil constricts in reaction to a directly applied light source. The response is usually coded as normal, sluggish, or non-reactive (Levin, 1990). The constriction of neither, one, or both pupils in response to the stimulus may be related to global outcome (Adoni & Mcnett, 2007). Atypical pupil response occurs because the parasympathetic oculomotor nuclei located in the midbrain are especially sensitive to brain stem compression. Thus, pupillary reactivity is often sensitive to increased ICP (Chen et. al., 2011).

The Marshall CT scan classification is a pathoanatomic system that identifies six groups of patients based on severity and abnormalities noted on a CT scan (Marshall et al. 1991). The categories include: Diffuse Injury I (no visible pathology), Diffuse Injury II (cisterns are present, the midline shift is less than 5 mm, and/or there is no high- or mixed-density lesion of more than 25 cc), Diffuse Injury III (includes swelling, where the cisterns are compressed or absent and the midline shift is 0 to 5 mm with no high- or mixed-density lesion of more than 25 cc) , Diffuse Injury IV (a midline shift of more than 5 mm and with no high- or mixed-density lesion of more than 25 cc), Evacuated Mass Lesion (any lesion surgically evacuated and Non-evacuated Mass Lesion (high or mixed-density lesion>25cc; not surgically evacuated) (See Appendix B). Marshall CT scan score has been noted to be powerful in predicting both the risk of increased ICP and global outcome (Maas et al., 2005). In recent years another CT scan classification system generally known as the Rotterdam was introduced by Maas et al.; (See Appendix C) but will not be used in this research.

Global Outcome Measures

Several scales have been developed as a means of measuring global outcome of individuals who have sustained a brain injury at various time points after the initial injury, both when the individual with a TBI or other disorder is in an acute care or in other facilities such as a rehabilitation hospital, nursing home, or back in the community. Outcome on these measures is in part dependent on the severity of the injury and the days post injury. Six months post injury is often the end-point for clinical trials. Most of the improvement takes place during that time period for the more serious injuries, though recovery of different aspects of cognition occur at differential rates (Kersel et al., 2001) and later on. This discussion will focus on the Glasgow Outcome Scale (GOS) (Jennett et al., 1981) and its derivatives, the GOS structured interview and the extended GOS structured interview (Wilson et al., 1998) and finally, the Disability Rating Scale (DRS) (Rappaport et al., 1982) which will be used in this study.

The Glasgow Outcome Scale (GOS) was developed in an attempt to assess physical and mental handicap that contribute to overall functional disability (Jennett & Bond, 1975). The GOS consists of 5 categories defined as follows (Jennett & Snoek, 1981): Death, Persistent Vegetative State (unable to interact with environment, unresponsive), Severe Disability (able to follow commands, unable to live independently), Moderate Disability (able to live independently; unable to return to work or school), and Good Recovery (able to return to work or school) (Jennett & Snoek, 1981).

The scale reflects functioning in major areas of life as opposed to particular deficits or symptoms caused by the patient's injury (World Health Organization, 1980). It is commonly used as a measure of outcome for clinical trials (Clifton et al., 1992) due to its ability to aid in the comparison of functional outcome amongst different groups of individuals (Marshall, 1987). It is problematic, however, because the categories usually need to be bifurcated in order to show significant differences between groups (Lu et al., 2012). Usually the bifurcation consists of poor recovery (Dead, Vegetative State and Severe Disability) vs. good recovery (Moderate Disability and Good Recovery) such that the analyses demonstrate the variation in patient recovery within the categories. The more recent forms of the test based on a structured interview (GOSS) and the extended GOS (GOSE) were developed by Wilson et al., (1998) to provide some standard questions related to information that would help raters to choose an outcome category. The structured interview was noted to result in the rating of more disability in TBI patients (Teasdale et al., 1998), in all likelihood, because information now required resulted in more questions were asked that directly related to the ratings.

A more recent outcome scale, the DRS (Rappaport et al., 1982) has the advantage of a large number of scores that range from 0-29. The scale greatly expands the range of scores for typifying the changes that take place in individuals having a severe disability and in a vegetative state. To a small degree it improves the range of scores for a moderate disability and good recovery. Thus it is likely to be more sensitive to changes in individuals with a severe injury over time. The larger range of scores adds the additional advantage of perhaps treating the outcome score as a continuous variable (and using parametric methods of analysis). For these reasons, the DRS was chosen as the outcome

measure in this study and aspects such as reliability and validity are mentioned in some detail. The DRS was developed to assess quantitatively the disability of severe head trauma patients. It was designed to facilitate clinical research investigating the relationship between evoked potentials and outcome in head injured patients (Rappaport et al. 1982). To encapsulate the spectrum of disability ranging from no impairment to vegetative state, the DRS measures residual ability via physical, cognitive and psychosocial functioning.

The DRS consists of 8 items divided into 4 categories. 1. Arousability, awareness, and responsivity (eye opening, communication and motor responses); 2. Cognitive ability to handle self-care functions (feeding, toileting and grooming dependence); 3. Physical dependence upon others; and 4. Psychosocial adaptability for work, housework, or school. Each area of functioning is rated on a scale of 0 to either 3, 4 or 5 with the highest scores indicating *higher* level of disability. This creates an observer-rated 30 point scale for individuals who survive the injury that provides information useful in documenting the progress of patients with TBI (Wright, 2011) (See Appendices D & E).

Numerous studies indicate acceptable reliability and validity for the DRS (Gouvier et al., 1987; Hall et al., 1993). Rappaport and colleagues reported inter-rater reliability correlations between .97 and .98 and further studies have supported this finding (Gouvier et al., 1987; Novack et al., 1991; Malec et al., 2012). High test-retest reliability has also been established (r=.95) by Gouvier et al., (1987). In regards to criterion and construct validity, studies show significant correlations between DRS scores a return to work (86.8% accuracy), life satisfaction at discharge ($r=-.31$, $p<.01$) and discharge status

(Eliason & Topp, 1984). The correlation between DRS and GOS scores (r=.67; Hall et al., 1985), between DRS and Stover Zeiger (SZ) Scale scores (r=.92; Gouvier et al., 1987), and between DRS and the Functional Assessment Measure (r=-.96) (Hall et al., 2001) are all quite significant.

Use of Neuropsychological Testing in Post-Acute Stages of TBI

Neuropsychological testing and mental status evaluations are often used during the early post-acute stages of TBI to determine awareness, orientation, post-traumatic amnesia (PTA), and improvement or deterioration on simple cognitive tasks (Lezak, 2012). Neuropsychological testing also is used commonly to assist in planning of rehabilitation. Neuropsychological testing has proven useful in predicting patient outcome. The less impairment shown on neuropsychological examinations performed soon after the injury, the better the prognosis will be for improvement over time; thus, assessment is useful in identifying improvement plateaus (Williams, et al., 2013). A review of 23 studies concerning the relationship between neuropsychological test results and employment outcome after TBI strongly supported the use of early neuropsychological assessment as a predictor of late employment outcome (Sherer et al., 2002a). Another study by Sherer and colleagues indicated that individuals scoring in the 75^{th} percentile had 2.46 time greater odds at being productive at follow-up (Sherer et al., 2002b). Boake et al., (2001) found that productivity at follow-up was predicted by the completion of at least 1 neuropsychological test before discharge. Also, normal range scores on more than 2/3rds of the 15 test battery increased long-term productivity by 40% to 130%. Patient testability, as measured by a patient's ability to complete an assessment

based task, has been shown to be predictive of outcome. Neuropsychological data, including the testability of patients, collected uniformly at 1 month following injury can contribute to the prediction of global outcome (Pastorek et al. 2004). He found that testability at 1 month post injury as measured by very basic tests of language comprehension and attention consistently accounted for a significant portion of the variance in DRS scores (10.1–13.2%) and significantly improved prediction of GOS scores. Galveston Orientation and Amnesia Test (GOAT) scores collected at 1 month post injury accounted for substantially less variance in DRS scores (7.7–8.4%).

Do Neuropsychological Tests Vary in Completion Difficulty?

Neuropsychologists know that some tests are easier to complete and resulting in less missing data, even within a particular cognitive domain. For instance, Digit Span (DS; Wechsler 1955) and the Paced Auditory Serial Addition Test (PASAT) are both measures of working memory as evidenced by factor analyses (Crawford et al. 1998). In that article, the PASAT load highly (.75) on the attention/concentration factor, its loading being comparable to those of Arithmetic (.632) and Digit Span (.709). Both are also specifically auditory and involve the presentation of single digit integers. The two components of DS, Digit Span Forward (DSF) and Digit Span Backward (DSB) are associated with a much higher rate of completion than the Paced Auditory Serial Addition Test (PASAT). A previous study by Wiegand et al., (2014) that examined test completion percentage and reasons for non-completion, found the PASAT had the highest non-completion rate (56%) at 3 months post injury, primarily because of difficulty understanding the test requirements on practice trials (31%) that precluded

further test administration. In comparison, 92.9% of individuals were able to complete a reliable administration of the Digit Span test. Non-completion rates for other tests in the battery ranged from 8%-18%. Reasons for non-completion varied. Medical complications (e.g., high fever, respiratory problems etc.) were the most frequent. Of those other measures in the battery, Digit Span was found to be the most likely to be completed with only 8% of the subjects failing to complete the measure.

The Digit Span Test

The Digit Span (DS) test was chosen as a marker of testability due to its simplicity and high rate of completion as previously noted. The most common format of the DS test is from the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1981). It is commonly used to measure span of immediate verbal recall, attention, and working memory. It is comprised of two different subtests, the Digit Span Forward (DSF) and Digit Span Backward (DSB). Though the DS score is a combination of these subtests, the tests often measure different cognitive abilities. Functional imaging findings in a healthy group of individuals indicates right dorsolateral pre-frontal cortex activation, as well as, bilateral occipital cortex and bilateral inferior parietal lobule activation (Gerton et al., 2004). Performance on the DS test appears to lower following a TBI (Ponsford 2008, Uzzell 1987).

In regards to DSF, a measure of focused attention, the participant is asked to repeat a sequence of numbers exactly as they are given. The examiner reads a series of numbers at a rate of one per second. The difficulty of the measure increases sequentially

and the subject continues to attempt the measure until they fail a pair of sequences of the same length or they complete the task (max 9 numbers).

For DSB, the participant is asked to repeat sequence of numbers in reverse order. The examiner again reads a series of numbers at a rate of one per second. The difficulty of the measure increases sequentially and the participant continues to attempt the measure until a pair of sequences is failed or the task (max 8 numbers) is completed. DSB requires storing and manipulation of numbers, which relies more heavily on the working memory, which differentiates it from the more attentional measure DSF (Banken, 1985).

The Paced Auditory Serial Addition Test

The PASAT was developed as a measure of speed of immediate memory and attention (Sampson, 1958) and was first used clinically in a head injured population with concussion to measure speed of information processing (Gronwall & Sampson, 1974). Several versions have been developed utilizing differing sensory input methods as well as variations in test parameters (Strauss, Sherman, & Spreen 2006). The most common versions include the Gronwall (61 item trials) (Gronwall, 1977) and the Levin version (50 item trials) (Levin, 1983) (See Appendices F & G). The PASAT is also recognized as a measure of multiple cognitive functions including sustained and divided attention (Hannay et. al., 2004) and working memory (Shucard, 2004), as well as basic mathematical ability (Hiscock et al., 1998). A factor analytic study of the PASAT indicated the measure had more in common with tests of attention and information processing than with memory, visuocontruction, or verbal knowledge (Larrabee, 1995).

PET studies aimed at determining the neuroanatomical structures and systems associated with PASAT performance indicate:

"*PASAT activated dispersed noncontiguous foci in the superior temporal gyri, bi-frontal and bi-parietal sites, the anterior cingulate and bilateral cerebellar sites". These sites are consistent with expectations for the systems involved in elements of the task that include auditory perception and processing, speech production and the cognitive domains of attention and executive control, working memory, and speed of information processing*" (Lockwood et al., 2004).

When the PASAT is used to assess cognitive effects of severe TBI, a consistent pattern of sensitivity to the presence of TBI emerges (Gronwall, 1981). Ponsford et al. (1992) and Stuss et al. (1989) noted that PASAT scores were significantly lower for patients with severe TBI when compared to normal orthopedic controls. D.D. Roman et al. (1991) noted that patients whose head injuries produced unspecified diffuse damage as opposed to more focal damage are most likely to perform the PASAT poorly. In a study by O'Shaughnessy et al. (1984) reported that only 11% of individuals who suffered a severe closed head injury performed in the normal range of functioning on this measure in the first week post injury. Six months later, 56% of the subjects were still classified as borderline or impaired as determined by Gronwall's (1977) normative sample. In regards to mild TBI, the PASAT appears to be a more sensitive indicator of information processing capacity in head injured patients than other standard measures of attention (Crossen, 1988) and performance is often related to time since head injury (Bate, 2001). However, in some studies, performance on the PASAT did not differentiate a mild head injury from controls 3-months post injury (Ponsford et al., 1996), but has been shown to

be sensitive to the presence of mild head injury up to 72 hours post injury (Stuss et al., 1989).

PASAT performance has shown mixed findings in regards to correlation with severity of injury measures. Gronwall et al. (1981) and Haslam et al. (1995) reported that PASAT scores significantly correlated with duration of PTA. Several other studies failed to show a significant correlation (O'Shaughnessy et al., 1984; Sherman et al., 1997; Stuss et al., 1989). Of course, it is possible that using PTA to define severity of injury was not sufficient. It has been shown that PTA criteria vary among investigators and reliable PTA estimates are often difficult to obtain, especially if assessed retrospectively (Binder et al., 1986; Gronwall et al., 1981). There is also substantial evidence that PTA and coma duration do not predict the development of post-concussive symptoms (Binder et al., 1997) Other researchers use post-resuscitation or BD1 GCS, pupillary reactivity at the time of the GCS measurement, as well as Marshall or Rotterdam CT scan classifications in modeling outcome from TBI (Steyerberg et al., 2008; M.C.T Collaborators 2008). With regard to PASAT performance, Hane et al. (2011) demonstrated a significant relationship between BD1 GCS and some aspects of PASAT performance.

The Patient Testability Confound

While a patient's testability may be a predictive factor for outcome, it is often a confounding element in research. A patient's inability to comprehend, execute, and complete a neuropsychological or other test for a variety of reasons can result in their not being included in data samples and subsequent data analyses. When a test is not completed by an individual, the cause is often undocumented or not reported in published

research (Bagiella et al., 2010). This is potentially problematic in that the results are then biased to those who are functioning at a higher level post injury. The reasons for non-completion of a test are many. For instance, an individual might attempt a test but be unable to complete it because of failure to understand task instructions, medical complications and fatigue. These are different situations than having missing data because the test was never administered perhaps because the individual was not available or the examiner was not available or the equipment broke down. Associated with our database is a code system that provide the reasons why data are missing so that the reasons for missing data can be sorted out. Different methods for replacing the missing scores have been utilized, some that involve statistical imputation of a value as discussed below and others that involve replacing the missing value with a specific value perhaps the lowest possible value on the task or a score one lower than the lowest score of any individual observed (Dikmen, et al. 1995).

Missing Data and PASAT Performance

The PASAT often produces "missing data." The PASAT is associated with the highest refusal/discontinue rate when compared with other measures (Aupperle et al., 2002; Wiegand et al., 2014). The task has acquired the reputation of being aversive and can increase stress (Lejuez et al., 2003) and fatigue (Johnson et al., 1997). It is noted to be one of the more difficult cognitive tests commonly given to individuals with TBI and thus may be given at the end of a test battery in order to avoid distressing patients who then might not want to proceed with the rest of the battery. Of course putting a difficult test at the end of the battery when the patient is likely to be more fatigued introduces

another problem. Due to the measure's difficulty, a large number of individuals are often incapable of completing the task, or successfully completing the practice trials if they have a serious TBI, even at 6 months post injury so they then have incomplete or no PASAT scores. Depending on how this missing information is statistically handled, there can be an effect on the findings. Goldstein et al. noted under similar circumstances "These analyses undoubtedly overestimated the capabilities of the patients because they only included individuals who could perform the tasks" (Goldstein et al., 1994). As mentioned previously, if the score was missing because the patient was cognitively incapable of performing the task, a bias may have been introduced that could restrict their findings with respect to severity of injury in their models to those who could complete the PASAT. Additionally, it is conceivable that severity of injury might play less of a role in those models because of less power to reject the null hypothesis with a smaller sample size and also because the range of severity of injury in these studies may be restricted to less severe injuries.

Treatment of Missing Data

A variety of techniques can be used to handle missing data. Such techniques include estimating the missing values using imputation algorithms (such as generalized estimating equations), 'last-observation-carried-forward', using the lowest score possible, and dropping participants with missing data entirely (Decrane et al. 2013). Many statistical methods used for handling missing data assume that the data is 'missing at random' (DeSouza, et al. 2009), in which case omission or 'likely score' substitution methods are appropriate. Many common statistical methods which generate possible

alternative data for missing values (such as multiple imputation) assume that the value is missing at random and should fall in a way that reflects the general variability of the factor (Abayomi et al., 2005). This, however, is often not the case with health-related research and these statistical techniques increase the risk of bias and reduce the reliability and interpretability of results from clinical trials (Fleming, 2005). Research involving acute and post-acute neurocognitive functioning is particularly prone to missing data. Reasons include prolonged post-traumatic amnesia, disruptions by medical personnel, medical equipment (i.e. intubation), patient scheduling difficulties, and a variety of other complications seen in an acute/post-acute setting. Though procedures are put in place to maximize likelihood of collecting data and/or reason for not collecting data, missing data still occur in this population. Differentiation and classification of the reasons for missing data can aid in determining which inclusion technique to use in statistical analysis (for more information on the statistical imputation methods used in this study, please refer to the design section.) One method for doing this is to use reliability of test administration codes that provide reasons why administration was not reliable, as well as test completion codes supplying additional information about the reasons for test non-completion.

Reliability, Test Completion, and Impairment Codes

The ability to complete a particular neuropsychological or other test depends on a variety of variables. It is often anticipated that participants may not be able to complete a battery at early stages of recovery, particularly for patients who have not emerged from a vegetative state or are not fully oriented to person, place and time and may still have post-traumatic amnesia in which there is not continuous memory for events after some

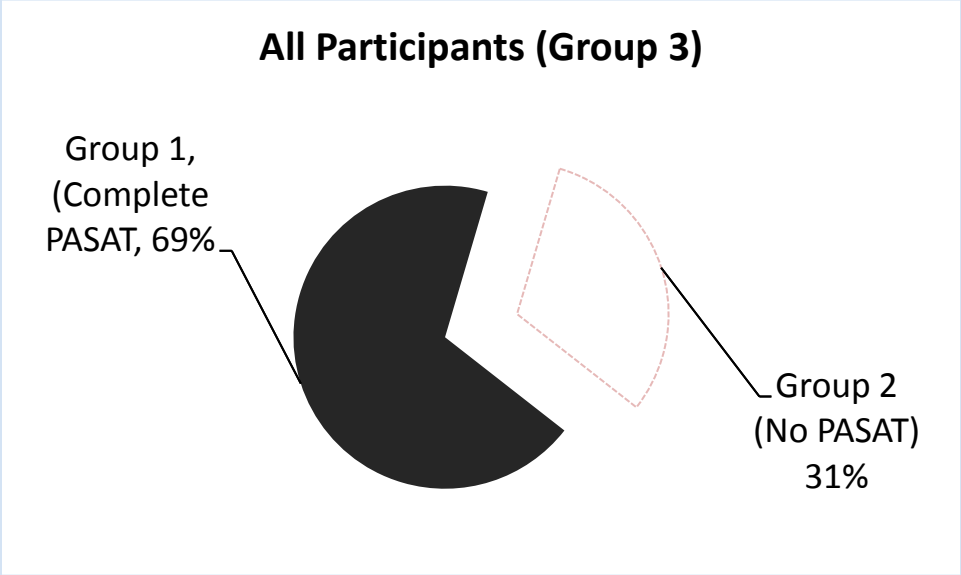
brain injury. Some patients never reach a level of recovery conducive to completing an entire test battery while completing, perhaps, some of the tests that have fewer demands related to specific injury effects. We think that it is important to document the reasons for missing values in order to distinguish the inability of the patient to complete the task due to brain-related impairment from other reasons such as unknown whereabouts of the patient. The codes address validity issues such as was the test administered correctly and did the participant complete the task to the best of his/her ability. The codes also indicate if the patient was unable to complete the test for medical reasons indirectly related to the TBI. The codes also identify situations in which the test was not completed or complicated by other unrelated medical issues such as cataracts or deafness, interrupted testing, or situational or behavioral issues such as a lack of cooperation. Distinctions made with such codes are imperative in understanding why there are missing data (Hannay et al 2004; Bagiella et al., 2010). A study by DeCrane et al. (2013) was able to increase its sample size by 20-32% when using a form of test completion codes. Data collectors had provided the reasons for data being missing using adjectives such a s 'confused,' 'incapable,' 'stuporous,' 'comatose,' and 'intubated' to assign numerical scores of "0" to tests in which older post-operative patients were cognitively incapable of performing the neuropsychological test. They concluded that by using this scoring system, they were able to lessen the chance of Type II error that is, lessoning the chance that a patient's cognitive impairment goes undetected (failure to reject a false null hypothesis). Our codes were used by Pastorek et al., (2004). His study of testability that found that testability for relatively simple tests of language comprehension and attention were better predictors of outcome than the Galveston Orientation and Amnesia Test

(GOAT) and test scores themselves. Many years ago, H. J. Hannay and M.A. Struchen created a series of codes for classifying performance on each test in the neuropsychological test battery (Hannay, personal communication, 2014). These were modified over time. They include reliability, test completion and impairment codes, each having a numeric value for the description and also for data analysis though all are nominal in nature (See Appendices H, I, J). These codes indicate the reliability of the test data and reasons for unreliable test data, completion information and reasons for non-completion of a test, and finally, further explanation of any factor such as a sensory or motor impairment, fatigue, and so on that could compromise performance on a particular test. For example, a reliability code of 4 indicates that patient attempted the task but was unable to complete it. His test completion code of 2 would indicate that this was for medical complications while an impairment code of 9 would indicate none. (See Appendix J).

The Current Study

This study had three aims: First, the study determined the nature of the differences in demographics, severity of injury, and global outcome on the DRS between participants who completed the PASAT (Group1) and those who could not complete the PASAT (Group 2) at 6 months post injury (a descriptive aim with possible clinical relevance) (See Figure 1).

Figure 1. PASAT Completion Percentage



Secondly, the relationship between the participants' PASAT scores and global outcome on the DRS at 6 months post injury for those who completed the PASAT (Group 1) was determined while controlling for demographic and injury severity measures. This allowed us to consider possible clinical utility of the PASAT in predicting global outcome.

Finally, the study determined if the inclusion of participants who had not completed the PASAT (Group 2) by imputation of PASAT scores would improve the ability of the PASAT to predict global outcome possibly by increasing the sample size. This allowed us to include all participants from Group 1 and Group 2 in the statistical analysis. The combined group was labeled Group 3. The imputation of missing data was intended to reduce the effects of the previously mentioned positive sample bias that may occur when measures are not included for individuals whose cognitive performance reflects poor recovery.

Hypotheses

Aim 1: It was hypothesized that individuals who completed the PASAT (Group 1) as opposed to those who did not complete the PASAT (Group 2) would be significantly younger in age, have a higher level of education, less severe injuries as measured by GCS and Marshall CT scan classifications. Additionally, Group1 would have better outcome on the DRS.

- **Hypothesis I**: Group 1 participants' mean age was expected to be significantly lower than for Group 2 participants.
- **Hypothesis II**: Group 1 participants' mean education was expected to be significantly higher than for Group 2 participants.
- **Hypothesis III**: Group 1 participants were predicted to have significantly less severe damage as measured by BD1 GCS and Marshall CT scan classification system than Group 2 participants.
- **Hypothesis IV**: Group 1 participants were predicted to have significantly lower DRS scores than Group 2 participants.

Aim 2; It was further hypothesized that PASAT performance would be predictive of DRS outcome in Group1 when controlling for demographic variables and injury severity variables.

- **Hypothesis V**: Group 1 participant's performance on the PASAT, as measured by total number of correct responses, would be related significantly to DRS scores when controlling for demographic variables (age and education) and injury severity measures (BD1 GCS).

Aim 3: Finally, it was hypothesized that the relationship between PASAT performance and DRS outcome would be improved by increasing the sample size through imputation of missing PASAT scores for those in group 2 thus producing Group 3, a combination of participants from groups 1 and 2.

- **Hypothesis VI:** Group 3 participants' performance on the PASAT, as measured by total number of correct responses, was predicted to relate significantly to DRS scores when controlling for demographic variables (age and education) and injury severity measures (BD1 GCS).
- **Hypothesis VII:** The strength of the relationship between PASAT performance and DRS scores was expected to be better for Group 3 participants than for Group 1 participants, as measured by comparison of R^2 values.

METHODS

Participants

Data were obtained retrospectively from a database of 169 patients with complicated mild, moderate or severe TBI admitted to the Neurosurgery Intensive Care Unit of level 1 Trauma Center who survived, agreed to take a neuropsychological battery at 6 months post injury, completed the Digit Span Test, and attempted the PASAT. The original research was conducted with the approval of the Institutional Review Board (IRB) of Baylor College of Medicine and by the University of Houston (UH) Committee for the Protection of Human Subjects (CPHS) as part of NIH grants. All data associated with this study were obtained with the consent of individuals having a TBI, family members, and/or legally authorized patient representatives as appropriate. UH CPHS approval was obtained for this archival study after the proposal was approved.

Exclusion criteria included existence of previous head injury that required medical attention, central nervous system disorder, or previous diagnosis of a major psychiatric disorder. Of the 169 participants, data from an additional 44 participants were removed for the following reasons. For 16 participants, a Spanish version of the PASAT was unavailable,13 due to a missing primary outcome measure (the 6 month DRS), 8 because of unreliable or incomplete Digit Span administration, 6 had a gunshot wound to the head, and finally 1 individual was removed because the Asian ethnicity/racial group was underrepresented in our sample ($N = 1$). In summary, data from 125 individuals were included the study analyses.

Sample Demographics and Clinical Characteristics

Participant demographics include age, gender, ethnicity, level of educational attainment, and mechanism of injury. The participants ranged in age from 15 to 78 (M = 31.8, SD = 13.3). This is consistent with previous studies of TBI from the facility, as well as, The Centers for Disease Control and Prevention (CDC, 2010).

As is consistent with previous studies from our databases, the ratio of males to females was about 4:1. The majority of patients in the sample were males under the age of 40 (60.8 %) as might be expected (CDC, 2010). Gender was not significantly related to age $F(1,123) = .148$, $p = .701$, or education $F(1,120) = 2.48$, $p = .12$. A Pearson Chi-Square test indicated that Gender was not related to ethnicity X^2 (2, N = 123) = 5.70, p = .07.

The ethnic/racial make-up was 48.8% Non-Hispanic Caucasian, followed by 27.2% Hispanic, and 24% African American. The ethnic/racial composition of the current sample differed somewhat from the city census data given by the U.S. Census Bureau at the time of admission to acute care. The most significant deviation from census information was the Hispanic sample, in which the study sample had 27.2% and the number of persons of Hispanic or Latino Origin in the area is over 40% (U.S. Census Bureau, 2000). A one-way ANOVA revealed that years of education varied significantly with ethnic/racial group [$F(2,119) = 9.96$, $p = .00$]. A post hoc Scheffe's test indicated Non-Hispanic Caucasians differed significantly ($p < .05$) from Hispanics and from African Americans ($p < .05$). No significant differences were noted between Hispanics and African Americans ($p > .05$). A one-way ANOVA indicated that the average age of the participant varied significantly by ethnic/racial group [$F(2,122) = 6.49$, $p = .00$]. A

post hoc Scheffe's test indicated Hispanic differed significantly from Non-Hispanic Caucasians ($p < .05$) and from African Americans ($p < .05$). No significant differences were noted between Non-Hispanic Caucasians and African Americans ($p > .05$)

Years of education ranged from 5 to 20 ($M = 11.53$, $SD = 2.56$). A relatively small percentage of the sample had a college education or higher degrees (7.2%). A Pearson Correlation did not indicate a strong relationship between age and education, $r(122) = .097$, $p = .29$.

In regards to mechanism of injury, automobile accident (53.6%) was the leading cause of injury followed by assault (20.8%). Motorcycle accidents (10.4%), Fall/Jump (6.4%) and Other/Unspecified (8.8%) injuries make up the rest of the sample. Greater than 60% of the participants had a motor vehicle related injury. These findings are similar to the literature (CDC, 2010). For more information regarding the breakdown of demographic variables, please see appendices K and L.

Injury Severity and Outcome Measures

The previously mentioned severity of injury measures (BD1 GCS, pupillary reactivity, and worst Marshall CT classification) were obtained from participants after admission to the trauma center. The BD1 GCS score was obtained on the each individual during the first 24 hours after NICU admission and had a $M = 7.92$. A one-way ANOVA showed that BD1 GCS did not vary significantly with any demographic variables including age [$F(44,78) = .891$, $p = .66$], education [$F(12,107) = 1.10$, $p = .37$], ethnicity [$F(2,120) = .176$, $p = .84$], or gender [$F(1,121) = .040$, $p = .84$]. BD1 GCS scores were

significantly related to pupillary responsivity [F(1,117) = 13.42, p = .00]. BD1 GCS scores were significantly related to DRS Scores [F(1,121)=10.03, p = .00]. BD1 GCS scores were not related significantly to Marshall CT Scan scores.

Pupillary reactivity score taken at the time of the BD 1 GCS score was included. In order to determine the patients' pupillary reactivity score, a score of 1 (normal or sluggish reactivity) and 0 (non-reactive) was assigned to each observation. The combined score (either 0, 1, or 2) for both eyes was then used to determine the patient's total score. Pupillary reactivity scores were available on 121 of the participants, 100 (82.6%) of those having reactive pupils and only 22 (17.4%) having either one or no reactive pupils. A one-way ANOVA with pupillary reactivity as the independent variable and DRS score as the dependent variable did not produce a significant main effect [$F(1,119) = .314$, $p=.58$). A Fisher-Freeman-Halton Exact test indicated that Pupillary Reactivity was not related to age ($p=.72$), education ($p=.60$), gender ($p=.20$), or ethnicity ($p=.79$).

Marshall CT scan classification was used to categorize individuals based on severity and abnormality of a CT brain scan. The worst CT scan classification score was used in the study. Of the six classifications, the most common participant classification was Diffuse Injury III (42.4%). Diffuse Injury IV and Non-evacuated Mass Lesion together only accounted for 2.4% of the sample's scan classification. A one-way ANOVA with Marshall CT scan classification as the independent variable and DRS score as the dependent variable did not produce a significant main effect (F=1.49, p=.70). A Fisher-Freeman-Halton Exact test indicated that Marshall CT scan classification was not related to age ($p=.81$), education ($p=.76$), gender ($p=.83$), or ethnicity ($p=.61$).

Outcome measures in our study were obtained by trained professionals at various intervals post injury, though only data from 6 months post injury will be involved DRS scores were selected as outcome measures for the reasons mentioned in the introduction. Participants were evaluated with the Disability Rating Scale (DRS) at numerous time points; including at 1, 3, and 6 months post-injury, as well as at hospital discharge. The DRS was administered by either a clinical neuropsychologist or a trained technician. The six-month post injury evaluation was used in this study. The average DRS score was 3.14 (SD=2.94, n=125). For more information on injury severity, and outcome measure breakdown, please see Appendices K and M.

PASAT Administration

Administration of the PASAT was attempted at 6 months post injury following written instructions (see Appendix F) using the Levin et al., (1987) version which includes 4 trial blocks of 50 random numbers (49 responses). Prior to trial administration, several practice trials were administered. If the participant was unable to provide a correct response to any of the trials, the test was discontinued. Otherwise the test was continued although an individual might or might not complete all of the test trials. During this evaluation a patient would hear a random series of numbers, 1 to 9, presented via audiotape recording in which the participant is instructed to add the numbers such that each number is added to only the number that immediately preceded rather than keep a running total by adding consecutive numbers together. During each consecutive trial, the length of time between numerical stimuli, interstimulus interval (ISI), was shortened, providing for an increasingly difficult task. The ISIs for the four respective trials were

2.4, 2.0, 1.6 and 1.2 seconds. Correct responses, commission and omission errors were recorded for each trial block. A total of 49 responses was available for the 50 item trial, giving the PASAT a total of 196 responses. Correct response (CR) was defined as the individual giving the correct sum of the most recent two numbers heard before presentation of the next number. Commissions (COM) occurred when the participant provided an incorrect response, that is, added the two numbers incorrectly. Omissions (OM) occurred when the individual did not give a response. These response categories are related as follow: CR + CM + OM =196 across the 4 trials. In the case of correct responses (CR) this value could be as low as -1 if the worst score is 0. For measure of incorrect responses, commissions (CM) and omissions (OM), the worst score could be 197 (+1), given no correct responses and a possible 196 incorrect responses. In this study, correct responses was the PASAT predictor variable.

Performance on the PASAT was not significantly related to age [$F(1,84) = .96$, $p = .33$] ethnicity [$F(63,22) = 1.06$, $p = .45$], education [$F(1,82) = .56$, $p = .46$], gender [$F(1,84) = .39$, $p = .53$], Marshall CT Scan classification [$F(1,84) = 4.26, .05$], or Pupillary Responsivity [$F(1,82) = .001$, $p = .98$], The PASAT was significantly related to DRS scores ($F(1,84) = 26.11$, $p = .38$) and BD1 GCS [$F(1,82) = 6.776$, $p = .01$]. (See appendix U)

Digit Span Test Administration

The Digit Span Test, similarly to the PASAT, is a measure of working memory. The first task required a participant to listen to a series of digits and then to repeat them. This process continued until the participant was unable to recall either the full sequence

of numbers or the correct order for two sequential trials. In the reverse trial, the participant was asked to repeat the sequence in reverse order. This sequence was continued also until the participant made sequential errors. A Digit Span Total score is derived from the addition of these subtest scores.

Design

The dataset was scanned for errors, outliers, and missing data following guidelines outlined in "Using Multivariate Statistics." (Tabachnick et al., 2007) Forty-five participants were excluded for reasons noted previously.

The design of the study involved the three groups noted under the "Current Study" section. Group 1 individuals reliably completed the PASAT. These individuals were deemed testable, as they were able to complete a simpler measure (DS) of attention and working memory. Group 2 individuals did not have a representative PASAT score. These individuals were able to complete the simpler test (DS) but unable to produce a reliable PASAT score. The reasons why some of the individuals in Group 2 could not complete the PASAT were all related to having a closed head injury (e.g., fatigue, confusion, agitation, task demands, aphasia, dysarthria, refusal to finish the task) despite a reliable administration, according to the test completion codes outlined in the introduction. Group 3 consists of all the participants in the study. For our statistical analysis of Group 3, separate techniques were used to impute missing PASAT information for those individuals in Group 2. This created multiple iterations of Group 3, hereafter referred to as Group 3a, Group 3b, Group 3c, and Group 3d. All methods used for imputing a PASAT score were single imputation techniques:

Group 3a: Unconditional Mean Imputation is the most widely used technique in statistics. This involves substituting the mean of the group for each individual missing case. This method assumes the data is missing at random. For our analysis, this involves replacing the missing data with the value 103.53 for individuals in Group 2.

Group 3b: The Minimum Score Imputation is often used when dealing with left censored data. A left censored value is one that is known to be less than a given value. This does not assume that data are Missing Completely at Random. Instead, it is used because a measure cannot be completed due to a lack of ability. If we assume that our missing data occur because individuals were unable to complete the assigned measure, a score equal to the lowest possible PASAT score of 1 is assigned for individuals in Group 2.

Groups 3c & 3d: Regression Coefficient Estimates are a way to use information that we know about the participants to aid in the prediction of unknown information. In this application, information about individuals in Group 1 was used to assist our prediction about PASAT scores for those individuals in Group 2. A linear regression equation was created from the data available. Two separate linear regression lines were created. The first regression equation was generated using Group 1 participants' performance on the Digit Span Total task and their PASAT performance ($R^2 = .349$) [$F(1,84) = 45.07, .00$]. The second regression equation was generated using Group 1 participants' Digit Span Backward Score and their PASAT performance ($R^2 = .298$) [$F(1,84) = 35.593, .00$]. (see appendix V) The resulting regression equations were as follows:

PASAT Score = 5.34 (Digit Span Total) + 29.19

PASAT Score = 10.05 (Digit Span Backward) + 42.79

Finally, by adding known information about Group 2, their DST and DSB scores, to this equation, PASAT scores were generated for participants. Those utilizing the DST score we called Group 3c. Those utilizing the DSB score we called Group 3d. This imputation information is summarized in Table 2.

Table 2. Group 3 PASAT Imputation Methods

Groups	Defined	Statistical Method
Group 3a Unconditional Mean Imputation	Substitutes missing data with the mean value for that variable.	Missing values are substituted with the mean for all PASAT scores, which was 103.53
Group 3b Minimum Score Imputation	Substitutes missing data with the minimum possible score available for that measure	Missing values are substituted with the lowest possible score, which was 1.
Group 3c Regression Coefficient: Digit Span Forward	Substitutes missing data with a value determined by a similar variable.	Missing values are determined using the regression equation: PASAT Score = 5.336 (Digit Span Total) + 29.187
Group 3d Regression Coefficient: Digit Span Backward	Substitutes missing data with a value determined by a similar variable.	Missing values are determined using the regression equation: PASAT Score = 10.049 (Digit Span Backward) + 42.793

CHAPTER THREE: RESULTS

Aim 1: "It was hypothesized that individuals who completed the PASAT (Group 1) as opposed to those who did not complete the PASAT (Group 2) would be significantly younger in age, have a higher level of education, less severe injuries and better outcome on the DRS."

Information on the demographics, injury severity and outcome scores for Group 1, Group 2 and all participants in the study appear in Table 3.

Table 3. Group Differences: Demographics, Injury Severity, and Outcome

		Group 1 Participants	**Group 2 Participants**	**All Participants**
Age				
	Age (years) n, M, SD	n=86, 30.33, 11.78	n=39, 35.15, 15.90	n=125, 31.8, 13.3
	15-20, n (%)	21 (24.4)	5 (12.8)	26 (20.8)
	21-30, n (%)	27 (31.4)	14 (35.9)	41 (32.8)
	31-40, n (%)	22 (25.6)	7 (17.9)	29 (23.2)
	41-50, n (%)	8 (9.3)	8 (20.5)	16 (12.8)
	51-60, n (%)	8 (9.3)	1 (2.6)	9 (7.2)
	61-78, n (%)	0 (0)	4 (10.3)	4 (3.2)
Gender				
	Gender, n	n=86	n=39	n=125
	Female, n (%)	20 (23.3)	6 (15.4)	26 (20.8)
	Male, n (%)	66 (76.7)	33 (84.6)	99 (79.2)
Ethnicity				
	Ethnicity, n	n=86	n=39	n=125
	Non-Hispanic Caucasian, n (%)	47 (54.7)	14 (35.9)	61 (48.8)
	Hispanic, n (%)	22 (25.6)	12 (30.8)	34 (27.2)
	African American, n (%)	17 (19.8)	13 (33.3)	30 (24.0)

Education				
	*Education Years, n, M, SD	n=84, 11.92, 2.61	n=38, 10.68, 2.26	n=122, 11.53, 2.6
	0-11, n (%)	34 (39.5)	21 (53.8)	55 (44)
	12, n (%)	21 (24.3)	12 (30.8)	33 (26.4)
	13-15, n (%)	20 (23.3)	5 (12.8)	25 (20.0)
	16-20, n (%)	9 (10.5)	0 (0)	9 (7.2)
Mechanism of Injury				
	MOI, n	n=86	n=39	n=125
	Automobile, n (%)	44 (51.2)	20 (51.3)	64 (51.2)
	Assault, n (%)	15 (17.4)	11 (28.2)	26 (20.8
	Motorcycle, n (%)	10 (11.6)	3 (7.7)	13 (10.4)
	Fall/Jump, n (%)	8 (9.3)	0 (0)	8 (6.4)
	Other, n (%)	9 (10.4)	5 (12.8)	11 (8.8)
BD1 GCS				
	BD 1 GCS, n, M, SD	n=84, 8.11, 3.72	n=39, 7.51, 2.74	n=123, 7.92, 3.4
Pupil Reactivity				
	Pupil Reactivity, n	n=84	n=37	n=121
	Both Reactive, n (%)	68 (79.1)	32 (82.1)	100 (80.0)
	One Reactive, n (%)	4 (4.7)	2 (5.1)	6 (4.8)
	No Reactivity, n (%)	12 (14)	3 (7.7)	15 (12.0)
Marshall CT				
	Marshall CT, n	n=86	n=38	n=124
	Diffuse I, n (%)	3 (3.5)	1 (2.6)	4 (3.2)
	Diffuse II, n (%)	37 (43)	16 (41.0)	53 (42.4)
	Diffuse III, n (%)	18 (20.9)	7 (17.9)	25 (20.0)
	Diffuse IV, n (%)	1 (1.2)	0 (0.0)	1 (.08)
	Evac. Mass, n (%)	25 (29.1)	14 (35.9)	39 (31.2)
	Non-Evacuated Mass, n (%)	2 (2.3)	0 (0.0)	2 (1.6)
DRS				
	*DRS, n, M, SD	n=86, 2.44, 2.16	n=39, 4.69, 3.78	n=125, 3.14, 2.9

* *Significant differences found between Group 1 and Group 2.* It should be noted that there were no significant gender, pupillary reactivity, or mechanism of injury group differences. (Appendix N)

Given Aim 1 consisted of 5 separate analyses, Alpha level = .01 (.05/5) was used.

Hypothesis I: *Group 1 participants' mean age was expected to be significantly lower than for Group 2 participants.* This hypothesis was not supported. Group 1 (M = 30.33, SD = 11.80) and Group 2 (M = 35.15, SD = 15.89) did not differ significantly in age per one-way ANOVA (F(1,123) = 3.591, p = .060). (Appendix N)

Hypothesis II: *Group 1 participants' mean education was expected to be significantly higher than for Group 2 participants.* This hypothesis was not supported. Group 1 (M = 11.92, SD = 2.61) and Group 2 (M = 10.68, SD = 2.26) did not differ significantly in years of education per one-way ANOVA [F(1,120) = 6.32, p = .013]. (Appendix N)

Hypothesis III: *Group 1 participants were predicted to have significantly less severe damage as measured by BD1 GCS and Marshall CT scan classification system than Group 2 participants.* This was not supported. In regards to BD 1 GCS, Group 1 (M = 8.11, SD = 3.72) and Group 2 (M = 7.51, SD = 2.74) did not differ significantly per one-way ANOVA [F(1,121) = .794, p = .38]. Group 1 and Group 2 also did not differ significantly in terms of Marshall CT classification as demonstrated with a Fisher Freeman Halton Exact test (p =.951). (Appendix N)

Hypothesis IV: *Group 1 participants were predicted to have significantly lower DRS scores than Group 2 participants.* This hypothesis was supported. Group 1 [M = 2.44, SD = 2.16] had significantly lower DRS scores than Group 2 (M = 4.69, SD = 3.78) as determined by one-way ANOVA. [F(1,123) = 17.83, p = .00]. (Appendix N)

Aim 2: "It was further hypothesized that PASAT performance would be predictive of DRS outcome in Group1 when controlling for demographic variables and injury severity variables."

Given Aim 2 consisted of one analysis, Alpha level = .05

Hypothesis V: *Group 1 participant's performance on the PASAT, as measured by total number of correct responses, would be related significantly to DRS scores when controlling for demographic variables (age and education) and injury severity measures (BD1 GCS).* This was supported. Group 1 consisted of only individuals able to complete the PASAT so the sample size was reduced by 32.8%, from $N = 125$ to $N = 84$. The hypothesis was tested using hierarchical regression. Covariates were entered into the model using a blockwise procedure. PASAT correct responses was the predictor variable and DRS score was the outcome variable. The data failed the Breush-Pagan and Koenker tests of heteroscedasticity (see appendix O). A natural LOG transformation of the dependent variable (DRS +1) was able to satisfy this assumption. Group 1 participants' performance on the PASAT was significantly related to DRS scores when controlling for age, education, and BD1 GCS. Using the transformed dependent variable, the coefficient of determination, or R2 change value was equal to .164. The F test of significance determined that this value was significant [$F(1,77) = 15.96$, $p = .00$]. That means 16.4% of the variance in our transformed DRS scores was determined by performance on the PASAT.

The overall model, which consisted of age, education, BD1 GCS, and PASAT performance had an R^2 value of .207 and it is significantly related to the transformed

DRS [$F(4,81) = 5.02$, $p = .00$]. The initial predictor variables (BD1 GCS, Age, and Education) alone were not related significantly to the transformed DRS score [$F(3,78) = 1.16$, $p = .33$], and the R^2 value equaled .043. See Appendix (P) for statistical output.

AIM 3: "Finally, it was hypothesized that the relationship between PASAT performance and DRS outcome would be improved by increasing the sample size through imputation of missing PASAT scores for those in group 2 thus producing Group 3, a combination of participants from groups 1 and 2."

Given Aim 3 consisted of 4 separate analyses, Alpha level = .0125 (.05/4) was used.

Hypothesis VI: *Group 3 participants' performance on the PASAT, as measured by total number of correct responses, was predicted to relate significantly to DRS scores when controlling for demographic variables (age and education) and injury severity measures (BD1 GCS).* This was supported. When entered into a linear regression analysis, Group 3 participants' performance on the PASAT was significantly related to DRS scores when controlling for age, education, and BD1 GCS for each statistical imputation type as given below.

Group 3A: When utilizing the Unconditional Mean Imputation method, the hypothesis was supported. PASAT performance accounted for significant variance in transformed DRS scores producing an R^2 change value of .066 [$F(1,115) = 9.19$, p =.00]. The overall model, which consisted of age, education, BD1 GCS, and PASAT performance was significantly related to DRS scores (R^2 =.175) [$F(4,119) = 6.11$, p =

.00]. The covariates (BD1 GCS, Age, and Education) alone were significant predictors of DRS performance (R^2=.109) [F(3,116) = 4.75, p =.00]. (See Appendix Q)

Group 3B: When utilizing the Minimum Score Imputation method, the hypothesis was supported. PASAT performance accounted for significant variance in transformed DRS scores producing an R^2 change value = .111 [F(1,115) = 16.36, p = .00]. The overall model, which consisted of age, education, BD1 GCS, and PASAT performance was significantly related to DRS scores (R^2 = .220) [F(4,119) = 8.11, p = .00]. The covariates (BD1 GCS, age, and education) alone were significant predictors of DRS scores (R^2 = .109) [F(3,116)= 4.75, p = .00]. (See Appendix R)

Group 3C: When utilizing the Regression Coefficient (DST) method, the hypothesis was supported. PASAT performance accounted for significant variance in transformed DRS scores producing an R^2 change value =.123 [F(1,115) = 18.47, p = .00]. The overall model, which consisted of age, education, BD1 GCS, and PASAT performance was significantly related to DRS scores (R^2 = .233) [F(4,119) = 8.71, p = .00]. The covariates (BD1 GCS, age, and education) alone were significant predictors of DRS scores (R2 = .109) [F(3,116) = 4.75, p = .00]. (See Appendix S)

Group 3D: When utilizing the Regression Coefficient (DSB) method, the hypothesis was supported. PASAT performance accounted for significant variance in transformed DRS scores producing an R^2 change value = .146 [F(1,115) = 22.46, p = .00]. The overall model, which consisted of age, education, BD1 GCS, and PASAT performance was significantly related to DRS scores (R^2 = .255) [F(4,119) = 9.84, p = .00]. The covariates (BD1 GCS, age, and education) alone were significant predictors of DRS scores (R^2 = .109) [F(3,116) = 4.75, p = .00]. (See Appendix T)

Hypothesis VII: *"The strength of the relationship between PASAT performance and DRS scores was expected to be better for Group 3 participants than for Group 1 participants, as measured by comparison of R^2 values."* This hypothesis was not supported. While imputation of missing value allowed for the reintroduction of 31.6% of the sample, it did not improve the R^2 change values associated with the PASAT as predictor variable. Three of the four statistical imputation methods (not Mean Imputation) appeared to improve the overall models predictive value of the DRS scores. All four imputation methods used maintained the PASAT's statistical significance. The following table illustrates the statistical differences by imputation method.

Table 4. Comparing Regression Analyses

Regression Analysis Type	N	R^2 Change Value	Total Model F Value	Total Model R^2
PASAT	82	0.164	5.02	0.207
Mean Imputation	120	0.066	6.11	0.175
Min Score Imputation	120	0.111	8.11	0.22
Regression Analysis (DST)	120	0.123	8.71	0.233
Regression Analysis (DSB)	120	0.146	9.84	0.255

CHAPTER FOUR: DISCUSSION

Summary and Conclusions

The first aim of the study was to determine the nature of the differences between individuals who could and could not complete the PASAT at 6 months post injury. The differences of interest included demographic, injury severity, and outcome measures. In regards to demographic variables, none of the variables tested were significantly different between the groups. Demographic variables that were evaluated included age, gender, education, and ethnicity. None of these variables appear to influence whether an individual complete the PASAT. Injury severity measures also had little influence on an individuals' ability to complete the PASAT. BD1 GCS, pupillary reactivity, and Marshall CT scan score were not significantly different between groups. Performance on the study outcome measure, that is, the DRS, was significantly different between groups. Those able to complete the PASAT had an average DRS score 2.24 points lower, which represents better functioning. In conclusion, participants' years of education and functional outcome were the two factors related to their ability to complete the PASAT at 6 months post injury.

The second aim of the study involved exploring the relationship between the participants' PASAT scores and their global outcome, as measured by the DRS at 6 months post injury. A regression model that controlled for significant demographic and injury severity measures was used to determine how much variance was accounted for by PASAT performance. Even though the sample size was reduced by 32.2% (due to the

low number of participants who reliably completed the PASAT), performance on the PASAT was still able to account for 16.4% of the variance in DRS scores, which was found to be significant. The overall model, which included age, education, and BD1 GCS, accounted for 20.7% of the variance in DRS Scores, which again was found to be significant.

The third and final aim of the study involved using statistical imputation methods to include the participants who were unable to complete the PASAT (Group 2) in the statistical analysis. A comparison was then made based on the amount of variance in DRS scores accounted for by the PASAT (R^2 change value).

The first statistical imputation method selected was the Mean Score imputation method. This was selected because it is the most commonly used method and is often used when data points are missing at random (DeSouza, et al. 2009). This was the least effective imputation method as test completion codes indicated the missing data was related to participants' ability, not "lost" data. PASAT performance that underwent Mean Score imputation accounted for 6.6% of the variance in DRS scores, which was statistically significant, but less than the 16.4% of the variance accounted for by the original model that only included group 1. The overall model, which included age, education, and BD1 GCS, accounted for 17.5% of the total variance, which again was still less than the 20.7% of the total variance accounted for by the original model.

Given the reasons for test incompletion, our next imputation was a left censoring technique called Minimum Score imputation. Left censoring is often used when a data point is predicted to be below a certain value, but it is unknown by how much. In this model PASAT performance accounted for 11.1% of the variance in the DRS, which was

again less than the PASAT performance in the original model (16.4%). The overall model, which included age, education, BD1 GCS, and PASAT accounted for 22% of the variance in the model, which means our new model accounts for more of the variance in DRS scores than the original model (20.7%).

The next two imputation methods involved regression analysis based imputation. Digit Span Total and Digit Span Backward were chosen due to their high completion percentage and similarities to the PASAT. Both assessments require auditory administration of single digit integers. They also load on similar cognitive domains including attention/concentration, and working memory. The DST and DSB measures also have a much higher completion rate than the PASAT. In the DST regression based model, PASAT performance accounted for 12.3% of the variance in the DRS, which is less than the PASAT performance in the original model (16.4%). The overall model accounted for 23.3%, which is more variance in the DRS than the total original model (20.7%). The DSB regression based imputation method accounted for more variance than the other imputation models. PASAT performance in this model accounted for 14.6% of the variance in the DRS, as compared to 16.4% in the original model. When we consider the entire model, the model with the DSB regression imputation accounted for 25.5% of the variance in the DRS, while the original total model only accounted for 20.7%.

All four imputation methods appeared to be suitable methods for handling missing data, in that they all accounted for a significant amount of variance in DRS score. Each method introduced new assumptions into the model. Mean Score imputation assumes the missing data is not weighted in either direction and Minimum Score

imputation assumes the missing data is left censored. Having a series of test completion codes that aid in describing why a measure was not completed appears to be useful in choosing between these two particular imputation methods. A regression based imputation assumes that the measure used to create your regression equation requires similar ability and cognitive resources. Therefore, it may be useful to have redundancy among tests of particular cognitive domains, especially if they are known to produce missing data elements.

When creating a battery for acute and post-acute assessment of head injury, PASAT performance yields some clinically significant information. According to this study, the ability to complete this measure may be associated with global functional outcome. Performance on the PASAT also accounts for variance in global outcome. Statistical imputation was able to introduce missing data points without sacrificing the statistical significance of the measure.

Study Limitations and Future Directions

The study was limited to a particular subset of head injured patients which may affect its generalizability to the head injured population. Aside from only containing individuals from one particular geographic location, it contained only 3 racial/ethnic groups. The study did not include mild head injury without CT abnormalities, penetrating head injuries, or individuals with pre-existing physical or psychological conditions. A number of Spanish speaking participants were removed from the study, as the Spanish version of the PASAT was not always available at the time of assessment.

A statistical transformation was performed on a DV in this study. This transformation was necessary to correct for heteroscedasticity. When using transformations, care must be taken in the interpretation of the results. It may be incorrect to make inferences about the results, as the data have been manipulated from its original version. Modern distribution free statistical approaches exist, such as Generalized Estimating Equations, can avoid many of the problems associated with assumption violations.

The imputation methods used were simplistic, which can reduce error and aid in replicability, however more complex imputation methods might provide a more accurate estimate of PASAT performance. In regards to our regression based imputation method, it might have proved beneficial to run a number of regressions to determine the best statistical fit for the PASAT. It could be possible that another measure in the battery could be a better predictor of the PASAT and may have yielded a more accurate regression equation than the ones used in this study, although that is unlikely because the measures were most similar to the PASAT in terms of cognitive demands.

The PASAT itself is a difficult, time consuming measure. In regards to predicting outcome, it might be just as beneficial to give a shorter, yet similar measure such as the DSB test. This assessment has a much shorter administration time. When using DSB as the predictor variable in a similar model to our aim III model, it accounts for a significant amount of variance in DRS score ($R^2 = .115$) ($F=17.00$), $p = .00$). That means the Digit Span Backward measure (which naturally includes more participants due to its simplicity) accounts for 11.5% of the variance in DRS scores. The total model, which includes covariates (age, education, and BD1 GCS) is significantly related to transformed

DRS scores (R2 = .224) [F(4,115) = 8.30), (p = .00)]. A further investigation of the clinical utility of DSB test is needed. (See appendix U)

Future directions could include more complex imputation methods, such as multiple imputation, which involves imputation, analysis, and pooling, or more complex regression equations that would increase the likely of predicting accurate missing data. In regards to predicting functional outcome, future studies could evaluate measures in other cognitive domains, to aid in predicting recovery from head injury. It may also prove useful to evaluate performance at different time-points and attempt to predict future outcome from an earlier cognitive state.

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Appendices:

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Glasgow Coma Scale (GCS) Acute Assessment
Eye Opening
4 Opens eyes Spontaneously 3 Opens eyes on command 2 Opens eyes to painful stimuli 1 No eye response
Verbal Response
5 Oriented conversation 4 Confused speech 3 Inappropriate words 2 Incomprehensible sounds (e.g., groans) 1 None
Motor response
6 Obeys simple commands 5 Localizes to pain 4 Normal Flexion/Withdraw to pain 3 Abnormal flexion to pain 2 Extension to pain 1 None

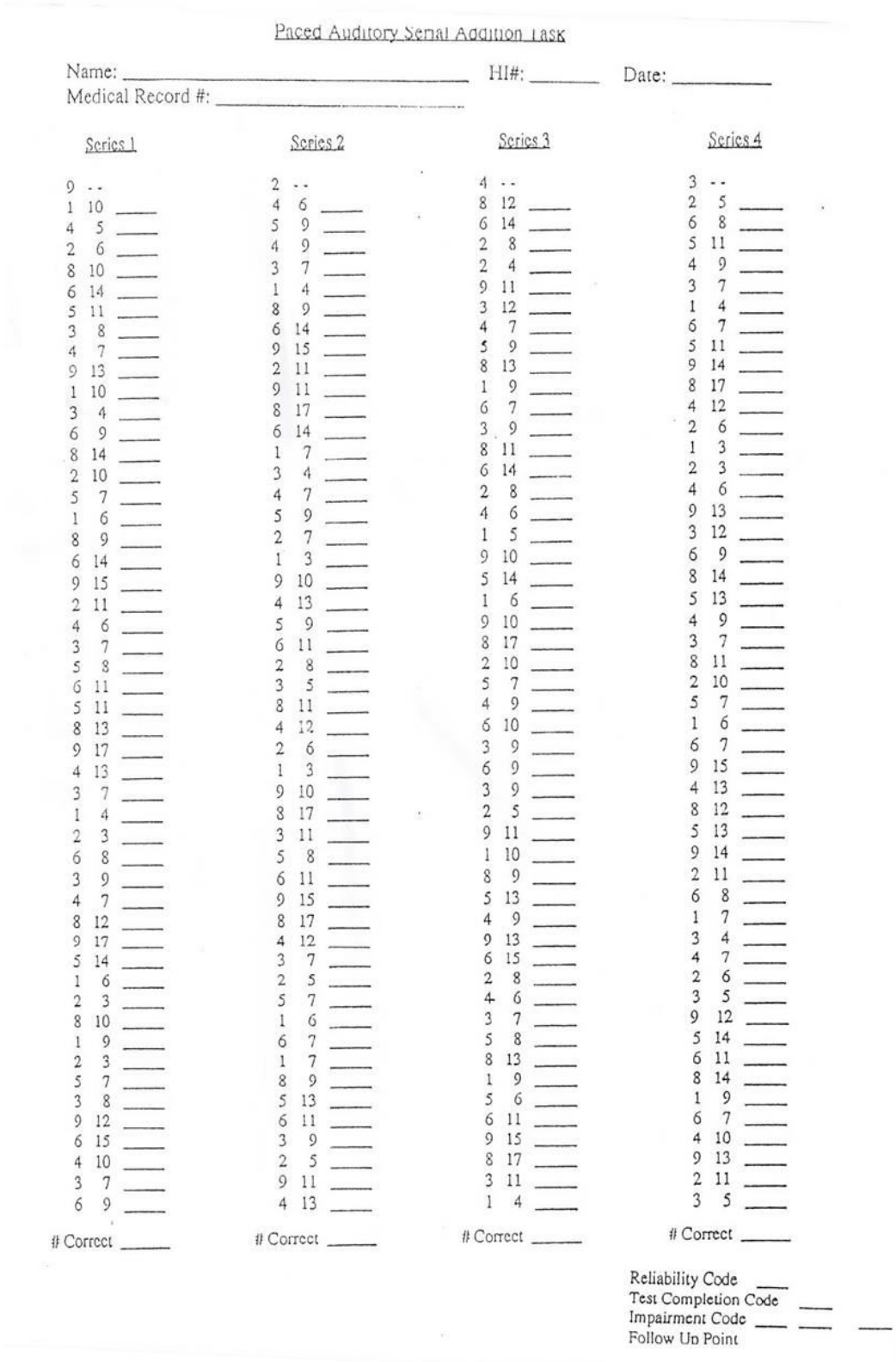
B. PASAT Instructions (Levin Version)

Verbal Instructions Given to the Patient: "I am going to ask you to listen to a recording. On this tape, you will hear some numbers. The numbers will only be from 1 to 9. You will hear a number followed by a short pause, another number, a short pause, and so on. Please add the first number and the second number and then say out loud the total. When you hear the third number, add it only to the second number and tell me the total. Remember, add each number to the immediately preceding number. Let's do some examples for practice." Present the following series of numbers slowly and correct any errors made by the patient. Training should continue until the patient gives at least 3 correct responses in at least 1 practice series. The examiner can create additional series as needed. The examiner may also write-out the practice series to explain it to the participant if necessary. Participants should be reminded not to keep running total. If a participant is unable to provide a correct response to any of the trials in the practice series, discontinue this test.

Practice Series A		Practice Series B		Practice Series C		Practice Series D	
1- - - - -	Response	3- - - - -	Response	6- - - - -	Response	4- - - - -	Response
2- - - - -	3	5- - - - -	8	3- - - - -	9	9- - - - -	13
3- - - - -	5	4- - - - -	9	7- - - - -	10	5- - - - -	14
4- - - - -	7	2- - - - -	6	1- - - - -	8	2- - - - -	7

Additional Verbal Instructions: "Very good. We will now begin the tape recorded series. Please say your answers quickly and indicate your answer before the next number is presented. If you lose your place and stop, try to resume your addition as soon as possible. Everyone finds that they have trouble keeping up as the numbers get faster. Just do your best." (Begin Test)

C. PASAT Response Form (Levin Version.)



Paced Auditory Serial Addition Task

Name: _____ HI#: _____ Date: _____

Medical Record #: _____

Series 1		Series 2		Series 3		Series 4	
9	--	2	--	4	--	3	--
1	10	4	6	8	12	2	5
4	5	5	9	6	14	6	8
2	6	4	9	2	8	5	11
8	10	3	7	2	4	4	9
6	14	1	4	9	11	3	7
5	11	8	9	3	12	1	4
3	8	6	14	4	7	6	7
4	7	9	15	5	9	5	11
9	13	2	11	8	13	9	14
1	10	9	11	1	9	8	17
3	4	8	17	6	7	4	12
6	9	6	14	3	9	2	6
8	14	1	7	8	11	1	3
2	10	3	4	6	14	2	3
5	7	4	7	2	8	4	6
1	6	5	9	4	6	9	13
8	9	2	7	1	5	3	12
6	14	1	3	9	10	6	9
9	15	9	10	5	14	8	14
2	11	4	13	1	6	5	13
4	6	5	9	9	10	4	9
3	7	6	11	8	17	3	7
5	8	2	8	2	10	8	11
6	11	3	5	5	7	2	10
5	11	8	11	4	9	5	7
8	13	4	12	6	10	1	6
9	17	2	6	3	9	6	7
4	13	1	3	6	9	9	15
3	7	9	10	3	9	4	13
1	4	8	17	2	5	8	12
2	3	3	11	9	11	5	13
6	8	5	8	1	10	9	14
3	9	6	11	8	9	2	11
4	7	9	15	5	13	6	8
8	12	8	17	4	9	1	7
9	17	4	12	9	13	3	4
5	14	3	7	6	15	4	7
1	6	2	5	2	8	2	6
2	3	5	7	4	6	3	5
8	10	1	6	3	7	9	12
1	9	6	7	5	8	5	14
2	3	1	7	8	13	6	11
5	7	8	9	1	9	8	14
3	8	5	13	5	6	1	9
9	12	6	11	6	11	6	7
6	15	3	9	9	15	4	10
4	10	2	5	8	17	9	13
3	7	9	11	3	11	2	11
6	9	4	13	1	4	3	5
# Correct	_____	# Correct	_____	# Correct	_____	# Correct	_____

Reliability Code ___
Test Completion Code ___
Impairment Code ___ ___ ___
Follow Up Point

D. DRS score sheet

Category	Item	Instructions	Score
Arousability, Awareness and Responsivity	Eye Opening	0 = spontaneous 1 = to speech 2 = to pain 3 = none	
	Communication Ability	0 = oriented 1 = confused 2 = inappropriate 3 = incomprehensible 4 = none	
	Motor Response	0 = obeying 1 = localizing 2 = withdrawing 3 = flexing 4 = extending 5 = none	
Cognitive Ability for Self Care Activities	Feeding	0 = complete 1 = partial 2 = minimal 3 = none	
	Toileting	0 = complete 1 = partial 2 = minimal 3 = none	
	Grooming	0 = complete 1 = partial 2 = minimal 3 = none	
Dependence on Others	Level of Functioning	0 = completely independent 1 = independent in special environment 2 = mildly dependent 3 = moderately dependent 4 = markedly dependent 5 = totally dependent	
Psychosocial Adaptability	Employability	0 = not restricted 1 = selected jobs 2 = sheltered workshop (non-competitive) 3 = not employable	
Total DR Score			

E. DRS Item Definitions

ITEM DEFINITIONS for DRS (Disability Rating Scale)

Eye opening

0— SPONTANEOUS: eyes open with sleep/wake rhythms indicating active and arousal mechanisms; does not assume awareness.
1— TO SPEECH AND/OR SENSORY STIMULATION: a response to any verbal approach, whether spoken or shouted, not necessarily the command to open the eyes. Also, response to touch, mild pressure.
2— TO PAIN: tested by a painful stimulus.(Standard painful stimulus is the application of pressure across index fingernail of best side with wood or a pencil; for quadriplegics pinch nose tip and rate as 0, 1, 2 or 5.)
3— NONE: no eye opening even to painful stimulation.

Best communication ability (if patient cannot use voice because of tracheostomy or is aphasic or dysarthric or has vocal cord paralysis or voice dysfunction then estimate patient's best response and enter note under comments.)

0— ORIENTED: implies awareness of self and the environment. Patient able to tell you a) who he is; b) where he is; c) why he is there; d) year; e) season; f) month; g) day; h) time of day.
1— CONFUSED: attention can be held and patient responds to questions but responses are delayed and/or indicate varying degrees of disorientation and confusion.
2— INAPPROPRIATE: intelligible articulation but speech is used only in an exclamatory or random way (such as shouting and swearing); no sustained communication exchange is possible.
3— INCOMPREHENSIBLE: moaning, groaning or sounds without recognizable words; no consistent communication signs.
4— NONE: no sounds or communication signs from patient.

Best motor response

0— OBEYING: obeying command to move finger on best side. If no response or not suitable try another command such as "move lips," "blink eyes," etc. Do not include grasp or other reflex responses.
1— LOCALIZING: a painful stimulus[1] at more than one site causes a limb to move (even slightly) in an attempt to remove it. It is a deliberate motor act to move away from or remove the source of noxious stimulation. If there is doubt as to whether withdrawal or localization has occurred after 3 or 4 painful stimulations, rate as localization.
2— WITHDRAWING: any generalized movement away from a noxious stimulus that is more than a simple reflex response.
3— FLEXING: painful stimulation results in either flexion at the elbow, rapid withdrawal with abduction of the shoulder or a slow withdrawal with adduction of the shoulder. If there is confusion between flexing and withdrawing, then use pin prick on hands, then face.
4— EXTENDING: painful stimulation results in extension of the limb.
5— NONE: no response can be elicited. Usually associated with hypotonia. Exclude spinal transection as an explanation of lack of response; be satisfied that an adequate stimulus has been applied.

Cognitive ability for feeding, toileting and grooming.

Rate each of the three functions separately. For each function answer the question, does the patient show awareness of how and when to perform each specified activity. *Ignore motor disabilities that interfere with carrying out a function, this is rated under Level of Functioning described below.* Rate best response for toileting based on bowel and bladder behavior. Grooming refers to bathing, washing, brushing of teeth, shaving, combing or brushing of hair and dressing.

0— COMPLETE: *continuously shows awareness that he knows how* to feed, toilet or groom self and can convey unambiguous information that he *knows when* this activity should occur.
1— PARTIAL: *intermittently shows awareness that he knows how* to feed, toilet or groom self and/or can intermittently convey reasonably clearly information he *knows when* the activity should occur.
2— MINIMAL: *shows questionable or infrequent awareness that he knows in a primitive way how* to feed, toilet or groom self and/or shows infrequently by certain signs, sounds or activities that he is *vaguely aware* when the activity should occur.
3— NONE: *shows virtually no awareness at any time that he knows how* to feed, toilet or groom self and *cannot convey information by signs, sounds, or activity that he knows when* the activity should occur.

Level of functioning

0— COMPLETELY INDEPENDENT: able to live as he wishes, requiring no restriction due to physical, mental, emotional or social problems.
1— INDEPENDENT IN SPECIAL ENVIRONMENT: capable of functioning independently when needed requirements are met (mechanical aids).
2— MILDLY DEPENDENT: able to care for most of own needs but requires limited assistance due to physical, cognitive and/or emotional problems (e.g. needs non-resident helper).
3— MODERATELY DEPENDENT: able to care for self partially but needs another person at all times.
4— MARKEDLY DEPENDENT: needs help with all major activities and the assistance of another person at all times.
5— TOTALLY DEPENDENT: not able to assist in own care and requires 24-hour nursing care.

"Employability"

The psychosocial adaptability or "employability" item takes into account overall cognitive and physical ability to be an employee, homemaker or student. This determination should take into account considerations such as the following:

1. Able to understand, remember and follow instructions; 2. Can plan and carry out tasks at least at the level of an office clerk or in simple routine, repetitive industrial situations or can do school assignments; 3. Ability to remain oriented, relevant and appropriate in work and other psychosocial situations; 4. Ability to get to and from work or shopping centers using private or public transportation effectively; 5. Ability to deal with number concepts; 6. Ability to make purchases and handle simple money exchange problems; 7. Ability to keep track of time schedules and appointments.

0— NOT RESTRICTED: can compete in the open market for a relatively wide range of jobs commensurate with existing skills; or can initiate, plan, execute and assume responsibilities associated with homemaking; or can understand and carry out most age relevant school assignments.
1— SELECTED JOBS, COMPETITIVE: can compete in a limited job market for a relatively narrow range of jobs because of limitations of the type described above and/or because of some physical limitations; or can initiate, plan, execute and assume many but not all responsibilities associated with homemaking; or can understand and carry out many but not all school assignments.
2— SHELTERED WORKSHOP, NON-COMPETITIVE: cannot compete successfully in job market because of limitations described above and/or because of moderate or severe physical limitations; or cannot without major assistance initiate, plan, execute and assume responsibilities for homemaking; or cannot understand and carry out even relatively simple school assignments without assistance.
3— NOT EMPLOYABLE: completely unemployable because of extreme psychosocial limitations of the type described above; or completely unable to initiate, plan, execute and assume any responsibilities associated with homemaking; or cannot understand or carry out any school assignments.

Instructions: Place date of rating at top of column. Place appropriate rating next to each of the eight items listed. Add eight ratings to obtain total DRS score

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[1] *Standard painful stimulus is the application of pressure across fingernail of best side with wood of a pencil; for quadriplegics nose tip and rate as 0, 1, 2 or 5.*

F. Marshall CT Classification System

Marshall CT classification of TBI

Category	Definition
Diffuse injury I (no visible pathology)	No visible intra-cranial pathology seen on CT scan
Diffuse injury II	Cisterns are present with midline shift < 5 mm and/or lesion densities present No high- or mixed-density lesion > 25 ml, may include bone fragments and foreign bodies
Diffuse injury III	Cisterns compressed or absent with mid-line shift 0–5 mm No high- or mixed-density lesion > 25 ml
Diffuse injury IV	Mid-line shift > 5 mm No high- or mixed-density lesion > 25 ml
Evacuated mass lesion	Any lesion surgically evacuated
Non-evacuated mass lesion	High- or mixed-density lesion > 25 ml, not surgically evacuated

G. Rotterdam Ct Score Information

Rotterdam CT score

CT abnormalities in brain trauma

Scoring items

Basal cisterns

- 0: normal
- 1: compressed
- 2: absent

Midline shift

- 0: no shift or <= 5mm
- 1: shift > 5mm

Epidural mass lesion

- 0: present
- 1: absent

Intraventricular blood or traumatic SAH

- 0: absent
- 1: present

Instructions for use

The final score is the sum of the scoring items + 1.

Mortality at 6 months post-injury

- Score 1: 0%
- Score 2: 7%
- Score 3: 16%
- Score 4: 26%
- Score 5: 53%
- Score 6: 61%

Reference

Maas AIR, Hukkelhoven CWPM, Marshall LF, Steyerberg EW. Prediction of outcome in traumatic brain injury with computed tomographic characteristics: a comparison between the computed tomographic classification and combinations of computed tomographic predictors. Neurosurgery. 2005 Dec.; 57(6):1173-82

H: Reliability Codes for the Individual Tested

Reliability Codes

1= Standard procedure
Tests administered in standard fashion. Multiple choice presentation of the GOAT should be considered to be standard procedure as the multiple choice format is part of standard administration instructions under certain conditions and will be coded under the GOAT administration column.

2=Irregular procedure, reliability affected minor.
If there are minor irregularities present in test administration, these should be coded as 2. Examples of such irregularities include presenting items out of order, providing multiple choice options on the GOAT to speaking patients with comprehension/impulsivity problems, and interrupting test administration due to nursing interventions (if the test is not a memory test).

3=Irregular procedure, unreliable.
If there are wide variations from standard test administration that are likely to affect the results of the test, they should be coded here. Examples of situations wehre this code applies include failing to time tests, testing the patient on visual tests without corrective lenses, interrupting memory tests or other tests with a timing component.

4=Patient attempted, abilities excused.
If patient tried to cooperate with the task, but was unable to complete the test, it should be coded here. Reasons for this inability include failure to understand task demands, medical complications, fatigue, etc. (Many of these reasons will be further explained in the impairment codes).

5=Patient attempted, then refused testing or became unresponsive.
If patient begins testing then refuses to complete the task, it should be coded here.

6=Patient refused testing or was unresponsive.
If patient will not even attempt the task, it should be coded here.

7=Not administered.
This code should only be used if the test is not presented to the patient. If the patient has had the tasks explained to him/her and then does not complete the task, it should be coded as either 4, 5, or 6- not as 7.

8=Not applicable (e.g., can't administer the CHART because the patient is in the hospital).

9= OK.

10= Dead.

I. Test Completion Codes for the Individual Tested

Test Completion Codes

0= Fully completed.
The test and/or battery was completely administered.

Unable to complete because:

1=Patient with acute confusional state, unable to follow motor commands, or unable to arouse. This applies to any situation where the testing is not fully administered due to level of arousal problems that are not due to specific medical complications.

2= Patient with medical complications.
This includes such situations as high fever, respiratory problems, vomiting, etc.

3=Patient refused testing or not responsive (not due to 1 or 2).
If patient refuses all or any part of the testing, code it here.

4=Patient not available.
If you are unable to reach the patient due to scheduled therapies, medical interventions, etc., code it here.

5=Examiner not available.
If you are ill or unable to come to the hospital for other reasons, document that and code it here.

6=Patient with endotracheal entubation or tracheostomy.
If all of the testing cannot be completed and the patient is trached or intubated, code that here.

7=Patient unable to understand instructions not due to aphasia or acute confusional state.

8= Not applicable (e.g., can't administer the CHART because the patient is in the hospital, or Test not part of the battery yet.)

9= Unknown.

10= Patient not consented.

11= Patient cannot complete the test because he/she is illiterate.

12= Patient actively psychotic and test not administered.

J. Impairment Codes for the Individual Tested

Impairment Codes
(9 should be used when no impairments are noted. There can be up to three codes for any one test, but only codes that apply to the patient's performance on the test under consideration should be used.)

0= Confusional State.
If the patient is so confused that he/she is unable to respond to test requirements, code here.

1= Vision.
If the patient has problems with vision that affect his/her performance on visual tasks, it should be coded here. This includes patients who are tested without their corrective lenses and patients who have double vision or loss of vision due to trauma.

2= Hearing.
If the patient has problems with vision that affect his/her performance on auditory tasks, code here.

3= Right or Left Hand.
If the patient has difficulty using the right or left hand due to paresis or other reasons which interfere with task performance, code here.

4= Nonpreferred Hand.
If the patient is required to use his/her nonpreferred hand on written tasks, code here. This code it given in addition to 3 if the patient is having to use his/her nonpreferred hand for that task.

5= Language Comprehension.
If the patient is unable to understand written or oral speech due to a language problem, code here. This should only be used for aphasic disturbances. If the patient has difficulty understanding directions to a particular test, but has no difficulty with other test instructions, code this in the reliability codes as a 4; DO NOT code this case as a language comprehension problem.

6= Oral Expression.
If the patient is unable to speak clearly due to dysarthria or is unable to speak due to an aphasic disturbance, or if the patient's voice is inaudible, code here. If the patient is unable to speak because of entubation or tracheostomy – code this under the test completion code as a 6: DO NOT code this case as an oral expression problem.

7= Extreme Fatigue.
If the patient is unable to remain awake during testing, code here.

8= Agitation.
If the patient is highly agitated and unable to complete tests, code here.

9= None.

10 = Not applicable

11= Patient actively psychotic

Appendix K. Demographic Variables Group Differences

T-Test

Group Statistics

	Ethnicity	N	Mean	Std. Deviation	Std. Error Mean
Education	Non-Hispanic Caucasian	60	12.48	2.369	.306
	African American	30	10.97	2.092	.382

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Education	Equal variances assumed	1.101	.297	2.973	88	.004
	Equal variances not assumed			3.100	64.957	.003

T-Test

Group Statistics

	Ethnicity	N	Mean	Std. Deviation	Std. Error Mean
Education	Non-Hispanic Caucasian	60	12.48	2.369	.306
	Hispanic	32	10.28	2.679	.474

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Education	Equal variances assumed	.330	.567	4.057	90	.000
	Equal variances not assumed			3.906	57.029	.000

T-Test

Group Statistics

	Ethnicity	N	Mean	Std. Deviation	Std. Error Mean
Education	African American	30	10.97	2.092	.382
	Hispanic	32	10.28	2.679	.474

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Education	Equal variances assumed	1.779	.187	1.118	60	.268
	Equal variances not assumed			1.127	58.151	.265

T-Test

Group Statistics

	Ethnicity	N	Mean	Std. Deviation	Std. Error Mean
Age	Non-Hispanic Caucasian	61	33.15	13.816	1.769
	African American	30	36.40	14.335	2.617

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Age	Equal variances assumed	.560	.456	-1.043	89	.300
	Equal variances not assumed			-1.030	55.911	.308

T-Test

Group Statistics

	Ethnicity	N	Mean	Std. Deviation	Std. Error Mean
Age	Non-Hispanic Caucasian	61	33.15	13.816	1.769
	Hispanic	34	25.44	8.736	1.498

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Age	Equal variances assumed	4.697	.033	2.938	93	.004	7.706
	Equal variances not assumed			3.324	91.423	.001	7.706

T-Test

Group Statistics

	Ethnicity	N	Mean	Std. Deviation	Std. Error Mean
Age	African American	30	36.40	14.335	2.617
	Hispanic	34	25.44	8.736	1.498

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Age	Equal variances assumed	9.548	.003	3.741	62	.000	10.959
	Equal variances not assumed			3.634	46.712	.001	10.959

GCS Total * Ethnicity

Report

GCS Total

Ethnicity	Mean	N	Std. Deviation
Non-Hispanic Caucasian	8.03	60	3.931
African American	7.59	29	3.134
Hispanic	8.00	34	2.763
Total	7.92	123	3.439

ANOVA Table

			Sum of Squares	df	Mean Square	F
GCS Total * Ethnicity	Between Groups	(Combined)	4.219	2	2.110	.176
		Linearity	.006	1	.006	.000
		Deviation from Linearity	4.213	1	4.213	.351
	Within Groups		1438.968	120	11.991	
	Total		1443.187	122		

ANOVA Table

			Sig.
GCS Total * Ethnicity	Between Groups	(Combined)	.839
		Linearity	.983
		Deviation from Linearity	.554
	Within Groups		
	Total		

Measures of Association

	R	R Squared	Eta	Eta Squared
GCS Total * Ethnicity	.002	.000	.054	.003

GCS Total * Age Grouped

Report

GCS Total

Age Grouped	Mean	N	Std. Deviation
<20	7.46	26	2.901
21-30	7.12	40	3.188
31-40	9.04	28	4.023
41-50	7.81	16	2.926
51-60	9.89	9	4.014
>61	7.00	4	3.559
Total	7.92	123	3.439

ANOVA Table

			Sum of Squares	df	Mean Square	F
GCS Total * Age Grouped	Between Groups	(Combined)	104.060	5	20.812	1.818
		Linearity	28.514	1	28.514	2.491
		Deviation from Linearity	75.546	4	18.887	1.650
	Within Groups		1339.127	117	11.446	
	Total		1443.187	122		

ANOVA Table

			Sig.
GCS Total * Age Grouped	Between Groups	(Combined)	.114
		Linearity	.117
		Deviation from Linearity	.166
	Within Groups		
	Total		

Measures of Association

	R	R Squared	Eta	Eta Squared
GCS Total * Age Grouped	.141	.020	.269	.072

GCS Total * Education Grouped

Report

GCS Total

Education Grouped	Mean	N	Std. Deviation
<12	7.89	54	3.300
12	7.58	33	3.553
13-15	7.40	25	3.403
>15	10.62	8	3.926
Total	7.88	120	3.474

ANOVA Table

			Sum of Squares	df	Mean Square	F
GCS Total * Education 2Grouped	Between Groups	(Combined)	69.098	3	23.033	1.954
		Linearity	9.044	1	9.044	.767
		Deviation from Linearity	60.053	2	30.027	2.547
	Within Groups		1367.269	116	11.787	
	Total		1436.367	119		

ANOVA Table

			Sig.
GCS Total * Education Grouped	Between Groups	(Combined)	.125
		Linearity	.383
		Deviation from Linearity	.083
	Within Groups		
	Total		

Measures of Association

	R	R Squared	Eta	Eta Squared
GCS Total * Education Grouped	.079	.006	.219	.048

Marshall Grouped * Ethnicity

Report

Marshall Grouped

Ethnicity	Mean	N	Std. Deviation
Non-Hispanic Caucasian	1.92	61	.881
African American	1.70	30	.877
Hispanic	1.94	33	.899
Total	1.87	124	.883

ANOVA Table

			Sum of Squares	df	Mean Square	F
Marshall Grouped * Ethnicity	Between Groups	(Combined)	1.167	2	.583	.745
		Linearity	.044	1	.044	.056
		Deviation from Linearity	1.123	1	1.123	1.433
	Within Groups		94.769	121	.783	
	Total		95.935	123		

ANOVA Table

			Sig.
Marshall Grouped * Ethnicity	Between Groups	(Combined)	.477
		Linearity	.813
		Deviation from Linearity	.234
	Within Groups		
	Total		

Measures of Association

	R	R Squared	Eta	Eta Squared
Marshall Grouped * Ethnicity	.021	.000	.110	.012

Marshall Grouped * Age Grouped

Report

Marshall Grouped

Age Grouped	Mean	N	Std. Deviation
<20	1.77	26	.815
21-30	1.82	40	.874
31-40	2.03	29	.906
41-50	1.62	16	.885
51-60	2.22	9	.972
>61	2.00	4	1.155
Total	1.87	124	.883

ANOVA Table

			Sum of Squares	df	Mean Square	F
Marshall Grouped * Age Grouped	Between Groups	(Combined)	3.274	5	.655	.834
		Linearity	.570	1	.570	.725
		Deviation from Linearity	2.704	4	.676	.861
	Within Groups		92.661	118	.785	
	Total		95.935	123		

ANOVA Table

			Sig.
Marshall Grouped * Age Grouped	Between Groups	(Combined)	.528
		Linearity	.396
		Deviation from Linearity	.490
	Within Groups		
	Total		

Measures of Association

	R	R Squared	Eta	Eta Squared
Marshall Grouped * Age Grouped	.077	.006	.185	.034

Marshall Grouped * Education Grouped

Report

Marshall Grouped

Education Grouped	Mean	N	Std. Deviation
<12	1.80	55	.869
12	2.00	32	.842
13-15	1.80	25	.957
>15	1.89	9	.928
Total	1.86	121	.879

ANOVA Table

			Sum of Squares	df	Mean Square	F
Marshall Grouped * Education Grouped	Between Groups	(Combined)	.923	3	.308	.392
		Linearity	.047	1	.047	.060
		Deviation from Linearity	.876	2	.438	.559
	Within Groups		91.689	117	.784	
	Total		92.612	120		

ANOVA Table

			Sig.
Marshall Grouped * Education Grouped	Between Groups	(Combined)	.759
		Linearity	.808
		Deviation from Linearity	.573
	Within Groups		
	Total		

Measures of Association

	R	R Squared	Eta	Eta Squared
Marshall Grouped * Education Grouped	.022	.001	.100	.010

Appendix L

Participant Demographics (Group 3)

Characteristic	N	(%)	M	SD	Range
Age (years)	125	100.0	31.8	13.3	15 -78
15-20	26	20.8	17.6		15 -20
21-30	41	32.8	24.6		21- 30
31-40	29	23.2	35.0		31- 40
41-50	16	12.8	45.2		41- 50
51-60	9	7.2	54.1		51- 59
61-78	4	3.2	71.0		61- 78
Gender	125				
Female	26	20.8			
Male	99	79.2			
Ethnicity	126				
Non-Hispanic Caucasian	61	48.8			
Hispanic	34	27.2			
African American	30	24.0			
Education	122	97.6	11.53	2.6	5 - 20
0-11 years	55	44	9.3		5 - 11
12 years	33	26.4	12.0		12
13-15 years	25	20	13.9		13 - 15
16 - 20 years	9	7.2	16.6		16 - 20
Mechanism of Injury	125	100			
Automobile	67	53.6			
Assault	26	20.8			
Motorcycle	13	10.4			
Fall/Jump	8	6.4			
Other	11	8.8			

Note. Demographic characteristics of the final sample (n=125) versus the original dataset were not statistically different.

Appendix M: *Acute Care Characteristics of All Study Participants*

Variable	N	(%)	M	SD	Min	Max
BD 1GCS Total	123	98.4	7.92	3.4	3.0	15.0
Pupil Reactivity	121	96.8				
Both Reactive to Light	100	80.0				
One Reactive to Light	6	4.8				
Neither Reactive to Light	15	12.0				
Marshall CT Classification[bc]	124	99.2				
Diffuse I	4	3.2				
Diffuse II	53	42.4				
Diffuse III	25	20.0				
Diffuse IV	1	0.8				
Evacuated Mass	39	31.2				
Non-Evacuated Mass	2	1.6				
Disability Rating Scale	125	100	3.14	2.9	0.0	15.0

Note: [b] Marshall Classifications are based upon initial CT scan. [c] Marshall CT classification: I, no visible intracranial pathology on CT scan; II, basal cisterns present, midline shift 0-5 mm, no lesion ≥ 25 ml, III, cisterns compressed or absent with midline shift 0-5 mm, no lesion ≥ 25 ml; IV, midline shift >5mm, no lesion ≥ 25 ml; Evacuated Mass, ≥ 25 ml surgically evacuated; Non-evacuated Mass, lesion ≥ 25 ml not surgically evacuated (Marshall et al., 1992)

Appendix N: Aim 1 Statistics

Age

ANOVA
Age

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	625.511	1	625.511	3.591	.060
Within Groups	21425.961	123	174.195		
Total	22051.472	124			

Mann-Whitney Test

Ranks

	P Comp CD	N	Mean Rank	Sum of Ranks
Age Grouped	Missing PASAT	39	70.42	2746.50
	Complete PASAT	86	59.63	5128.50
	Total	125		

Test Statistics[a]

	Age Grouped
Mann-Whitney U	1387.500
Wilcoxon W	5128.500
Z	-1.590
Asymp. Sig. (2-tailed)	.112

a. Grouping Variable: P Comp CD

Gender:

Sex * P Comp CD Crosstabulation

			P Comp CD Missing PASAT	Complete PASAT	Total
Sex	Female	Count	6	20	26
		Expected Count	8.1	17.9	26.0
	Male	Count	33	66	99
		Expected Count	30.9	68.1	99.0
Total		Count	39	86	125
		Expected Count	39.0	86.0	125.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.009[a]	1	.315		
Continuity Correction[b]	.588	1	.443		
Likelihood Ratio	1.052	1	.305		
Fisher's Exact Test				.353	.224
Linear-by-Linear Association	1.001	1	.317		
N of Valid Cases	125				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.11.
b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.090	.315
	Cramer's V	.090	.315
N of Valid Cases		125	

Ethnicity

Ethnicity * P Comp CD Crosstabulation

			P Comp CD		
			Missing PASAT	Complete PASAT	Total
Ethnicity	Non-Hispanic Caucasian	Count	14	47	61
		Expected Count	19.0	42.0	61.0
	African American	Count	13	17	30
		Expected Count	9.4	20.6	30.0
	Hispanic	Count	12	22	34
		Expected Count	10.6	23.4	34.0
Total		Count	39	86	125
		Expected Count	39.0	86.0	125.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.257[a]	2	.119
Likelihood Ratio	4.251	2	.119
Linear-by-Linear Association	1.108	1	.292
N of Valid Cases	125		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.36.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.185	.119
	Cramer's V	.185	.119
N of Valid Cases		125	

Education

ANOVA
Education

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	39.742	1	39.742	6.320	.013
Within Groups	754.627	120	6.289		
Total	794.369	121			

Education Grouped * P Comp CD Crosstabulation

			P Comp CD Missing PASAT	Complete PASAT	Total
Education Grouped	<12	Count	21	34	55
		Expected Count	17.1	37.9	55.0
	12	Count	12	21	33
		Expected Count	10.3	22.7	33.0
	13-15	Count	5	20	25
		Expected Count	7.8	17.2	25.0
	>15	Count	0	9	9
		Expected Count	2.8	6.2	9.0
Total		Count	38	84	122
		Expected Count	38.0	84.0	122.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.208[a]	3	.066
Likelihood Ratio	9.921	3	.019
Linear-by-Linear Association	6.056	1	.014
N of Valid Cases	122		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 2.80.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.243	.066
	Cramer's V	.243	.066
N of Valid Cases		122	

Mechanism Of Injury

Injury Code * P Comp CD Crosstabulation

			P Comp CD Missing PASAT	Complete PASAT	Total
Injury Code	Automobile	Count	20	47	67
		Expected Count	20.9	46.1	67.0
	Assault	Count	11	15	26
		Expected Count	8.1	17.9	26.0
	Motorcycle	Count	3	10	13
		Expected Count	4.1	8.9	13.0
	Fall	Count	0	8	8
		Expected Count	2.5	5.5	8.0
	Other	Count	5	6	11
		Expected Count	3.4	7.6	11.0
Total		Count	39	86	125
		Expected Count	39.0	86.0	125.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.620[a]	4	.157
Likelihood Ratio	8.858	4	.065
Linear-by-Linear Association	.004	1	.948
N of Valid Cases	125		

a. 3 cells (30.0%) have expected count less than 5. The minimum expected count is 2.50.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.230	.157
	Cramer's V	.230	.157
N of Valid Cases		125	

Pupillary Reactivity

Pupil Reactivity * P Comp CD Crosstabulation

			P Comp CD Missing PASAT	Complete PASAT	Total
Pupil Reactivity	unresponsive	Count	3	12	15
		Expected Count	4.6	10.4	15.0
	Mixed Responsivity	Count	2	4	6
		Expected Count	1.8	4.2	6.0
	Responsive	Count	32	68	100
		Expected Count	30.6	69.4	100.0
Total		Count	37	84	121
		Expected Count	37.0	84.0	121.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.907[a]	2	.635
Likelihood Ratio	.972	2	.615
Linear-by-Linear Association	.765	1	.382
N of Valid Cases	121		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.83.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.087	.635
	Cramer's V	.087	.635
N of Valid Cases		121	

BD 1 GCS

ANOVA
GCS Total

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.408	1	9.408	.794	.375
Within Groups	1433.779	121	11.849		
Total	1443.187	122			

Marshall CT Scan Score

Marshall Coded * P Comp CD Crosstabulation

			P Comp CD Missing PASAT	Complete PASAT	Total
Marshall Coded	D1	Count	1	3	4
		Expected Count	1.2	2.8	4.0
	D2	Count	16	37	53
		Expected Count	16.2	36.8	53.0
	D3	Count	7	18	25
		Expected Count	7.7	17.3	25.0
	D4	Count	0	1	1
		Expected Count	.3	.7	1.0
	M1	Count	14	25	39
		Expected Count	12.0	27.0	39.0
	M2	Count	0	2	2
		Expected Count	.6	1.4	2.0
Total		Count	38	86	124
		Expected Count	38.0	86.0	124.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.979[a]	5	.852
Likelihood Ratio	2.839	5	.725
Linear-by-Linear Association	.136	1	.712
N of Valid Cases	124		

a. 6 cells (50.0%) have expected count less than 5. The minimum expected count is .31.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.126	.852
	Cramer's V	.126	.852
N of Valid Cases		124	

DRS

ANOVA
DRS

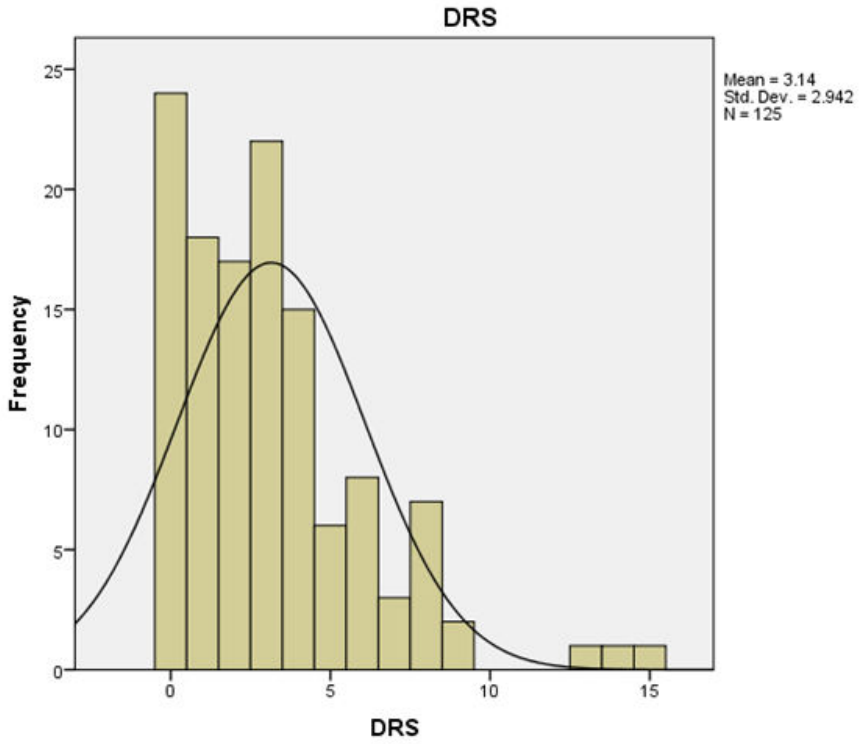
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	135.891	1	135.891	17.829	.000
Within Groups	937.517	123	7.622		
Total	1073.408	124			

Appendix O: Tests of Heteroscedasticity

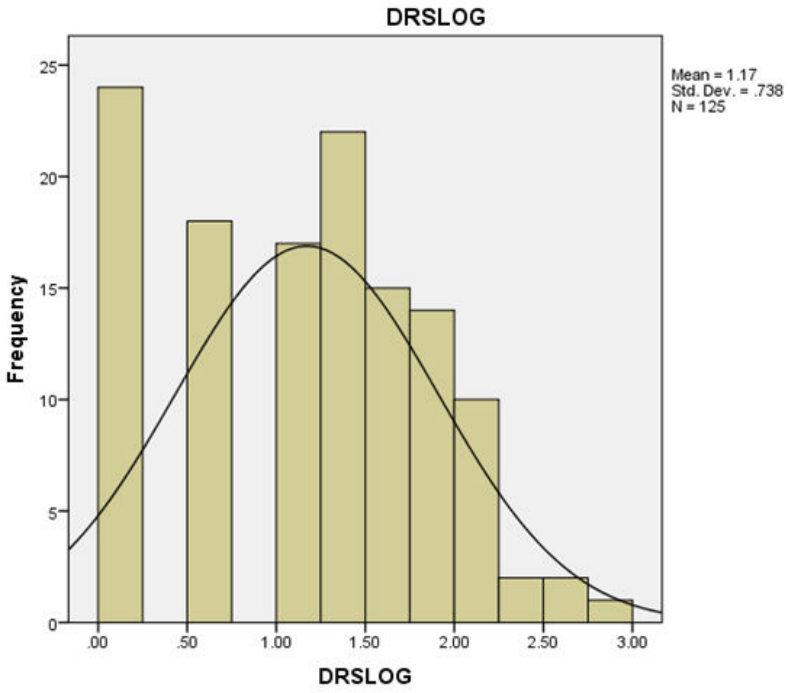
```
Null hypothesis: heteroscedasticity not present (homoscedasticity)
if sig-value less than 0.05, reject the null hypothesis
Note: Breusch-Pagan test is a large sample test and assumes the residuals to
be normally distributed

Original Regression model:
PASAT Score
Dependent variable
 DRS6
------- Breusch-Pagan and Koenker test statistics and sig-values --------
                LM        Sig
BP           6.177       .013
Koenker      7.457       .006


Original Regression model:
PASAT Mean
Dependent variable
 DRS6
------- Breusch-Pagan and Koenker test statistics and sig-values --------
                LM        Sig
BP           1.201       .273
Koenker       .424       .515

Original Regression model:
PASAT Min
Dependent variable
 DRS6
------- Breusch-Pagan and Koenker test statistics and sig-values --------
                LM        Sig
BP          30.388       .000
Koenker     14.760       .000


Original Regression model:
PASAT DST
Dependent variable
 DRS6
------- Breusch-Pagan and Koenker test statistics and sig-values --------
                LM        Sig
BP          10.328       .001
Koenker      3.766       .052

Original Regression model:
PASAT DSB
Dependent variable
 DRS6
------- Breusch-Pagan and Koenker test statistics and sig-values --------
                LM        Sig
BP          10.930       .001
Koenker      3.960       .047
```

Note: Tests run after natural log transformation performed on DV:

DRS Distribution Prior to Transformation



DRS distribution Post Transformation



Tests of Heteroscedasticity Post Transformation

Original Regression model:
PASAT Score
Dependent variable
DRSLOG

------- Breusch-Pagan and Koenker test statistics and sig-values --------

	LM	Sig
BP	.259	.611
Koenker	.456	.499

Original Regression model:
PASAT Min
Dependent variable
DRSLOG

------- Breusch-Pagan and Koenker test statistics and sig-values --------

	LM	Sig
BP	.162	.687
Koenker	.230	.631

Original Regression model:
PASAT Mean
Dependent variable
DRSLOG

------- Breusch-Pagan and Koenker test statistics and sig-values --------

	LM	Sig
BP	1.240	.266
Koenker	1.728	.189

Original Regression model:
PASAT Regression DST
Dependent variable
DRSLOG

------- Breusch-Pagan and Koenker test statistics and sig-values --------

	LM	Sig
BP	.112	.738
Koenker	.136	.712

Original Regression model:
PASAT Regression DSB
Dependent variable
DRSLOG

------- Breusch-Pagan and Koenker test statistics and sig-values --------

	LM	Sig
BP	.006	.938
Koenker	.007	.932

Appendix P: Aim 2 Statistics

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
DRSLOG	1.0525	.67320	82
Age	30.04	11.840	82
Education	11.83	2.484	82
GCS Total	8.07	3.757	82
PASAT Score	103.23	35.531	82

Correlations

		DRSLOG	Age	Education	GCS Total	PASAT Score
Pearson Correlation	DRSLOG	1.000	.142	-.048	-.092	-.442
	Age	.142	1.000	.289	.197	-.106
	Education	-.048	.289	1.000	.099	.066
	GCS Total	-.092	.197	.099	1.000	.287
	PASAT Score	-.442	-.106	.066	.287	1.000
Sig. (1-tailed)	DRSLOG	.	.102	.336	.206	.000
	Age	.102	.	.004	.038	.172
	Education	.336	.004	.	.187	.278
	GCS Total	.206	.038	.187	.	.004
	PASAT Score	.000	.172	.278	.004	.
N	DRSLOG	82	82	82	82	82
	Age	82	82	82	82	82
	Education	82	82	82	82	82
	GCS Total	82	82	82	82	82
	PASAT Score	82	82	82	82	82

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GCS Total, Education, Age[b]	.	Enter
2	PASAT Score[b]	.	Enter

a. Dependent Variable: DRSLOG

b. All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics F Change	Change Statistics df1	Change Statistics df2
1	.206[a]	.043	.006	.67127	.043	1.155	3	78
2	.455[b]	.207	.166	.61491	.164	15.956	1	77

Model Summary[c]

Model	Change Statistics Sig. F Change
1	.332
2	.000

a. Predictors: (Constant), GCS Total, Education, Age

b. Predictors: (Constant), GCS Total, Education, Age, PASAT Score

c. Dependent Variable: DRSLOG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.561	3	.520	1.155	.332[b]
	Residual	35.147	78	.451		
	Total	36.709	81			
2	Regression	7.594	4	1.899	5.021	.001[c]
	Residual	29.114	77	.378		
	Total	36.709	81			

a. Dependent Variable: DRSLOG

b. Predictors: (Constant), GCS Total, Education, Age

c. Predictors: (Constant), GCS Total, Education, Age, PASAT Score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B
		B	Std. Error	Beta	t	Sig.	Lower Bound
1	(Constant)	1.191	.390		3.052	.003	.414
	Age	.011	.007	.192	1.629	.107	-.002
	Education	-.025	.031	-.091	-.784	.435	-.087
	GCS Total	-.022	.020	-.121	-1.067	.289	-.062
2	(Constant)	1.855	.394		4.706	.000	1.070
	Age	.006	.006	.108	.981	.330	-.006
	Education	-.014	.029	-.052	-.485	.629	-.072
	GCS Total	.003	.020	.016	.145	.885	-.036
	PASAT Score	-.008	.002	-.432	-3.994	.000	-.012

Coefficients[a]

Model		95.0% Confidence Interval for B Upper Bound
1	(Constant)	1.968
	Age	.024
	Education	.038
	GCS Total	.019
2	(Constant)	2.640
	Age	.019
	Education	.044
	GCS Total	.042
	PASAT Score	-.004

a. Dependent Variable: DRSLOG

Coefficient Correlations[a]

Model			GCS Total	Education	Age	PASAT Score
1	Correlations	GCS Total	1.000	-.045	-.177	
		Education	-.045	1.000	-.276	
		Age	-.177	-.276	1.000	
	Covariances	GCS Total	.000	-2.875E-5	-2.394E-5	
		Education	-2.875E-5	.001	-5.790E-5	
		Age	-2.394E-5	-5.790E-5	4.469E-5	
2	Correlations	GCS Total	1.000	-.014	-.225	-.313
		Education	-.014	1.000	-.287	-.092
		Age	-.225	-.287	1.000	.191
		PASAT Score	-.313	-.092	.191	1.000
	Covariances	GCS Total	.000	-7.847E-6	-2.740E-5	-1.253E-5
		Education	-7.847E-6	.001	-5.176E-5	-5.443E-6
		Age	-2.740E-5	-5.176E-5	3.892E-5	2.445E-6
		PASAT Score	-1.253E-5	-5.443E-6	2.445E-6	4.189E-6

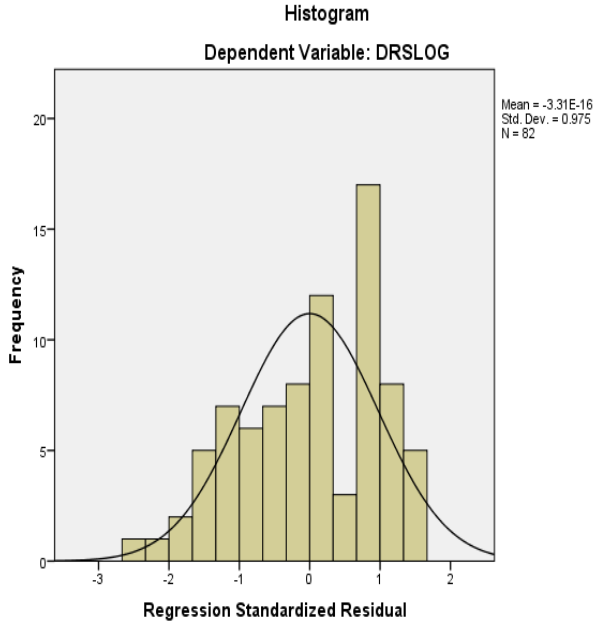
a. Dependent Variable: DRSLOG

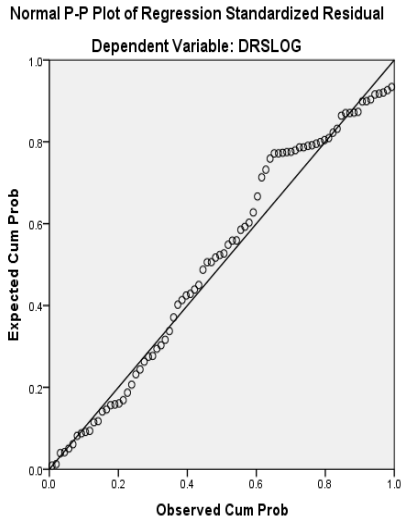
Residuals Statistics[a]

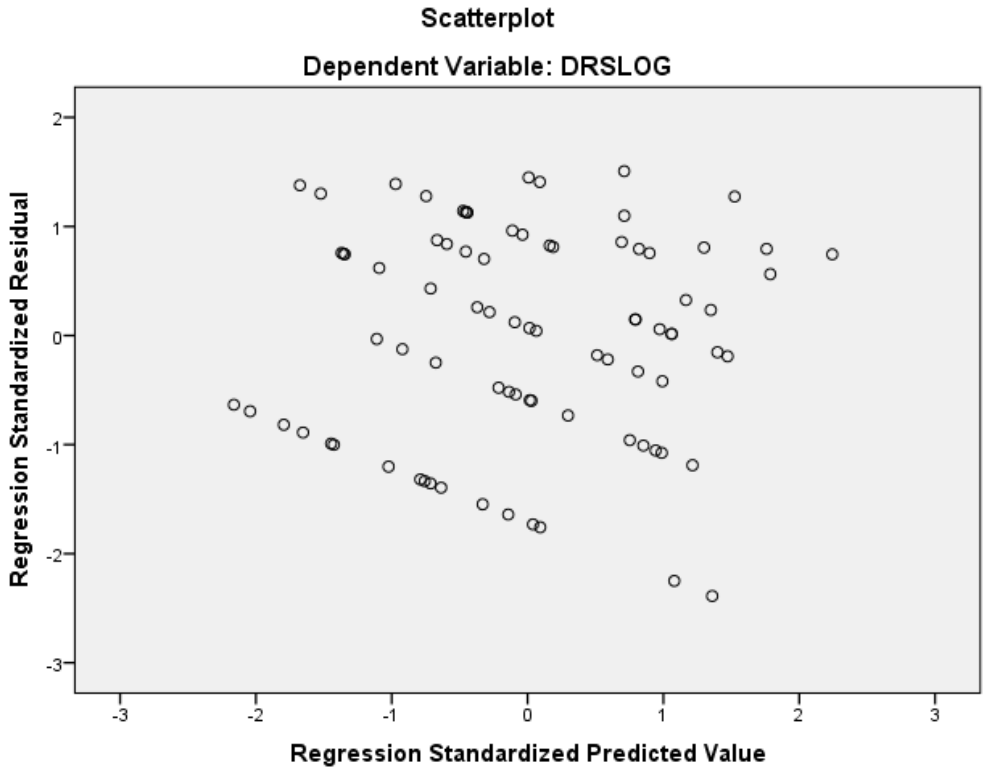
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.3902	1.7393	1.0525	.30620	82
Residual	-1.46866	.92693	.00000	.59953	82
Std. Predicted Value	-2.163	2.243	.000	1.000	82
Std. Residual	-2.388	1.507	.000	.975	82

a. Dependent Variable: DRSLOG

Charts


Histogram
Dependent Variable: DRSLOG
Mean = -3.31E-16
Std. Dev. = 0.975
N = 82
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: DRSLOG
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: DRSLOG
Regression Standardized Residual
Regression Standardized Predicted Value

Appendix Q: Aim 3 statistics Group A (Mean Imputation)

Descriptive Statistics

	Mean	Std. Deviation	N
DRSLOG	1.1955	.72873	120
Age	31.73	13.479	120
Education	11.47	2.463	120
GCS Total	7.88	3.474	120
P with Mean	103.33	29.315	120

Correlations

		DRSLOG	Age	Education	GCS Total	P with Mean
Pearson Correlation	DRSLOG	1.000	.182	-.067	-.237	-.335
	Age	.182	1.000	.098	.143	-.076
	Education	-.067	.098	1.000	.056	.054
	GCS Total	-.237	.143	.056	1.000	.256
	P with Mean	-.335	-.076	.054	.256	1.000
Sig. (1-tailed)	DRSLOG	.	.023	.232	.005	.000
	Age	.023	.	.144	.060	.205
	Education	.232	.144	.	.273	.279
	GCS Total	.005	.060	.273	.	.002
	P with Mean	.000	.205	.279	.002	.
N	DRSLOG	120	120	120	120	120
	Age	120	120	120	120	120
	Education	120	120	120	120	120
	GCS Total	120	120	120	120	120
	P with Mean	120	120	120	120	120

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GCS Total, Education, Age[b]	.	Enter

2	P with Mean[b]	.	Enter

a. Dependent Variable: DRSLOG

b. All requested variables entered.

Model Summary[c]

					Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2
1	.331[a]	.109	.086	.69656	.109	4.749	3	116
2	.419[b]	.175	.147	.67319	.066	9.193	1	115

Model Summary[c]

	Change Statistics
Model	Sig. F Change
1	.004
2	.003

a. Predictors: (Constant), GCS Total, Education, Age

b. Predictors: (Constant), GCS Total, Education, Age, P with Mean

c. Dependent Variable: DRSLOG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.913	3	2.304	4.749	.004[b]
	Residual	56.282	116	.485		
	Total	63.195	119			
2	Regression	11.079	4	2.770	6.112	.000[c]
	Residual	52.116	115	.453		
	Total	63.195	119			

a. Dependent Variable: DRSLOG

b. Predictors: (Constant), GCS Total, Education, Age

c. Predictors: (Constant), GCS Total, Education, Age, P with Mean

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B
		B	Std. Error	Beta	t	Sig.	Lower Bound
1	(Constant)	1.499	.346		4.328	.000	.813
	Age	.012	.005	.227	2.557	.012	.003
	Education	-.022	.026	-.075	-.851	.397	-.074
	GCS Total	-.056	.019	-.265	-2.996	.003	-.092
2	(Constant)	2.076	.385		5.391	.000	1.313
	Age	.011	.005	.195	2.257	.026	.001
	Education	-.018	.025	-.061	-.720	.473	-.068
	GCS Total	-.041	.019	-.193	-2.173	.032	-.077
	P with Mean	-.007	.002	-.268	-3.032	.003	-.011

Coefficients[a]

Model		95.0% Confidence Interval for B Upper Bound
1	(Constant)	2.185
	Age	.022
	Education	.029
	GCS Total	-.019
2	(Constant)	2.839
	Age	.020
	Education	.032
	GCS Total	-.004
	P with Mean	-.002

a. Dependent Variable: DRSLOG

Coefficient Correlations[a]

Model			GCS Total	Education	Age	P with Mean
1	Correlations	GCS Total	1.000	-.042	-.138	
		Education	-.042	1.000	-.091	
		Age	-.138	-.091	1.000	
	Covariances	GCS Total	.000	-2.043E-5	-1.237E-5	
		Education	-2.043E-5	.001	-1.140E-5	
		Age	-1.237E-5	-1.140E-5	2.310E-5	
2	Correlations	GCS Total	1.000	-.027	-.165	-.268
		Education	-.027	1.000	-.097	-.052
		Age	-.165	-.097	1.000	.122
		P with Mean	-.268	-.052	.122	1.000
	Covariances	GCS Total	.000	-1.247E-5	-1.441E-5	-1.098E-5
		Education	-1.247E-5	.001	-1.140E-5	-2.905E-6
		Age	-1.441E-5	-1.140E-5	2.190E-5	1.253E-6
		P with Mean	-1.098E-5	-2.905E-6	1.253E-6	4.821E-6

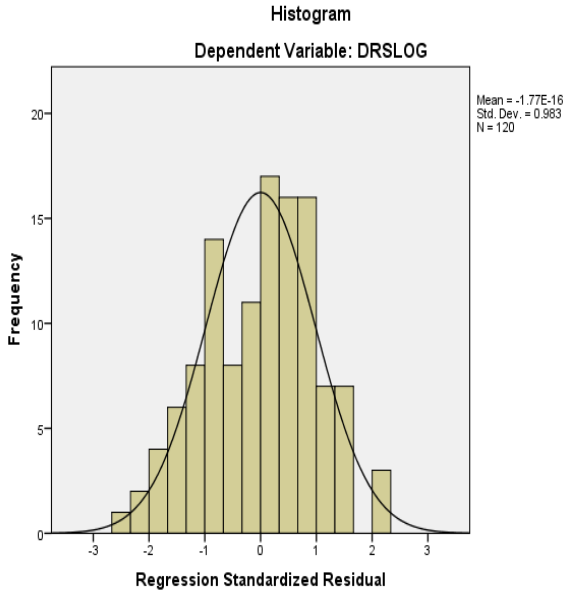
a. Dependent Variable: DRSLOG

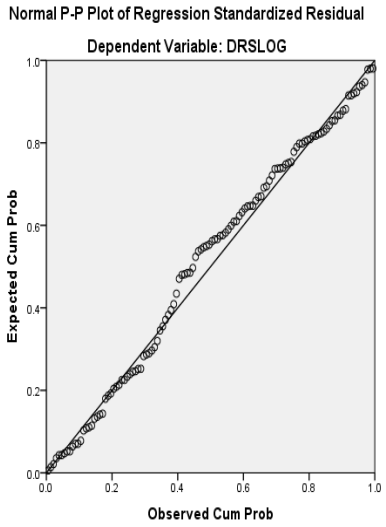
Residuals Statistics[a]

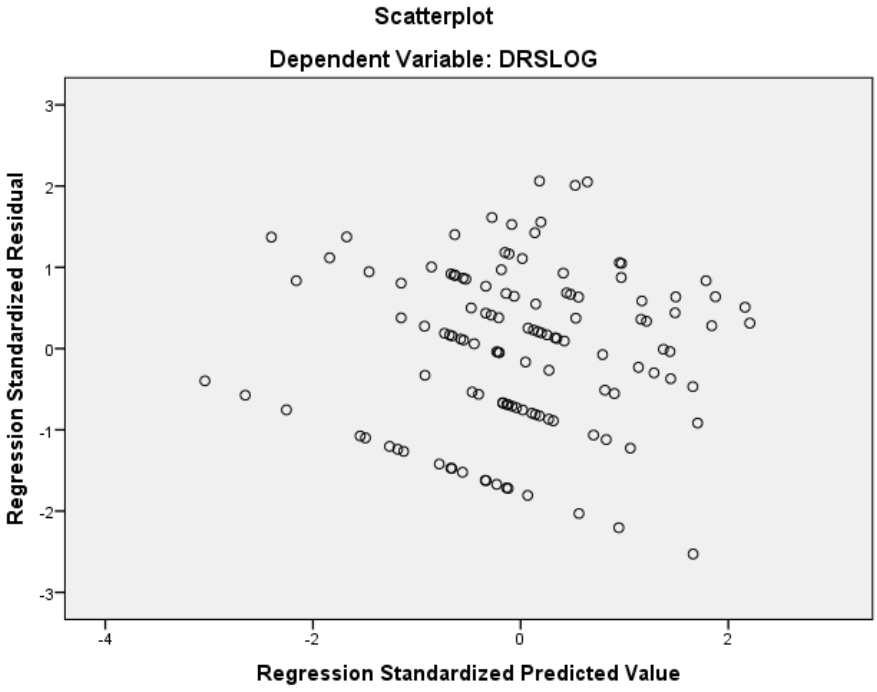
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.2678	1.8688	1.1955	.30513	120
Residual	-1.70211	1.38817	.00000	.66178	120
Std. Predicted Value	-3.040	2.207	.000	1.000	120
Std. Residual	-2.528	2.062	.000	.983	120

a. Dependent Variable: DRSLOG

Charts


Histogram
Dependent Variable: DRSLOG
Mean = -1.77E-16
Std. Dev. = 0.983
N = 120
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: DRSLOG
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: DRSLOG
Regression Standardized Residual
Regression Standardized Predicted Value

Appendix R: Aim 3 statistics Group B (Minimum Imputation)

Descriptive Statistics

	Mean	Std. Deviation	N
DRSLOG	1.1955	.72873	120
Age	31.73	13.479	120
Education	11.47	2.463	120
GCS Total	7.88	3.474	120
P with Min	70.86	56.035	120

Correlations

		DRSLOG	Age	Education	GCS Total	P with Min
Pearson Correlation	DRSLOG	1.000	.182	-.067	-.237	-.423
	Age	.182	1.000	.098	.143	-.198
	Education	-.067	.098	1.000	.056	.214
	GCS Total	-.237	.143	.056	1.000	.203
	P with Min	-.423	-.198	.214	.203	1.000
Sig. (1-tailed)	DRSLOG	.	.023	.232	.005	.000
	Age	.023	.	.144	.060	.015
	Education	.232	.144	.	.273	.010
	GCS Total	.005	.060	.273	.	.013
	P with Min	.000	.015	.010	.013	.
N	DRSLOG	120	120	120	120	120
	Age	120	120	120	120	120
	Education	120	120	120	120	120
	GCS Total	120	120	120	120	120
	P with Min	120	120	120	120	120

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method

1	GCS Total, Education, Age[b]	. Enter
2	P with Min[b]	. Enter

a. Dependent Variable: DRSLOG

b. All requested variables entered.

Model Summary[c]

					Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2
1	.331[a]	.109	.086	.69656	.109	4.749	3	116
2	.469[b]	.220	.193	.65456	.111	16.362	1	115

Model Summary[c]

	Change Statistics
Model	Sig. F Change
1	.004
2	.000

a. Predictors: (Constant), GCS Total, Education, Age

b. Predictors: (Constant), GCS Total, Education, Age, P with Min

c. Dependent Variable: DRSLOG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.913	3	2.304	4.749	.004[b]
	Residual	56.282	116	.485		
	Total	63.195	119			
2	Regression	13.923	4	3.481	8.124	.000[c]
	Residual	49.272	115	.428		
	Total	63.195	119			

a. Dependent Variable: DRSLOG

b. Predictors: (Constant), GCS Total, Education, Age

c. Predictors: (Constant), GCS Total, Education, Age, P with Min

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B
		B	Std. Error	Beta	t	Sig.	Lower Bound
1	(Constant)	1.499	.346		4.328	.000	.813
	Age	.012	.005	.227	2.557	.012	.003
	Education	-.022	.026	-.075	-.851	.397	-.074
	GCS Total	-.056	.019	-.265	-2.996	.003	-.092
2	(Constant)	1.576	.326		4.833	.000	.930
	Age	.007	.005	.137	1.579	.117	-.002
	Education	.002	.025	.006	.074	.941	-.048
	GCS Total	-.039	.018	-.184	-2.149	.034	-.074
	P with Min	-.005	.001	-.360	-4.045	.000	-.007

Coefficients[a]

Model		95.0% Confidence Interval for B Upper Bound
1	(Constant)	2.185
	Age	.022
	Education	.029
	GCS Total	-.019
2	(Constant)	2.222
	Age	.017
	Education	.052
	GCS Total	-.003
	P with Min	-.002

a. Dependent Variable: DRSLOG

Coefficient Correlations[a]

Model			GCS Total	Education	Age	P with Min
1	Correlations	GCS Total	1.000	-.042	-.138	
		Education	-.042	1.000	-.091	
		Age	-.138	-.091	1.000	
	Covariances	GCS Total	.000	-2.043E-5	-1.237E-5	
		Education	-2.043E-5	.001	-1.140E-5	
		Age	-1.237E-5	-1.140E-5	2.310E-5	
2	Correlations	GCS Total	1.000	.016	-.191	-.235
		Education	.016	1.000	-.147	-.236
		Age	-.191	-.147	1.000	.259
		P with Min	-.235	-.236	.259	1.000
	Covariances	GCS Total	.000	7.070E-6	-1.604E-5	-4.886E-6
		Education	7.070E-6	.001	-1.728E-5	-6.886E-6
		Age	-1.604E-5	-1.728E-5	2.187E-5	1.404E-6
		P with Min	-4.886E-6	-6.886E-6	1.404E-6	1.340E-6

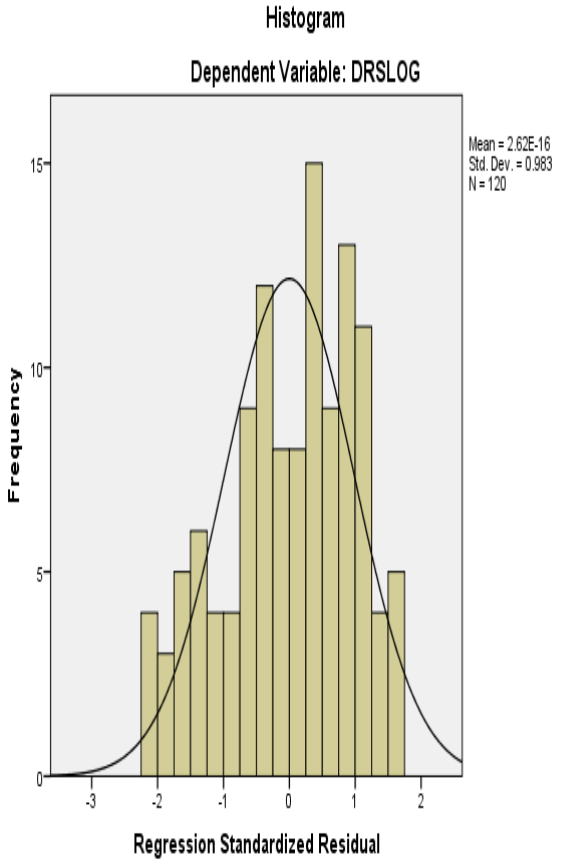
a. Dependent Variable: DRSLOG

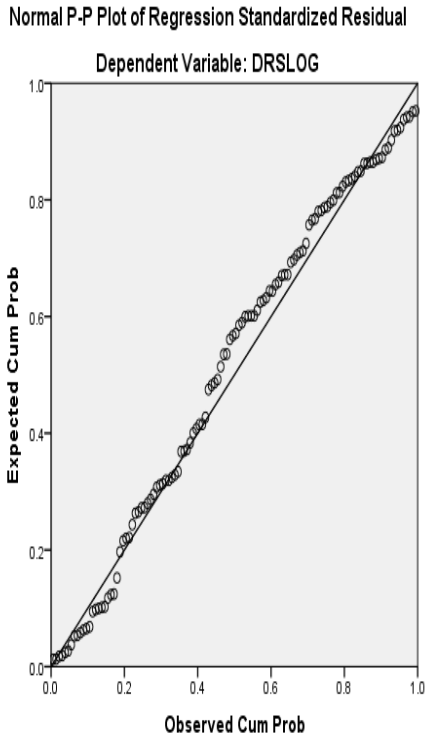
Residuals Statistics[a]

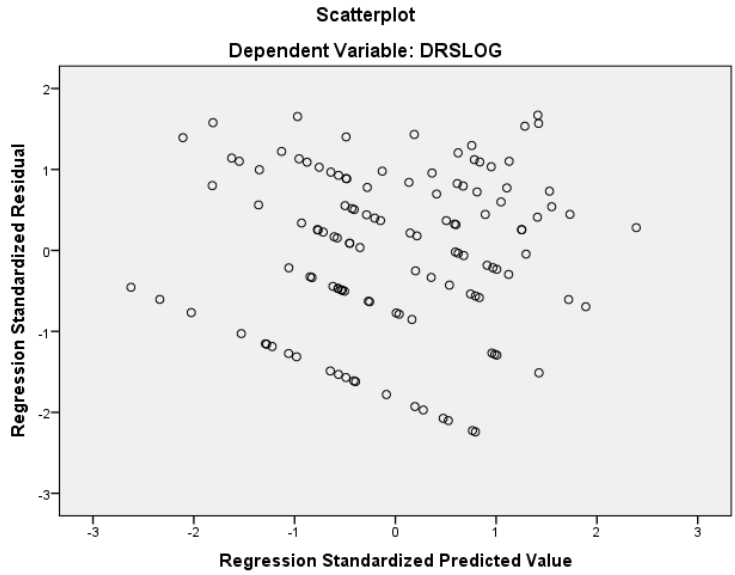
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.2983	2.0131	1.1955	.34206	120
Residual	-1.46719	1.09346	.00000	.64347	120
Std. Predicted Value	-2.623	2.390	.000	1.000	120
Std. Residual	-2.241	1.671	.000	.983	120

a. Dependent Variable: DRSLOG

Charts


Histogram
Dependent Variable: DRSLOG
Mean = 2.62E-16
Std. Dev. = 0.983
N = 120
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: DRSLOG
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: DRSLOG
Regression Standardized Residual
Regression Standardized Predicted Value

Appendix S. Aim 3 statistics , Group C (DST Regression Imputation)

Descriptive Statistics

	Mean	Std. Deviation	N
DRSLOG	1.1955	.72873	120
Age	31.73	13.479	120
Education	11.47	2.463	120
GCS Total	7.88	3.474	120
P with DST	97.44	33.392	120

Correlations

		DRSLOG	Age	Education	GCS Total	P with DST
Pearson Correlation	DRSLOG	1.000	.182	-.067	-.237	-.439
	Age	.182	1.000	.098	.143	-.183
	Education	-.067	.098	1.000	.056	.137
	GCS Total	-.237	.143	.056	1.000	.215
	P with DST	-.439	-.183	.137	.215	1.000
Sig. (1-tailed)	DRSLOG	.	.023	.232	.005	.000
	Age	.023	.	.144	.060	.023
	Education	.232	.144	.	.273	.068
	GCS Total	.005	.060	.273	.	.009
	P with DST	.000	.023	.068	.009	.
N	DRSLOG	120	120	120	120	120
	Age	120	120	120	120	120
	Education	120	120	120	120	120
	GCS Total	120	120	120	120	120
	P with DST	120	120	120	120	120

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method

1	GCS Total, Education, Age[b]	. Enter
2	P with DST[b]	. Enter

a. Dependent Variable: DRSLOG

b. All requested variables entered.

Model Summary[c]

					Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2
1	.331[a]	.109	.086	.69656	.109	4.749	3	116
2	.482[b]	.233	.206	.64939	.123	18.465	1	115

Model Summary[c]

	Change Statistics
Model	Sig. F Change
1	.004
2	.000

a. Predictors: (Constant), GCS Total, Education, Age

b. Predictors: (Constant), GCS Total, Education, Age, P with DST

c. Dependent Variable: DRSLOG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.913	3	2.304	4.749	.004[b]
	Residual	56.282	116	.485		
	Total	63.195	119			
2	Regression	14.700	4	3.675	8.714	.000[c]
	Residual	48.496	115	.422		
	Total	63.195	119			

a. Dependent Variable: DRSLOG

b. Predictors: (Constant), GCS Total, Education, Age

c. Predictors: (Constant), GCS Total, Education, Age, P with DST

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B
		B	Std. Error	Beta	t	Sig.	Lower Bound
1	(Constant)	1.499	.346		4.328	.000	.813
	Age	.012	.005	.227	2.557	.012	.003
	Education	-.022	.026	-.075	-.851	.397	-.074
	GCS Total	-.056	.019	-.265	-2.996	.003	-.092
2	(Constant)	2.107	.353		5.977	.000	1.409
	Age	.008	.005	.141	1.653	.101	-.002
	Education	-.006	.025	-.021	-.247	.806	-.055
	GCS Total	-.037	.018	-.176	-2.066	.041	-.072
	P with DST	-.008	.002	-.373	-4.297	.000	-.012

Coefficients[a]

Model		95.0% Confidence Interval for B Upper Bound
1	(Constant)	2.185
	Age	.022
	Education	.029
	GCS Total	-.019
2	(Constant)	2.806
	Age	.017
	Education	.043
	GCS Total	-.002
	P with DST	-.004

a. Dependent Variable: DRSLOG

Coefficient Correlations[a]

Model			GCS Total	Education	Age	P with DST
1	Correlations	GCS Total	1.000	-.042	-.138	
		Education	-.042	1.000	-.091	
		Age	-.138	-.091	1.000	
	Covariances	GCS Total	.000	-2.043E-5	-1.237E-5	
		Education	-2.043E-5	.001	-1.140E-5	
		Age	-1.237E-5	-1.140E-5	2.310E-5	
2	Correlations	GCS Total	1.000	-.003	-.188	-.244
		Education	-.003	1.000	-.123	-.153
		Age	-.188	-.123	1.000	.236
		P with DST	-.244	-.153	.236	1.000
	Covariances	GCS Total	.000	-1.382E-6	-1.550E-5	-8.268E-6
		Education	-1.382E-6	.001	-1.398E-5	-7.104E-6
		Age	-1.550E-5	-1.398E-5	2.126E-5	2.058E-6
		P with DST	-8.268E-6	-7.104E-6	2.058E-6	3.587E-6

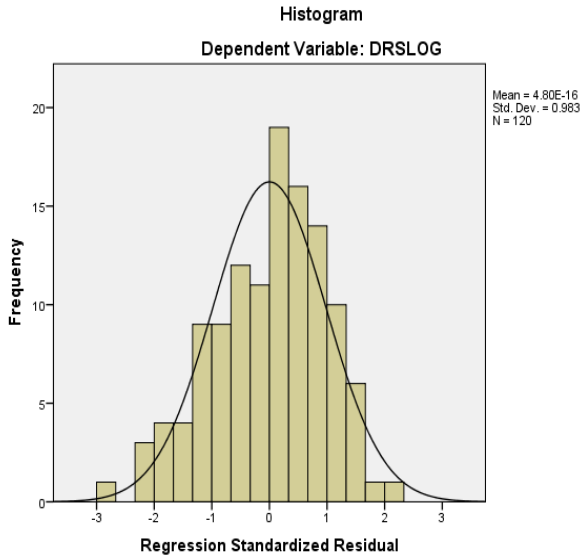
a. Dependent Variable: DRSLOG

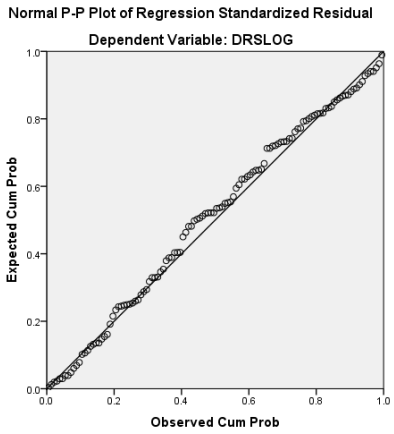
Residuals Statistics[a]

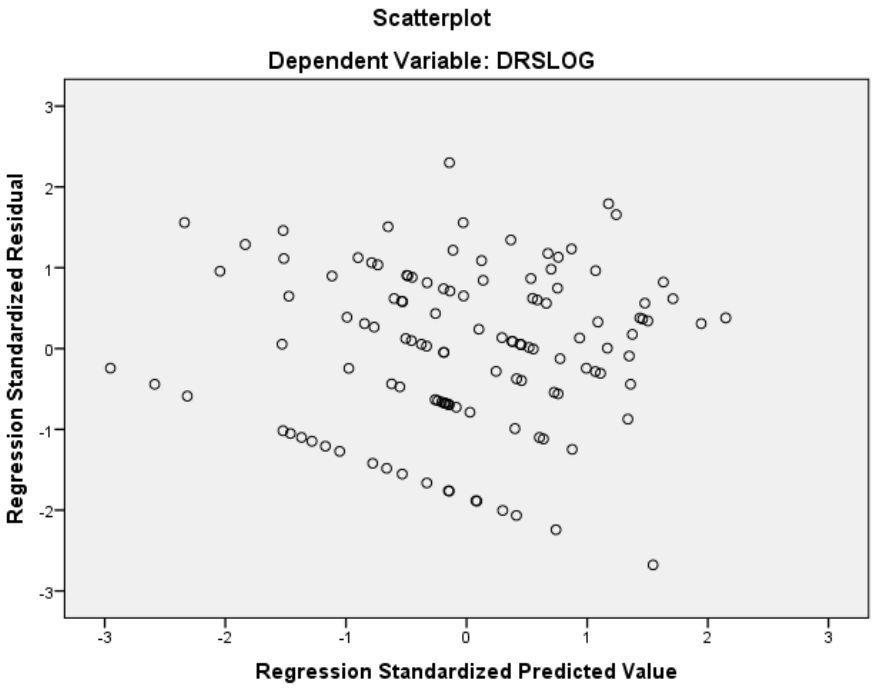
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.1575	1.9507	1.1955	.35146	120
Residual	-1.73888	1.49365	.00000	.63838	120
Std. Predicted Value	-2.953	2.149	.000	1.000	120
Std. Residual	-2.678	2.300	.000	.983	120

a. Dependent Variable: DRSLOG

Charts


Histogram
Dependent Variable: DRSLOG
Mean = 4.80E-16
Std. Dev. = 0.983
N = 120
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: DRSLOG
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: DRSLOG
Regression Standardized Residual
Regression Standardized Predicted Value

Appendix T: Aim 3 statistics Group D (DSB Regression Imputation)

Descriptive Statistics

	Mean	Std. Deviation	N
DRSLOG	1.1955	.72873	120
Age	31.73	13.479	120
Education	11.47	2.463	120
GCS Total	7.88	3.474	120
P with DSB	97.73	33.293	120

Correlations

		DRSLOG	Age	Education	GCS Total	P with DSB
Pearson Correlation	DRSLOG	1.000	.182	-.067	-.237	-.469
	Age	.182	1.000	.098	.143	-.162
	Education	-.067	.098	1.000	.056	.113
	GCS Total	-.237	.143	.056	1.000	.238
	P with DSB	-.469	-.162	.113	.238	1.000
Sig. (1-tailed)	DRSLOG	.	.023	.232	.005	.000
	Age	.023	.	.144	.060	.038
	Education	.232	.144	.	.273	.109
	GCS Total	.005	.060	.273	.	.004
	P with DSB	.000	.038	.109	.004	.
N	DRSLOG	120	120	120	120	120
	Age	120	120	120	120	120
	Education	120	120	120	120	120
	GCS Total	120	120	120	120	120
	P with DSB	120	120	120	120	120

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GCS Total, Education, Age[b]	.	Enter
2	P with DSB[b]	.	Enter

a. Dependent Variable: DRSLOG

b. All requested variables entered.

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			
					R Square Change	F Change	df1	df2
1	.331[a]	.109	.086	.69656	.109	4.749	3	116
2	.505[b]	.255	.229	.63988	.146	22.461	1	115

Model Summary[c]

Model	Change Statistics
	Sig. F Change
1	.004
2	.000

a. Predictors: (Constant), GCS Total, Education, Age
b. Predictors: (Constant), GCS Total, Education, Age, P with DSB
c. Dependent Variable: DRSLOG

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.913	3	2.304	4.749	.004[b]
	Residual	56.282	116	.485		
	Total	63.195	119			
2	Regression	16.109	4	4.027	9.836	.000[c]
	Residual	47.086	115	.409		
	Total	63.195	119			

a. Dependent Variable: DRSLOG
b. Predictors: (Constant), GCS Total, Education, Age
c. Predictors: (Constant), GCS Total, Education, Age, P with DSB

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B
		B	Std. Error	Beta	t	Sig.	Lower Bound
1	(Constant)	1.499	.346		4.328	.000	.813
	Age	.012	.005	.227	2.557	.012	.003
	Education	-.022	.026	-.075	-.851	.397	-.074
	GCS Total	-.056	.019	-.265	-2.996	.003	-.092
2	(Constant)	2.172	.348		6.233	.000	1.482
	Age	.008	.005	.142	1.695	.093	-.001
	Education	-.008	.024	-.027	-.328	.744	-.056
	GCS Total	-.033	.018	-.160	-1.890	.061	-.069
	P with DSB	-.009	.002	-.404	-4.739	.000	-.013

Coefficients[a]

Model		95.0% Confidence Interval for B Upper Bound
1	(Constant)	2.185
	Age	.022
	Education	.029
	GCS Total	-.019
2	(Constant)	2.862
	Age	.017
	Education	.040
	GCS Total	.002
	P with DSB	-.005

a. Dependent Variable: DRSLOG

Coefficient Correlations[a]

Model			GCS Total	Education	Age	P with DSB
1	Correlations	GCS Total	1.000	-.042	-.138	
		Education	-.042	1.000	-.091	
		Age	-.138	-.091	1.000	
	Covariances	GCS Total	.000	-2.043E-5	-1.237E-5	
		Education	-2.043E-5	.001	-1.140E-5	
		Age	-1.237E-5	-1.140E-5	2.310E-5	
2	Correlations	GCS Total	1.000	-.007	-.188	-.265
		Education	-.007	1.000	-.115	-.125
		Age	-.188	-.115	1.000	.216
		P with DSB	-.265	-.125	.216	1.000
	Covariances	GCS Total	.000	-3.114E-6	-1.502E-5	-8.759E-6
		Education	-3.114E-6	.001	-1.256E-5	-5.628E-6
		Age	-1.502E-5	-1.256E-5	2.045E-5	1.823E-6
		P with DSB	-8.759E-6	-5.628E-6	1.823E-6	3.489E-6

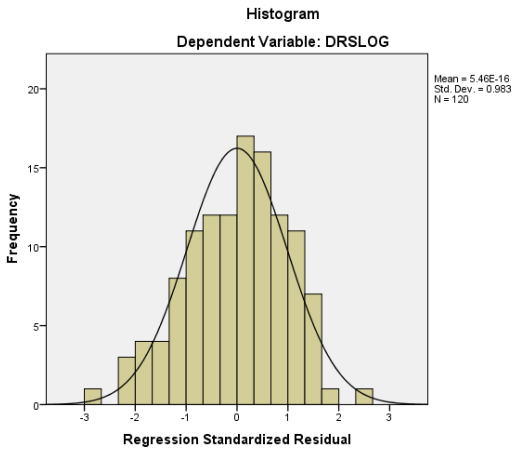
a. Dependent Variable: DRSLOG

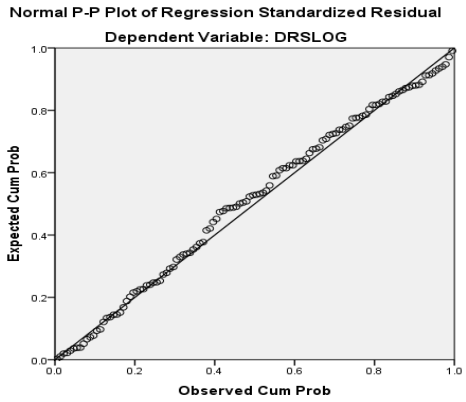
Residuals Statistics[a]

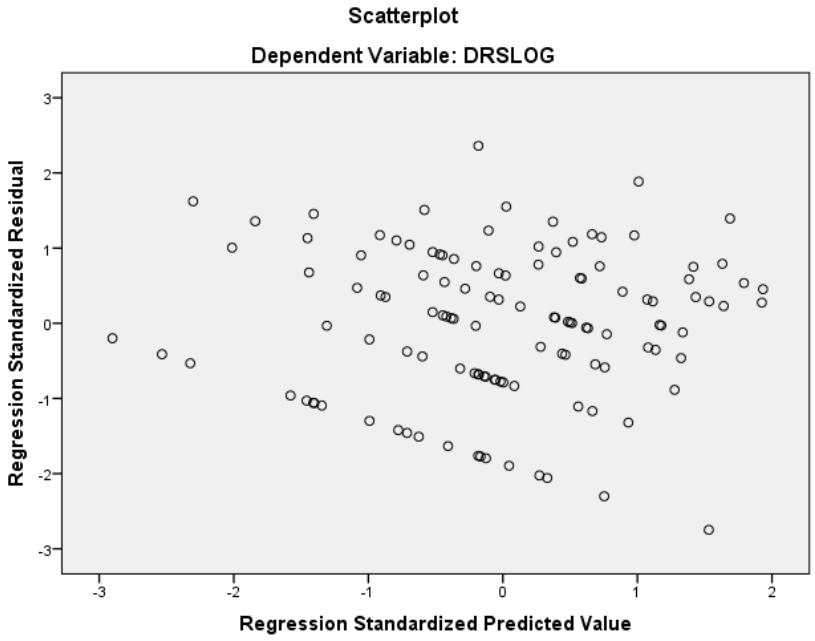
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.1278	1.9068	1.1955	.36793	120
Residual	-1.75864	1.51045	.00000	.62903	120
Std. Predicted Value	-2.902	1.933	.000	1.000	120
Std. Residual	-2.748	2.361	.000	.983	120

a. Dependent Variable: DRSLOG

Charts


Histogram
Dependent Variable: DRSLOG
Mean = 5.46E-16
Std. Dev. = 0.983
N = 120
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: DRSLOG
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: DRSLOG
Regression Standardized Residual
Regression Standardized Predicted Value

Appendix U: Digit Span Regression Analysis

Digit Span Total and PASAT Score regression analysis

Descriptive Statistics

	Mean	Std. Deviation	N
Pasat Score	103.38	36.027	86
DS Tot	14.07	3.895	86

Correlations

		Pasat Score	DS Tot
Pearson Correlation	Pasat Score	1.000	.591
	DS Tot	.591	1.000
Sig. (1-tailed)	Pasat Score	.	.000
	DS Tot	.000	.
N	Pasat Score	86	86
	DS Tot	86	86

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	DS Tot[b]	.	Enter

a. Dependent Variable: Pasat Score

b. All requested variables entered.

Model Summary

					Change Statistics			
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2
1	.591[a]	.349	.341	29.237	.349	45.073	1	84

Model Summary

	Change Statistics
Model	Sig. F Change
1	.000

a. Predictors: (Constant), DS Tot

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	38527.338	1	38527.338	45.073	.000[b]
	Residual	71800.999	84	854.774		
	Total	110328.337	85			

a. Dependent Variable: Pasat Score
b. Predictors: (Constant), DS Tot

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	29.190	11.881		2.229	.028
	DS Tot	5.342	.814	.591	6.714	.000

a. Dependent Variable: Pasat Score

Digit Span Backward and PASAT Score regression analysis

Descriptive Statistics

	Mean	Std. Deviation	N
Pasat Score	103.38	36.027	86
DS Back	6.07	1.969	86

Correlations

		Pasat Score	DS Back
Pearson Correlation	Pasat Score	1.000	.546
	DS Back	.546	1.000
Sig. (1-tailed)	Pasat Score	.	.000
	DS Back	.000	.
N	Pasat Score	86	86
	DS Back	86	86

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	DS Back[b]	.	Enter

a. Dependent Variable: Pasat Score
b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2
1	.546[a]	.298	.289	30.373	.298	35.593	1	84

Model Summary

Model	Change Statistics Sig. F Change
1	.000

a. Predictors: (Constant), DS Back

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32835.927	1	32835.927	35.593	.000[b]
	Residual	77492.410	84	922.529		
	Total	110328.337	85			

a. Dependent Variable: Pasat Score
b. Predictors: (Constant), DS Back

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	42.794	10.670		4.011	.000
	DS Back	10.049	1.673	.546	5.966	.000

a. Dependent Variable: Pasat Score

Comparing Regression Analyses (With DSB)

Regression Analysis Type	**N**	**R^2 Change Value**	**Total Model F Value**	**Total Model R^2**
PASAT	82	0.164	5.021	0.207
Mean Imputation	120	0.066	6.112	0.175
Min Score Imputation	120	0.111	8.108	0.220
Digit Span Backward	**120**	**0.115**	**8.304**	**0.224**
Regression Analysis (DST)	120	0.123	8.714	0.233
Regression Analysis (DSB)	120	0.146	9.836	0.255