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Practice effects and anxiety level differences among the paced auditory serial addition task aural sequential paced arithmetic test and visual sequential paced arithmetic test

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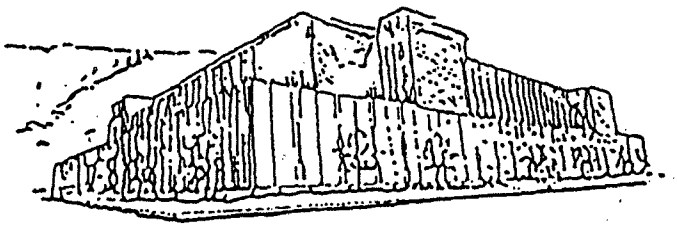

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Practice Effects and Anxiety Level Differences

Among the Paced Auditory Serial Addition Task,

Aural Sequential Paced Arithmetic Test,

and Visual Sequential Paced Arithmetic Test

by

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B.A. University of Central Florida, 1994

presented in partial fulfillment of the requirements

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Approved by:

Stuart Hall

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Practice Effects and Anxiety Level Differences Among the Paced Auditory Serial Audition Task, Aural Sequential Paced Arithmetic Test, and Visual Sequential Paced Arithmetic Test (74pp).

Director: Dr. Stuart Hall

The purpose of this experiment was to determine if practice effects and anxiety levels differ among three neuropsychological test instruments designed to measure information processing capacity. The instruments were the Paced Auditory Serial Addition Task (PASAT), the Aural Sequential Paced Arithmetic Test (ASPAT), and the Visual Sequential Paced Arithmetic Test (VSPAT). Each of the three tests was administered four times over a seven week period. Anxiety was assessed pre- and posttest of administrations one and four. It was hypothesized that the ASPAT and the VSPAT would result in lower practice effects and anxiety levels then would the PASAT. Results indicate the practice effects are similar for all three tests, reaching asymptote by administration three. The three tests were also similar in regard to anxiety level. Anxiety increased significantly from pre- to posttest one and from pre- to posttest four. Although not significantly different, the VSPAT evoked less anxiety than the other two tests. There was significantly less anxiety at posttest four compared to posttest one indicating that repeated testing resulted in a decrease in anxiety arousal, especially on the VSPAT.

Dedication

This project is dedicated to:

Joseph and Marian Boyle

Acknowledgments

There are many people to whom I am indebted for helping me with this thesis. First and foremost, I need to thank Dr. Stuart Hall for suggesting this project and for his guidance and patience in seeing it through to the end.

Thank you to my committee members, Dr. David Schuldberg, Dr. William Docktor, and Dr. Nabil Haddad. Your insight, knowledge and support were invaluable.

Thank you to my research assistants, Jean Higgins, Jillian Jurica, Tana Mennie, and Liesel Shoquist. Your persistence and dedication made the completion of this project possible.

A special thanks to my husband, Mark Mielke, for surviving the process.

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Chapter One

Review of the Literature

With over 2 million serious head injuries and as many as 750,000 mild Traumatic Brain Injuries (TBI) incurred each year (Lezak, 1995), it's not surprising that neuropsychologists have focused much of their attention on the assessment and evaluation of TBI. Additionally, these figures don't begin to estimate the many mild head injuries which go undiagnosed due to the lower severity of the trauma, failure to seek medical treatment or late onset of distressing symptoms.

Brain injuries can be divided into two distinct categories, open head injuries and closed head injuries. Open head injuries are those injuries which involve the penetration of the brain by a foreign object, such as a bullet, missile or flying debris. These injuries tend to result in concentrated tissue damage following the path of the foreign object. These injuries often produce specific behavioral deficits, dependent upon the region of the brain damage (Lezak, 1995) (See Appendix O).

Closed head injuries typically result in two stages of brain injury; primary injury which occurs at the time of impact and secondary injury which consists of the physiological effects set into motion by the primary injury (Lezak, 1995). These injuries may result in both coup (the point at at which the impact hits the head) lesions and contrecoup (the area of

the brain opposite the point of impact) lesions. These lesions account for the specific and localized behavioral changes that accompany closed head injuries. (Lezak, 1995; See Appendix O). Another common type of primary closed head injury, generally caused by motor vehicle accidents or falls is "...rotational acceleration of the brain within the bony structure of the skull" (Lezak, 1995, p.177). This is accompanied by rapid acceleration/deceleration. This action causes shearing effects and microscopic lesions throughout the brain (Lezak, 1995). Secondary injury swelling is caused by hemorrhages or edema resulting from the primary involves the swelling of the brain within its solid, inflexible casing. The injury to the brain. Both of these conditions result in additional tissue damage as they expand, compressing air and liquid filled spaces as well as brain tissue.

A subdivision of closed head injury is mild traumatic brain injury, MTBI. MTBI has been variously defined as an injury resulting in a posttraumatic amnesia of less then one hour, a Glasgow Coma Scale score of between 13 and 15, a hospital stay of less than three days, no hospital stay, a change in or loss of consciousness for less than two minutes or a combination of these criteria (Gronwall, 1991). Reitan (1994) prefers to use the definition of MTBI put forth by Rimel, Giordani, Barth et al. (1981) as a head blow causing a loss of consciousness of

twenty minutes or less, a Glasgow Coma Scale score on hospital admission of 13 to 15, and a hospitalization of 48 hours or less, because of the general adoption of these criteria by other researchers.

In 1987 Rutherford defined MTBI as "an acceleration/deceleration injury to the head almost always associated with a period of amnesia, and followed by a characteristic group of symptoms such as headache, poor memory, and vertigo". In some cases, no loss of consciousness occurs, but rather an alteration of consciousness as in when a person is dazed or confused. No structural damage of either the brain or the skull is detectable (Binder, 1986). With the use of magnetic resonance imaging (MRI), physical evidence of brain damage has been found in some cases of MTBI (Gronwall, 1991). Damage may occur at the site of impact or coup, contrecoup, as diffuse tissue damage throughout the brain, or damage to the brain stem and its related structures (Gronwall & Samson, 1974; Van Zomeren, Brouwer, & Deelman, 1984).

The early symptoms of MTBI may include confusion, disorientation, blurred vision, headache, dizziness, vomiting, nausea, drowsiness, retrograde amnesia and post-traumatic amnesia of various durations as well as several other symptoms (Rutherford, 1989, Gronwall, 1991).

Most of the symptoms of MTBI resolve within the first three months, with post-traumatic amnesia usually ending within 24 hours of injury (Lezak, 1995). However, for some patients the symptoms can continue indefinitely, reported in research as long as fifteen years post concussion (Gronwall, 1991, p. 259). Particularly vulnerable are those who have suffered multiple TBI's. It has been found that multiple TBI's result in increased impairment, longer recovery times, and a decrease in information processing. Other factors affecting recovery rates are age, substance use, life stressors and psychological make up of the individual (Gronwall, 1989, 1991).

Assessment of Mild Traumatic Brain Injury

Given the difficulty in defining MTBI, it is not surprising that many different assessment tools have been employed in its diagnosis. But one of the most reliable has been the Paced Auditory Serial Addition Test (PASAT). The PASAT (Sampson, 1956) has proven to obtain significant results in differentiating between severe TBI and MTBI, as confirmed by the growing body of normative validation data on this subject (Gronwall, 1991). Additional research on the PASAT has shown consistent utility in MTBI assessment of attention and concentration and overall processing capabilities (Lezak, 1995; Deary, Langan, Hepburn & Frier, 1991). However, in a study by Stuss et al., in 1989, conflicting results were

found regarding the ability of the PASAT to differentiate mild head injury subjects from controls. The PASAT was found to be sufficiently sensitive to differentiate mild head injury subjects from controls, but not at levels of significance. This may have been due to the criteria for inclusion in the mild head injury group, variability of symptoms, time since injury of persistent symptoms during repeated measures evaluation or inadequate statistical power due to the small sample.

PASAT

The PASAT (Gronwall & Sampson, 1974; Gronwall, 1977; Gronwall & Wrightson 1974, 1978, 1981) was developed to assess the effects of MTBI, specifically as a test of processing speed and capacity, memory, concentration and attention. Gronwall and her associates used the PASAT as a means of tracking the progress of MTBI patients within a clinical setting. It continues to be used as one measure of determining patient readiness for return to work. Its use has been extended to tracking the progression of brain lesions as well. The PASAT measures processing speed and capacity, memory, concentration and attention through the use of single digit numbers presented sequentially to be added in pairs. While the PASAT has proven very useful in assessing MTBI, it is not without its shortcomings. Evidence of practice effects (Sampson, 1961; Stuss et al., 1987), increased levels of anxiety during

testing and significant correlations to IQ (Kanter 1984; Epperson & Cripe, 1985, as cited in Brittain et al., 1991) and arithmetic ability (Weber, 1988; Bateman & Hall, 1997) have been reported (See Appendix O).

Practice Effects

In addition to the difficulties inherent in testing the subtle effects of mild TBI is the confounding problem of practice effects. Practice effects elevate scores artificially over subsequent testings, due to familiarity with the instrument, instead of as a result of the measures functioning as an objective index of the characteristic in question. This matter is germane to a variety of assessment situations.

It is apparent that the role of practice effects arising from repeated administrations of neuropsychological tests is important for many reasons. There may be the need for repeat testing to monitor the progression of a disease, to evaluate therapeutic efficacy of a drug or rehabilitation training program, or because of the demand for second opinions as litigation increases (Lezak, 1995). In litigation cases, as clinical psychologists present themselves to the courts as expert witnesses, the importance of estimating practice effects from previous test exposure has taken on renewed significance. Attorneys may refer their clients to a professional of their own choosing for repeated

assessment and evaluation. This may result in several neurological exams within a short time frame. The very nature of personal injury litigation virtually guarantees that in many cases the client will be examined multiple times (Putnam, Adams, & Schneider, 1992).

In a growing literature regarding practice effects and test-retest reliability, research efforts have focused on mainstays of clinical neuropsychological assessment, the Wechsler WAIS-R and WMS-R and the Halstead-Reitan Neuropsychological Test Battery (HRNB). Significant practice effects have been found on portions of the original WAIS and WMS, but the practice effects differ between neuropsychologically impaired participants and unimpaired individuals. They also differ across several other variables, including "age, severity of deficit, and type and progression of lesion" (Shatz, 1981). Practice effects within neuropsychologically impaired populations have shown greater variability and must be addressed on an individual basis (Shatz, 1981) (See Appendix O).

The practice effects associated with the PASAT have received limited research with variable findings (Sampson, 1956, 1958a, 1958b, 1961) (See Appendix O). Roman, Edwall, Buchanan & Patton wrote of the PASAT in 1991, that Gronwall and Sampson (1974) reported significantly improved performance from the first to the second PASAT administration

in their control subjects, but found minimal improvements with subsequent administrations. In contrast, Stuss, Stethem, Hugenholtz, and Richard (1989), although not focusing on practice effects, also found significantly better performance from first to second administrations of the PASAT, but with steady improvements in the performance of their controls across three to four administrations and a leveling off of performance by the fifth trial. Practice effects still existed at the third and fourth trials and were different for different presentation rates. Performance at all presentation rates (2.4, 2.0, 1.6, 1.2s) was significantly different from each other, and performance decreased as presentation rate increased. The MTBI subjects always performed significantly worse than the controls (Stuss, et al., 1989, p. 149). These variable findings illustrate the necessity for research to expand the PASAT's database in regard to practice effects within repeated neuropsychological testing.

The client's level of anxiety may also play an important role in neuropsychological test performance. In addition to interpreting the role of practice effects on PASAT results when dealing with multiple administrations, clinicians need to assess the effects of anxiety the PASAT has been shown to cause (Lezak, 1995; Deary, Emeier, MacLeod,

Dougall, Hepburn, Frier, & Goodwin, 1994; Stuss et al., 1989). Level of anxiety and its effects may also differ across administrations.

Anxiety

Anxiety, as defined by Spielberger (1983, p.1), ". . . is an unpleasant emotional state or condition". Spielberger further defines anxiety as two distinct states, State Anxiety and Trait Anxiety. State anxiety is a physiological reaction to a stressful situation at a given time and level of intensity. Trait anxiety refers to individual differences in anxiety-proneness which, for that person, remain relatively stable. That is the stable differences between people in their perception of stressful situations as dangerous or threatening and their response to such situations results in short-term elevations in the intensity of their State anxiety reactions. Trait anxiety may also reflect individual differences in the frequency and intensity with which anxiety states have been experienced in the past, and in the probability that State anxiety will be experienced in the future. The stronger the anxiety trait, the more probable that the individual will experience more intense elevations in State anxiety in a stressful situation. In other words, if a person tends to perceive stressful situations as frightening, their level of State anxiety will tend to be higher then those who do not perceive most stressful situations as frightening.

Stress, (as measured by anxiety level) is associated with lower performance on neuropsychological tests and is also viewed as an agent in delaying recovery for mild TBI patients (Gronwall, 1977). Specifically, increased stress may cause a leveling off or regression of scores in repeated PASAT testing. In an earlier comparison of three MTBI assessment instruments, the Trail Making Test (TMT), Auditory Short Term Memory Test under Interference (CCC) and the PASAT, Stuss et al.(1989) found the PASAT sufficiently effective, but cautioned its use because it is stressful for patients. Stuss stated, "In our experience, the PASAT, although proven effective in identifying deficits after TBI, is unnecessarily stressful. Our previous research also suggested that it is affected by level of education in normal subjects to a greater degree than either the TMT or CCC." (1989, p. 153). They suggested that if equally effective and less demanding tests exist, that are relatively independent of confounding by age and/or education, they should be used. This view was echoed by Lezak (1995) (See Appendix O).

In a study by Deary et al., 1994, comparing two groups of participants with Type I diabetes mellitus, the Spielberger State Anxiety scale was used to assess the anxiety levels of participants at rest and immediately after administration of the PASAT. Both of the diabetic groups, those with no severe hypoglycaemic episodes and those who had

five or more hypoglycaemic episodes, show a dramatic increase in anxiety level as reported on the Spielberger State Anxiety scale immediately following administration of the PASAT as compared to scores prior to administration of the PASAT. This is the only study in the literature that makes a formal assessment of anxiety and PASAT performance. However, this study is based on a population with a serious, chronic medical illness. Results for a population of control participants in normal health may differ in regard to anxiety levels and PASAT performance.

Gender and age have also been debated as a factors in performance on the PASAT with inconclusive results regarding gender, and variable results regarding age (Stuss, Stethem, & Poirier, 1987; Brittain, La Marche, Reeder, Roth, & Boll, 1991) (See Appendix O).

Purpose

Revisions to the PASAT were developed by Bateman and Hall (1996, 1997) to address the various shortcomings of the PASAT. First the ASPAT, which is also an auditory test, was shortened in number of items, the stimulus presentation rate was modified, and the arithmetic simplified. Second, the VSPAT was developed. This is a visual version of the ASPAT, delivered by computer, utilizing the exact same number of items, stimulus presentation rate and arithmetic. These modifications attempt to address potentially problematic features of the PASAT, such

as, practice effects, anxiety and correlation with arithmetic ability (Bateman & Hall, 1997).

Chapter Two

Purpose

The purpose of this study is two fold. First, this study proposes to evaluate the practice effects occurring during repeated administration of the PASAT compared to the modified versions developed by Bateman and Hall (1996), the ASPAT and the VSPAT. Second, this study will measure the level of anxiety generated by the administration of the PASAT and compare those anxiety levels to those experienced during administration of the ASPAT and the VSPAT. A mixed model (between and within) design will be implemented using Psychology 100 students in a test-retest format. There will be one group of subjects exposed to each of the three test formats. Each of the three groups will be tested four times over a seven week period, once every two weeks. Results will be examined to determine differences in practice effects and level of anxiety with regard to test format.

Specifically, the following comparisons will be examined.

1. Do the three tests differ in the nature of their practice effects across the four administrations?

2. Are the characteristics of the practice effects different for the four different presentation rates within each test?

3. Are there changes in anxiety level from pretest to posttest within the first administration and the fourth administration of each test. If so, what is the nature of the change?

4. Do the changes in anxiety level from pretest to posttest of administration one and four differ between the three tests?

5. Does the level of anxiety change across repeated test administration, from posttest administration one to posttest administration four for each of the three tests?

6. For each of the three tests is there a correlation between anxiety level and test performance?

It is hypothesized that the ASPAT and VSPAT will show lower practice effects and lower anxiety levels than the PASAT due to the reduced item format, simplified arithmetic and modified stimulus presentation rate. It is also hypothesized that a leveling off of performance scores will occur at an earlier administration for slower presentation rates than for faster presentation rates for all three tests within subjects.

Chapter Three

Methodology

Participants

Participants consisted of 56 students selected from the Introductory Psychology subject pool at the University of Montana in the Spring, Summer and Fall semesters of 1997. Participants received course credit for their participation. The participants were randomly assigned to the three separate conditions. The modified version of the Medical Health Screening Questionnaire (modified from Tindall, 1990; see appendix A) was used to screen participants for potential confounding conditions. Participants were free of the following exclusionary criteria: 1. Neurological disorder, 2. Experience of major TBI, 3. Diagnosis of psychosis or Major Affective Disorder, 4. If they smoke or have smoked marijuana more than four times per week over a period of at least one year or within 24 hours of testing, 5. Use of hallucinogens more than 50 times, 6. Use of stimulants more than twenty times per year, 7. Use of major tranquilizers, antidepressants, or anticonvulsants on a regular basis for at least one year preceding the study, 8. Use of inhalants more than ten times, 9. If they have suffered more than three minor head injuries with at least one resulting in concussion or loss of consciousness, 10. If they ever lost consciousness for more than fifteen

minutes. In addition to the modified Medical Health Screening Questionnaire, participants would have been excluded if their self-reported (Appendix B) level of effort in completing the experiment was less then three, indicating less than "moderately hard" effort. A total of 106 participants were run. After screening, the PASAT, ASPAT, and VSPAT conditions had 18, 17, and 21 participants respectively for a total of 56 participants who completed the repeated measures testing.

Materials

The following pretest stimulus materials were used prior to administration one: An Informed Consent Form (Appendix C), and the modified Medical Health Screening Questionnaire. A five point scale was used to record the participant's self-characterized level of effort posttest for all four test administrations. The Spielberger State Anxiety Scale was only administered pretest and posttest for administrations one and four to measure level of anxiety.

The test materials for the PASAT, ASPAT and VSPAT include the standardized test instructions (PASAT, Appendix F; ASPAT, Appendix D; VSPAT, Appendix E) and scoring forms (PASAT, Appendix J; ASPAT/VSPAT, Appendix G). The PASAT consists of 60 items for each of four presentation rates; 2.4, 2.0, 1.6, and 1.2s. The ASPAT and VSPAT consist of 40 items for each of the four presentation rates; 2.5, 2.0, 1.5,

and 1.0s. The PASAT and ASPAT were administered aurally using an audio cassette recorder. The results were recorded on the scoring form with pencil by the experimenter. The VSPAT was administered visually on a computer. The results were recorded on the scoring form with pencil by the experimenter. The number correct for each rate of presentation as well as total correct were computed for each test. In addition, the percent correct for each rate of presentation and total percent correct were computed for each test.

The Spielberger State Anxiety Scale was used to assess anxiety level pre- and posttest for test administrations one and four as an indication of the level of stress experienced by the participant. The results were evaluated to determine any differences between the three test formats and within each test format. The Spielberger State Anxiety Scale has been found to significantly correlate with stress experienced by a population of university students. It is not significantly correlated with Academic Aptitude and Achievement (-.07 to .00) (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Specifically, the Spielberger State Anxiety Scale has been found to be sensitive to the anxiety associated with administration of the PASAT (Deary et al., 1994).

Procedures

Each participant was tested individually at the University of Montana. Following the protocol (Appendix H) the experimenter gave each participant an introduction to the experiment. The participant was then asked to read and sign the informed consent form. Demographic information i.e., gender and age, were noted on a Face Sheet (Appendix L) as well as any visual or auditory deficits that may have interfered with testing. Each participant was given the following pre-test measures: modified Medical Health Screening Questionnaire, and Spielberger State Anxiety Scale. The Level of Effort Scale was given following all four test administrations. The Spielberger State Anxiety Scale was given pre- and posttest for test administrations one and four only.

To determine practice effect differences between the PASAT, ASPAT, and VSPAT, participants were tested across a seven week period, once every two weeks. Each participant was randomly assigned by the drawing of a number to one of the following three conditions: 1. PASAT with baseline administration and retest every two weeks, for four total administrations. 2. ASPAT given according to the same schedule. 3. VSPAT given according to the same schedule.

Testing

At the beginning of each test and retest the participant was read the standardized test instructions for the test condition they were assigned to, PASAT, ASPAT or VSPAT. (See Appendix E and F). They were then administered the test for the condition to which they had been assigned, PASAT, ASPAT, or VSPAT.

Before and after administration of tests one and four the participant was be asked to complete the Spielberger State Anxiety Scale. Pretest administration asked the participant to answer how they feel "right now". Posttest administration asked the participant to answer on the basis of their experience of the test (Spielberger, et al., 1983).

At the end of each test administration the participant was asked to self-characterize their level of effort on the test by completing a five point scale, 1 being no effort and 5 being maximum effort. The total length of time for each individual's inclusion in the experiment was seven weeks. After the final test administration they were debriefed (Appendix I).

Analysis

In order to make the comparisons specified on pages 13 and 14, the following analyses were conducted.

Comparisons 1 and 3 question if practice effects exist for each test, and, if so, are they different for each test? A split-plot ANOVA was

conducted to evaluate the results. To determine if practice effects exist, the total percent correct score for each of the four test administrations within each test were compared. The main effect for administration was evaluated. To determine if practice effects differ between the three tests, the percentage correct across the four repeated administrations was compared. In this case, the main effect for test was evaluated. A Tukey's HSD pairwise comparison was conducted when significant differences for main effects were found. The interaction, 3(test) X 4(administration), was also evaluated.

Comparison 2 asks if practice effects differ within each test for the four different presentation rates. Due to insufficient power, effects involving presentation rate were not evaluated. However, group means (+/-SD) were visually inspected and apparent patterns of practice effects were described.

Because of the lack of statistical analysis, these findings must be considered extremely tentative.

Comparisons 4 and 5 (see below) were also evaluated for all three tests using a split-plot ANOVA. Tukey's HSD pairwise comparisons were conducted when significant differences were found. The 3(test) X 4(anxiety ratings) interaction was also evaluated.

Comparison 4 questions if, within each test, there is a difference in anxiety level between pretest one and posttest one and between pretest four and posttest four as measured on the Spielberger State Anxiety Scale? The main effect for anxiety was evaluated.

Comparison 5 questions if the three tests differ in anxiety level response. The score for each test on the Spielberger State Anxiety Scale for all four administrations, pre- and posttest one and pre- and posttest four, were compared. The main effect for test was evaluated.

Comparison 6 asks if there is a correlation between anxiety level and test performance. A Pearson product-moment correlation between total percent correct and posttest anxiety level for administration one was computed.

Chapter Four

Results

Practice Effects

There was a significant main effect for administration, $F(3, 159) = 232.54$, $p < .0005$. This indicates that significant practice effects occurred for all three tests across the four administrations. A Tukey's HSD pairwise comparison was conducted. This analysis showed that for all three tests a significant increase in test performance, as measured by the total percent correct score, occurred between administrations one and two and between administrations two and three at the .05 alpha level. There were not significant differences between test administrations three and four for all three tests
(see Table 1).

There was also a main effect for test, $F(2, 53) = 18.33$, $p < .0005$. This indicates that participants performed at different levels depending on the test they were administered. A Tukey's HSD pairwise comparison indicates that those participants administered the PASAT obtained significantly lower total percent correct scores than those administered the VSPAT. There were no significant differences in level of performance between the PASAT and ASPAT or between the ASPAT and VSPAT (see Table 1 and Figure 1).

The interaction between 3(test) and 4(administration) was not significant. This indicates that there was no difference in the pattern of practice effects for the three tests across the four administrations. In other words, they all demonstrated similar practice effects (see Table 1 and Figure 1).

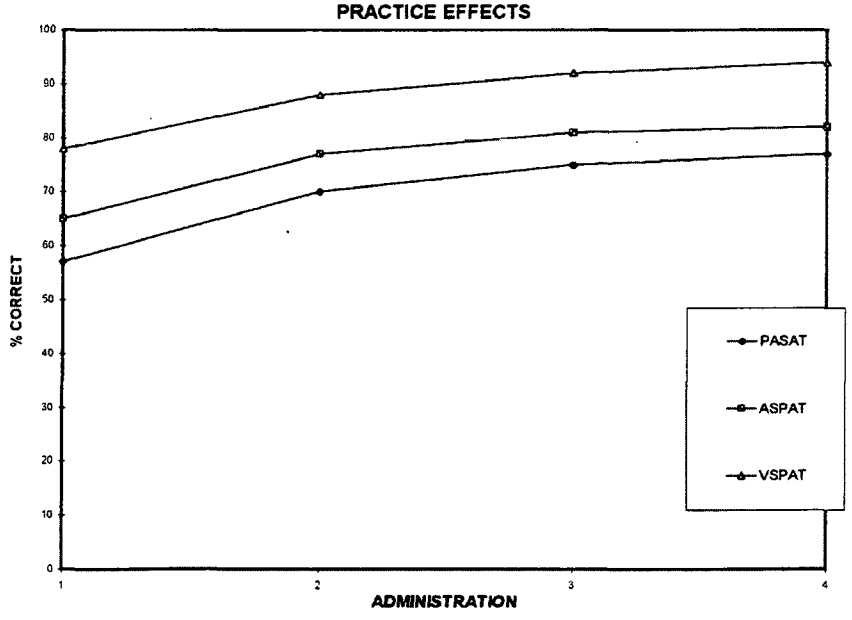
Table 1

Mean (+/- SD) Total Percent Correct on the PASAT, ASPAT, and VSPAT for each Administration

	ADMIN.1	ADMIN.2	ADMIN.3	ADMIN.4
PASAT (n = 18)	57.66 (13.95)[a]	70.13 (14.32)[b]	75.40 (12.61)[c]	75.60 (10.69)[c]
ASPAT (n = 17)	65.12 (11.26)[a]	77.25 (10.15)[b]	81.81 (9.36)[c]	81.25 (12.68)[c]
VSPAT (n = 21)	77.12 (11.42)[a]	87.75 (7.89)[b]	91.37 (7.56)[c]	93.62 (5.36)[c]

Note: Row means with different superscripts are significantly different, $p<.05$.

Figure One



Although there was insufficient power to statistically examine the practice effects at different presentation rates, (Comparison 2), it may be useful to view the means and standard deviations for the three tests over the four administrations in regard to presentation rate. As a very general statement, the pattern of practice effects seen within presentation rates is similar to that seen for the overall total correct score. Typically, there was a notable increase in performance for each test at the various presentation rates from administration one to administration two. From administration two to administration three and from administration three to administration four, the pattern of practice effects for each test at the different presentation rates was variable, with no entirely consistent pattern. However, there was a tendency for continued increases in performance at the faster rates of presentation, particularly for the later administration of the ASPAT and VSPAT. Again, it should be emphasized that this description must be considered extremely tentative (see Table 2).

Table 2

Percent Correct for the PASAT, ASPAT, and VSPAT for each Presentation Rate by Administration Mean (+/- SD)

PASAT (N=18)

Rate	Administration 1	Administration 2	Administration 3	Administration 4
2.4	72.00 (+/- 18.39)	86.61 (+/- 11.40)	89.00 (+/- 9.74)	93.06 (+/- 7.79)
2.0	63.50 (+/- 14.34)	78.72 (+/- 13.86)	81.56 (+/- 13.38)	84.11 (+/-10.89)
1.6	53.11 (+/- 13.17)	65.56 (+/- 15.56)	71.67 (+/- 13.94)	73.39 (+/-14.56)
1.2	41.06 (+/- 11.45)	47.56 (+/- 17.39)	57.44 (+/- 13.79)	56.56 (+/-16.06)

ASPAT (N=17)

Rate	Administration 1	Administration 2	Administration 3	Administration 4
2.5	81.29 (+/- 12.26)	94.65 (+/- 5.48)	95.94 (+/- 4.94)	95.76 (+/- 6.32)
2.0	73.53 (+/- 16.39)	85.76 (+/-10.62)	91.65 (+/- 8.45)	91.24 (+/- 9.96)
1.5	61.59 (+/- 14.79)	75.65 (+/-13.92)	82.00 (+/-15.98)	80.29 (+/-16.57)
1.0	42.76 (+/- 12.07)	52.88 (+/-12.81)	55.88 (+/-13.79)	59.06 (+/-15.78)

VSPAT (N=21)

Rate	Administration 1	Administration 2	Administration 3	Administration 4
2.5	93.48 (+/- 9.27)	97.52 (+/- 3.74)	99.29 (+/- 1.45)	99.00 (+/- 1.92)
2.0	88.05 (+/-11.25)	96.57 (+/- 4.23)	97.19 (+/- 5.80)	99.10 (+/- 1.48)
1.5	75.67 (+/-16.68)	89.19 (+/-11.94)	92.95 (+/- 7.98)	97.52 (+/- 4.76)
1.0	55.86 (+/-14.04)	70.14 (+/-17.14)	76.90 (+/-17.46)	82.48 (+/-17.27)

Anxiety Level

There was a main effect for administration (Spielberger anxiety rating administered pre- and posttest one and pre- and posttest four), $F(3, 159) = 57.51$, $p < .0005$. This indicates that significant differences in anxiety level response occurred across the four administrations. A Tukey's HSD pairwise comparison was conducted. There was no difference between the three groups

in the pretest anxiety levels at pretest one and pretest four indicating that participants entered the testing situation on both occasions with basically the same level of baseline anxiety. The analysis demonstrated

there was a significant increase in anxiety level for all three tests between pretest one and posttest one. There was also a significant increase in anxiety level between pretest four and posttest four for all three tests. In addition, there was a significant decrease in anxiety level between posttest one and posttest four for all three tests. There was no significant difference for the main effect of test

$F(2, 53) = .83$, $p = .444$. All three tests evoked similar changes in anxiety level as discussed above. However, there was an interaction effect for the Spielberger administration X test $F(6, 159) = 3.08$, $p < .007$. This indicates that although the tests were not significantly different, the anxiety response at different times of administration varied. (See Table 3 and Figure 2.)

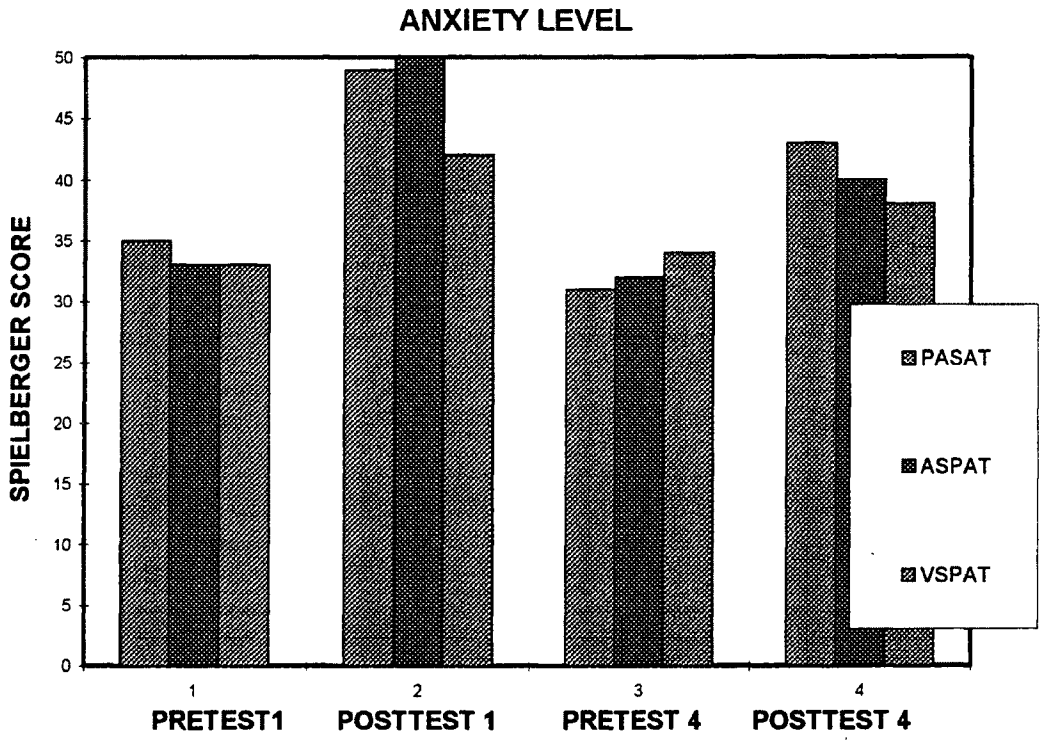
Table 3

Mean (+/- SD)Anxiety Level as Measured by the Spielberger State Anxiety Inventory

Test	N	Pre 1	Post 1	Pre 4	Post 4
PASAT	18	35.00(+/- 9.80)[a]	49.33(+/-12.98)[b]	31.11(+/- 7.49)[a]	42.94(+/-13.39)[c]
ASPAT	17	32.71(+/- 6.66)[a]	50.47(+/- 10.93)[b]	32.47(+/- 5.39)[a]	39.88(+/-10.02)[c]
VSPAT	21	32.52(+/- 8.44)[a]	41.86(+/- 11.92)[b]	33.81(+/- 8.00)[a]	37.76 (+/- 9.82)[c]

Note: Row means and column means with different superscripts are significantly different, $p<.05$.

Figure 2



Correlation of Anxiety and Test Performance

A Pearson's product-moment correlation was conducted to determine the correlation of test performance by anxiety level on the total percent correct for posttest administration one across all three tests. It indicated a significant negative correlation showing that as anxiety level increased, overall performance for all three tests decreased, r (54) = -.404, p =.002. This result can be viewed in several ways. First, it may be that anxiety interferes with performance such that participants who experienced greater anxiety during the test tended to score lower. On the

other hand, it may be that the experience of performing poorly may cause one to feel anxious which is subsequently reported at the posttest measurement. Therefore, those participants who score lower would have a greater anxiety response. It should be noted that these two possibilities are not mutually exclusive, and some combination of these two responses is possible.

Chapter Five

Discussion

The PASAT is a sensitive measure of information processing capacity frequently used in assessment of MTBI. Modified versions of the PASAT, the ASPAT and the VSPAT were developed to address certain problems found with the PASAT. Those shortcomings are its significant correlation to arithmetic ability (Weber, 1988; Bateman & Hall, 1997) and IQ (Kanter, 1984; Epperson & Cripe, 1985, as cited in Brittain et al., 1991), practice effects (Gronwall, 1977) and anxiety provoking qualities (Deary et al., 1994; Lezak, 1995).

Practice Effects

It was hypothesized that the ASPAT and VSPAT would show lower practice effects than the PASAT due to the reduced item format, simplified arithmetic and modified stimulus presentation rate. It is apparent from this research that the three tests of information processing capacity evaluated produce similar practice effects despite differences in presentation rate, difficulty of arithmetic, format length or the modality of presentation, i.e., auditory versus visual. The greatest practice effects occurred from the first administration to the second administration over a two week interval. Practice effects for all three tests

reached asymptote by the third administration. There were no significant differences in the pattern of practice effects between the three tests. Therefore, the modified format appears to have no significant impact on practice effects.

It was also hypothesized that a leveling off of performance scores would occur at an earlier administration for slower presentation rates than for faster presentation rates for all three tests within subjects. Although there was no analysis of the data due to insufficient power, inspection of the data suggests that, consistent with this hypothesis, there was a tendency for continued increases in performance at faster rates of presentation, especially for the ASPAT and VSPAT. However, this pattern of performance was not entirely consistent and results were somewhat variable between the tests and the various presentation rates. It should be noted that this trend must be considered extremely tentative. Future research with a sufficient sample size would be helpful to more clearly examine this issue.

Practice effects for the PASAT in past research have shown conflicting points of asymptote (Gronwall, 1977; Stuss, 1989; Puchkoff, 1997). One explanation which may account for this difference is the length of time between repeated testing. In some research, practice effects have been found to reach asymptote sooner when tests have been

administered at closer intervals. At one week intervals practice effects level off after the second test administration (Gronwall, 1977). In the present study, tests were given at two week intervals and practice effects leveled off after the third administration with a trend towards significance between the third and fourth test administration. In repeated testing of five test administrations over three months, Stuss et al., (1989) found practice effects continuing even after the fourth test administration with improvement into the fifth and final administration for two of the four presentation rates. It may be that administering the tests at close intervals allows the subject to gain maximum practice effects due to the increased familiarity with the test. Longer intervals may result in greater forgetting, causing more gradual practice effects such that asymptote is not reached until later administrations.

Counter to this assumption are the recent findings of Puchkoff, 1997. In Puchkoff's study, subjects were administered the PASAT three times over one week to inoculate for practice effects prior to the experiment. The subjects were then administered the PASAT three times within three hours during the experiment. This resulted in a total of six administrations of the PASAT within one week, with three in less then twenty-four hours. Unlike the previously documented practice effect findings on the PASAT, Puchkoff's subjects continued to improve their

scores through the fifth administration for two of three presentation rates and continued to increase into the sixth administration for one of the three presentation rates. This pattern of results may be due in part to the motivation and unique characteristics of subjects required for inclusion in Puchkoff's study and to the modified administration of the PASAT. The ten subjects were selected on their physical fitness to match the high level of physical performance required of wildland firefighters. Subjects volunteered to be tested on their information processing capabilities while undergoing physical endurance testing and to have blood drawn at intervals to test hydration. The PASAT's slowest presentation rate was omitted from the testing procedure which may also have affected the results.

An additional difference between these studies descibed above, was the population tested. In Gronwall's (1977) study postconcussion rehabilitation patients were tested. In Stuss (1989), TBI patients referred for neuropsychological assessment were tested. In a study by Puchkoff (1997) participants were selected on demanding physical fitness characteristics. In the study presented here, Psychology 100 students were tested to fulfill their course research participation credits. Differences in cognitive ability, normals versus head injured patients and motivation, compensation seeking versus noncompensation seeking

individuals, have been found to result in performance differences in neuropsychological testing (Cullum & Thompson, 1997).

In the present research, the ASPAT and VSPAT, at two week intervals of administration, appear to have the same pattern of practice effects as the PASAT. Although the pattern of practice effects were similar, levels of performance varied between the three tests. The PASAT appeared to be the most difficult for subjects, resulting in the lowest percent correct performance scores of the three tests. The ASPAT was moderately difficult. The VSPAT was least difficult and resulted in the highest performance scores. These results are similar to the findings of Bateman and Hall, 1996.

Anxiety

Previous research has shown the PASAT to increase anxiety (Deary et al., 1994). As Lezak stated, ". . . patients experience this sensitive test as very stressful: most persons -- whether cognitively intact or impaired - feel under great pressure and that they are failing, even when doing well." (p.373).

It was hypothesized that the ASPAT and VSPAT would display significantly lower anxiety levels than the PASAT due to the reduced item format, simplified arithmetic and modified stimulus presentation rate. This research did not entirely support this hypothesis. All three tests

increased anxiety significantly from pretest to posttest assessment during the first administration and the fourth administration. There was no significant difference in anxiety between the three tests on either posttest one or on posttest four. However, it may be clinically significant that the VSPAT produced lower scores on the Spielberger State Anxiety Scale at posttest one and at posttest four than either the PASAT or ASPAT. The VSPAT had a mean increase in anxiety rating from pretest one to posttest one of 9.34 points. The ASPAT mean increased 17.76 points and the PASAT mean increased 14.33 points. This suggests that a visually presented test of information processing capacity is less stressful for this group of participants then either of the aurally presented tests, the PASAT and ASPAT. The ASPAT had the greatest increase followed by the PASAT. On the fourth test administration, increases in anxiety from pretest to posttest were also significant, but the posttest results were significantly lower than on the posttest of the first administration. This indicates that with repeated testing, participants on all three tests, developed a tolerance for the anxiety evoking qualities of these information processing capacity tests. Taking the test the fourth time was less anxiety evoking than the first, although still significantly anxiety evoking compared to baseline levels. On the fourth test administration, the VSPAT again resulted in the lowest increase, 3.95 points, in anxiety

as measured by the Spielberger State Anxiety Inventory. The PASAT had an increase of 11.83 points and the ASPAT had an increase of 7.41 points (see Table 3, Figure 2).

This study measured anxiety level between test participants. Each participant was administered only one version of the test, the PASAT, ASPAT, or VSPAT, therefore preventing any comparison of the three tests by an individual. A future direction for research may be to evaluate participant's anxiety responses to all three tests. They may discern subtle differences between the three tests that would result in a range of anxiety responses untapped by this between subjects design. By administering the tests in counterbalanced order a within subject comparison could be analyzed.

Additionally, measuring Trait Anxiety as well as State Anxiety may allow for more fine grained analysis of the anxiety response to these tests. Batchelor, Harvey, and Bryant (1995) utilized both Spielberger State and Trait Anxiety Scales to investigate the influence of anxiety on performance by MTBI patients and controls on the Stroop Colour Word Test (Stroop, 1935), a measure of attention. Batchelor et al., 1995, found only State Anxiety influenced performance negatively on the Stroop, but they were also able to compare levels of Trait Anxiety at baseline. As

stated in the manual for administration of the Spielberger State-Trait Anxiety Scale, individuals with higher levels of Trait Anxiety also tend to exhibit higher level responses on the State Anxiety Scale to stressful situations. Knowledge of the magnitude of change for participants pre- and posttest may increase our understanding of the anxiety evoking effects of the PASAT, ASPAT, and VSPAT.

This research suggests that the VSPAT has qualities relevant to improved clinical use in that it appears to be less stressful for a nonclinical population of participants than the PASAT or ASPAT. This finding warrants further research in a population of MTBI patients as well as other clinical populations. As noted by previous researchers, stress has been found to lower performance scores in neuropsychological testing and to slow recovery in MTBI patients (Gronwall, 1977; Stuss et al., 1989). This study found an inverse correlation between anxiety and performance on three information processing capacity tests. If a nonclinical population's performance was adversely affected by the anxiety evoking nature of these tests, it may be suggested that a clinical population's performance would also, if not to a greater extent, be adversely affected.

In sum, if the VSPAT proves to be less stressful, is not significantly correlated with arithmetic ability, yet retains sensitivity to information

processing capacity, and has no more significant practice effects than the original PASAT, its utility in neuropsychological assessment of MTBI is worth further investigation.

Research on MTBI patients over the past decade has focused on refining assessment instruments to be sufficiently sensitive to the subtle effects of MTBI. The PASAT has proven to be an extremely sensitive measure of information processing capacity, a function often affected in MTBI. More recent research is focusing on the possibility that instruments such as the PASAT which are sensitive to MTBI sequelae may actually result in overdiagnosis of MTBI in the form of false-positive results (Cicerone, 1997). It is suggested that a wide variety of factors other then MTBI often result in the same symptomatology, such as pain, fatigue, depression, or secondary gain (Cicerone, 1997; Cullum & Thompson, 1997). Future research may be needed to study not only the sensitivity of the PASAT and the two modified versions, the ASPAT and VSPAT, but also the specificity of those findings. Research on a clinical population of MTBI patients, other neuropsychology patients, psychiatric patients and chronic pain patients, as well as other medical populations, may prove useful in refining these assessment instruments.

References

Batchelor, J., Harvey, A. G., & Bryant, R. A. (1995). Stroop colour word test as a measure of attentional deficit following mild head injury. The Clinical Neuropsychologist, 9(2),180-186.

Bateman, G. D., & Hall, S. (1996). Development of a neuropsychological assessment device: The visual sequential paced arithmetic test (VSPAT). Journal of the International Neuropsychological Society, 2, 4.

Bateman, G. D., & Hall, S. (1997). The contribution of arithmetic ability to performance on three tests of information processing speed: The PASAT, VSPAT and ASPAT. Journal of the International Neuropsychological Society, in press.

Beck, A. T., & Steer, R. A. (1987). Beck Depression Inventory Manual. San Antonio, TX: Psychological Corporation.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. Archives of General Psychiatry, 4, 561-571.

Binder, L. M. (1986). Persisting symptoms after mild head injury: A review of post-concussive syndrome. Journal of Clinical and Experimental Neuropsychology, 8, 323-346.

Brittain, J. L., La Marche, J. A., Reeder, K. P., Roth, D. L., & Boll, T. J. (1991). Effects of age and IQ on Paced Auditory Serial Addition Task (PASAT) performance. Clinical Neuropsychologist, 5, 163-175.

Cicerone, K. D. (1997). Clinical sensitivity of four measures of attention to mild traumatic brain injury. The Clinical Neuropsychologist, 11(3), 266-272.

Cullum, C. M., & Thompson, L. L. (1997). Neuropsychological diagnosis and outcome in mild traumatic brain injury. Applied Neuropsychology, 4(1), 6-15.

Deary, I. J., Langan, S. J., Hepburn, D. A., & Frier, B. M. (1991). Which abilities does the PASAT test? Personality and Individual Differences, 12(10),
983-987.

Deary, I. J., Ebmeier, K. P., MacLeod, K. M., Dougall, N., Hepburn, D. A., Frier, B. M., and Goodwin, G. M. (1994). PASAT performance and the pattern of uptake of 99m Tc-exametazime in brain estimated with single photon emission tomography. Biological Psychology, 3, 1-18.

Dodrill, C. B., & Troupin, A. S. (1975). Effects of repeated administrations of a comprehensive neuropsychological battery among chronic epileptics. The Journal of Nervous and Mental Disease, 161(3), 185-190.

Egan, V. (1988). PASAT: Observed correlations with IQ. Personality and Individual Differences, 9, 179-180.

Epperson, R. C., & Cripe, L. (1985). Relationship of PASAT performance and IQ. Unpublished manuscript.

Gronwall, D. M. A. (1976b). Performance changes during recovery from closed head injury. Proceedings of the Australian Association of Neurologists. 13, 143-147.

Gronwall, D. M. A. (1977). Paced Auditory Serial-Addition Task: A measure of recovery from concussion. Perceptual and Motor Skills, 44, 367-373.

Gronwall, D. M. A. (1989). Cumulative and persisting effects of concussion on attention and cognition. In H. S. Levin, H. M. Eisenberg, and A. L. Benton (Eds.), Mild Head Injury (pp. 153-162.) New York: Oxford University Press.

Gronwall, D. M. A. (1991). Minor head injury. Neuropsychology, 5, 253-265.

Gronwall, D. M. A., & Sampson, H. (1974). The Psychological Effects of Concussion. New York: Oxford University Press.

Kanter, G. (1984). PASAT performance and intelligence: A relationship? International Journal of Clinical Neuropsychology, 6, 84.

Levin, H. S., Eisenberg, H. M. & Benton, A. L. (1989). Mild Head Injury. New York: Oxford Press.

Lezak, M. D. (1983). Neuropsychological Assessment. New York: Oxford University Press.

Lezak, M. D. (1995). Neuropsychological Assessment. New York: Oxford University Press.

Matarazzo, J. D., Carmody, T. P., & Jacobs, L. D., (1980). Test-retest reliability and stability of the WAIS: A literature review of implications for clinical practice. Journal of Clinical Neuropsychology, 2, 89-105.

McCaffrey, R. J., Ortega, A., Orsillo, S. M., Nelles, W. B., & Haase, R. F. (1992). Practice effects in repeated neuropsychological assessments. The Clinical Neuropsychologist, 6(1), 32-42.

McCaffrey, R. J., & Westervelt, H. J. (1995). Issues associated with repeated neuropsychological assessments. Neuropsychology Review, 5(3), 203-221.

Puchkoff, J. E. (1997). The Effects of hydration status and blood glucose on mental performance during extended exercise in the heat. Unpublished master's thesis, University of Montana, Missoula.

Putnam, S. H., Adams, K. M., & Schneider, A. M. (1992). One-day test-retest reliability of neuropsychological tests in a personal injury case. Psychological Assessment, 4(3), 312-316. Roman, D. D., Edwall, G. E., Buchanan, R. J., & Patton, J. H. (1991). Extended norms for the paced auditory serial addition task. The Clinical Neuropsychologist, 5(1), 33-40.

Rutherford, W. H. (1989). Postconcussion symptoms: Relationship to acute neurological indices, individual differences, and circumstances of injury. In H. S. Levin, H. M. Eisenberg, and A. L. Benton (Eds.), Mild Head Injury (pp. 217-228). New York: Oxford University Press.

Sampson, H. (1956). Pacing and performance on a serial addition task.

Canadian Journal of Psychology, 10, 219-225.

Sampson, H. (1958a). Stimulus duration and paced performance. Canadian Journal of Psychology, 12, 7-12.

Sampson, H. (1958b). Serial addition as a function of stimulus duration and pacing. Canadian Journal of Psychology, 12, 179-183.

Shatz, M. W. (1981). WAIS practice effects in clinical neuropsychology. Journal of Clinical Neuropsychology, 3(2), 171-179.

Stroop, J. R. (1935). Studies in interference in serial verbal reactions. Journal of Experimental Psychology, 9, 371-377.

Stuss, D. T., Stethem, L. L., Hugenholtz, H., and Richard, M. T. (1989). Traumatic Brain Injury: A Comparison of Three Clinical Tests, and Analysis of Recovery. The Clinical Neuropsychologist, 3(2), 145-156.

Van Zomeren, A. H., Brouwer, W. H., & Deelman, B. G. (1984). Attentional deficits: The riddles of selectivity, speed, and alertness. In N. Brooks (Ed.), Closed Head Injury: Psychological, Social, and Family Consequences (pp. 74 -107). New York: Oxford University Press.

Wechsler, D. (1981). WAIS-R manual: Wechsler Adult Intelligence Scale-Revised. New York: Psychological Corporation.

Wechsler, D. (1987). WMS-R manual: Wechsler Memory Scale-Revised. New York: Psychological Corporation.

Wrightson, P. (1989). Management of disability and rehabilitation services after mild head injury. In H. S. Levin, H. M. Eisenberg, and A. L. Benton (Eds.), Mild Head Injury (pp. 245-256). New York: Oxford University Press.

Appendix A

ALL INFORMATION YOU PROVIDE WILL BE HELD STRICTLY CONFIDENTIAL

Subject #_____ **Please fill out this medical history questionnaire. When finished, place this form back into the envelope and read the enclosed instructions.**

Neurological History	Yes	No
1. Have you ever been evaluated or treated by a neurologist or neurosurgeon? If yes, please list condition _____	___	___
2. Have you ever had an injury to the head in which you received a concussion? If yes, how many concussions have you had?_____	___	___
3. Have you ever had an injury to your head that resulted in unconsciousness? If yes, how many times ?_____ For each instance, how long were you unconscious?_____	___	___
4. Have you ever had any seizures?	___	___
Psychiatric History		
1. Have you ever been diagnosed with depression or any other psychiatric condition? If yes, please list diagnosis:_____	___	___
2. Have you ever been hospitalized for mental health treatment? If yes, please list diagnosis:_____	___	___
Drug History		
1. Are you currently taking any of the following types of medication: antidepressants, anticonvulsants (i.e., seizure medication), or tranquilizers? If yes, for how long?_____	___	___
2. Have you used hallucinogens or opiates more than 50 times? (e.g., LSD, Mescaline, Peyote, STP, DMT, Psilocybin (mushrooms), Heroin, Morphine, Opium)	___	___
3. Have you used marijuana or hashish in the past 24 hours?	___	___
Have you used marijuana or hashish more than 4 time per week over at least a year?	___	___
4. Have you used cocaine, crack, or ecstasy more than 50 times?	___	___
5. Have you used inhalants (e.g., glue, gasoline) more than 10 times?	___	___
6. Have you used stimulants (e.g., amphetamine) more than 20 time per year?	___	___
7. Have you used antianxiety agents or sleeping medication in the past 24 hours?	___	___
8. Have you used pain medication in the past 24 hours?	___	___
9. Have you ever been treated for alcoholism?	___	___
10. Are you taking any medications not listed above at this time? If yes, please list: _____	___	___

Appendix B

Self-characterization of Level of Effort

How hard did you try to perform at your absolute best during the last test?

Circle the answer that best describes your performance.

1	2	3	4	5
not very hard		moderately		very hard

(Following first test only) Have you ever taken a test like this before? If so, when and for what reason? What was it like?

Appendix C

Informed Consent Form

I, _____, agree to participate in the experiment "Differences
(print name) Among the PASAT, ASPAT, and VSPAT".

I understand that I will be filling out paper and pencil forms, interacting with a computer or listening to an audiotape. I further understand that the physical, psychological, emotional, and social risks involved in this experiment are minimal. However, many participants often feel as if they are failing when they are actually performing well. The screening questionnaire will ask neuropsychological, psychological and substance use questions, the answers to which may exclude some participants from the study. The study will require up to one half hour of testing, every other week, over a seven week period, for a total of four half hour test periods.

I understand that "Differences Among the PASAT, ASPAT, and VSPAT" does not involve deception. I understand that I will be debriefed and the purpose of the experiment explained to me after the conclusion of the experiment.

I understand that my participation in this experiment is voluntary and that I may withdraw from the experiment at any time. The benefits to myself of participation include earning from four to six experimental credit units to fulfill the experimental requirement for Introductory Psychology (Psych 100) at the University of Montana and also enhancing my knowledge of the experimental method of scientific investigation as it applies to the study and practice of neuropsychology. Potential benefits to society include an enhanced ability to assess cognitive information processing capability and to clinically evaluate potential subtle neuropsychological deficits (e.g., those caused by mild traumatic brain injuries, depression, early Alzheimer's disease, mild stroke, etc.) with the three assessment devices being tested.

I hereby confirm that I do not have any knowledge about this experiment other then what has been described to me by the experimenters. I understand that unauthorized information about the methods and purposes of this study may adversely affect the results. Because of this fact, I agree not to discuss this experiment with other potential participants or with members of the general public. I understand that if I have any questions or concerns regarding this experiment that I can contact the project supervisor, Dr. Stuart Hall or the project director, Jeannine Mielke, through the Department of Psychology, University of Montana, at phone number 406-243-4521 for further information.

In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title 2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims Representative or Legal Counsel.

(participant signature)	(date)
(experimenter)	(date)

Appendix D

ASPAT Directions

You are about to take a test designed to evaluate your attention, concentration, and ability to process information. It is very much like an arithmetic test. You will hear a series of single-digit numbers on the audiocassette. Your task is to add together pairs of the numbers so that each number is added only to the one immediately preceding it. Do not keep a running total by adding the numbers that you hear to your previous answer. You will add the first number to the second, the second to the third, the third to the fourth, etc. Give me your answers out loud. For example, if you hear the number 6 followed by a 2, your answer would be "8". If the next number were 3, you would add it to the 2 and answer "5". If the next number were 7, you would add it to the 3 and answer "10".

The numbers come at a relatively fast pace. This task is hard and you are not expected to get all of the answers correct or even be able to respond to all of the pairs of digits. If you lose track of what you are doing, just wait until you hear two more numbers, add them together, and keep on going. Do your best to try to keep going as long as you can without stopping. If you have to stop, try to pick up the task again as quickly as you can.

First you will hear a list of practice numbers, and then we will start the main part of the task. During the main task, there will be four separate strings of digits presented, each string at a slightly faster pace than the previous one. Do you have any questions? Are you ready? (See right hand column on answer sheet.)

(Participants should be able to get all of one of the practice sequence correct. To be certain that they understand the task, repeat the practice sequence until the participant meets this criteria of performance, a maximum of 4 times. Then say:)

Now that you have had time to practice and know what to do, let's start the main part of the task. (Run the first sequence of digits.)

(After each sequence in the main task, say the following:) That was the end of the sequence of digits. We will take a few seconds before the next sequence. Remember, because of the difficulty of the task, you are not expected to be able to get all of the answers correct. Try to keep going as long as you can. If you lose track of what you are doing and have to stop, do your best to try to pick up the tack again as quickly as you can.

Appendix E

VSPAT Instructions

You are about to take a test designed to evaluate your attention, concentration, and ability to process information. It is very much like an arithmetic test. You will see a series of single-digit numbers on the computer screen. Your task is to add together pairs of the numbers so that each number is added only to the one immediately preceding it. Do not keep a running total by adding the numbers that you see to your previous answer. You will add the first number to the second, the second to the third, the third to the fourth, etc. Give me your answers out loud. For example, if you see the number 6 followed by a 2, your answer would be "8". If the next number were 3, you would add it to the 2 and answer "5". If the next number were 7, you would add it to the 3 and answer "10".

The numbers come at a relatively fast pace. This task is hard and you are not expected to get all of the answers correct or even be able to respond to all of the pairs of digits. If you lose track of what you are doing, just wait until you see two more numbers, add them together, and keep on going. Do your best to try to keep going as long as you can without stopping. If you have to stop, try to pick up the task again as quickly as you can.

First you will see a list of practice numbers, and then we will start the main part of the task. During the main task, there will be four separate strings of digits presented, each string at a slightly faster pace than the previous one. Do you have any questions? Are you ready? (See right hand column on answer sheet.)

(Participants should be able to get all of one of the practice sequence correct. To be certain that they understand the task, repeat the practice sequence until the participant meets this criteria of performance, a maximum of 4 times. Then say:)

Now that you have had time to practice and know what to do, let's start the main part of the task. (Run the first sequence of digits.)

(After each sequence in the main task, say the following:) That was the end of the sequence of digits. We will take a few seconds before the next sequence. Remember, because of the difficulty of the task, you are not expected to be able to get all of the answers correct. Try to keep going as long as you can. If you lose track of what you are doing and have to stop, do your best to try to pick up the tack again as quickly as you can.

Appendix F

Instructions for PASAT administration:

You will hear a list of single numbers read one after the other. I want you to add the numbers in pairs and give your answer aloud. Add each number to the one just before it, not to your answer. Add the second number to the first, the third to the second, and so on.

They will then be given a written demonstration using the following example until the participant understands what to do:

6	2	5	1	3	9	4	7	2	8
	(8)	(7)	(6)	(4)	(12)	(13)	(11)	(9)	(10)

They will then be given a practice trial. (10 Item) (Record response)

3	2	4	6	1	3	5	7	2	9
	(5)	(6)	(10)	(7)	(4)	(8)	(12)	(9)	(11)

After this trial they will be told:

> Now we will try the first trial. This first one is just as fast as the practice part you have just done, but it is a lot longer, six times as long. Don't worry if you make a mistake or leave some out. I want to see not only how long you can keep going without stopping, but also how quickly you can pick up again if you do stop.

Approximately 30 second interval between trials.

*Discontinuation rules:

1. Must be able to do written example
2. Must be able to get 20 correct on 2.0-second trial

Appendix G

ASPAT/VSPAT Scoring Form

6	2.5	2.0	1.5	1.0
1: 7				
7: 8				
2: 9				
3: 5				
1: 4				
5: 6				
3: 8				
4: 7				
5: 9				
1: 6				
2: 3				
5: 7				
2: 7				
6: 8				
4:10				
5: 9				
3: 8				
2: 5				
6: 8				
1: 7				

Errors: 2.5 _____
2.0 _____
1.5 _____
1.0 _____
Total _____

	2.5	2.0	1.5	1.0
5: 6				
4: 9				
6:10				
1: 7				
8: 9				
2:10				
6: 8				
2: 8				
3: 5				
5: 8				
1: 6				
4: 5				
5: 9				
1: 6				
4: 5				
2: 6				
6: 8				
2: 8				
8:10				
2:10				

Blocking: 2.5 _____
2.0 _____
1.5 _____
1.0 _____
Total _____

9	2.5
1:10	
6: 7	
2: 8	
8:10	
2:10	
5: 7	
4: 9	
2: 6	
6: 8	
3: 9	

9	2.5
1:10	
6: 7	
2: 8	
8:10	
2:10	
5: 7	
4: 9	
2: 6	
6: 8	
3: 9	

Arithmetic: 2.5 _____
2.0 _____
1.5 _____
1.0 _____
Total _____

Appendix H

Introduction and Protocol for Practice Effects and Anxiety Level Measurement Experiment

"This experiment is a study designed to evaluate a neuropsychological assessment device. It is an evaluation of a person's ability to concentrate, pay attention, and rapidly process information. After we go over the Informed Consent form, you will fill out a series of short paper and pencil tests. You will then be given a short arithmetic test, after which you will fill out two more short forms. You will be asked to come back every two weeks to take the test for a total of four administrations. After the final test, I will answer any questions regarding the test you may have. Do you have any questions?"

"Please review and sign the Informed Consent form."

Record the participant's name, section number and Psychology 100 instructor's name.

Record the participant's date of birth, gender, education level, and visual and auditory acuity.

Administer the following pre-test instruments:

Medical Health Screening Questionnaire
Spielberger State Anxiety Scale Questionnaire

Run the participant through either the PASAT, ASPAT, or VSPAT as randomly assigned.

Have the participant fill out the following:

Spielberger State Anxiety Scale Questionnaire
Level of Effort Self-characterization

Inform the participant of the retest date. Write it down for them to take with them.

Inform them that you will call before the retest date to confirm.
At the end of the last retest, debrief the participant.

Appendix I

An extensive debriefing will not be conducted due to the obvious nature of the experiment. Participants will be informed that the assessment instrument they were tested on was one of three neuropsychological tests under review comparing auditory versus visual presentation. They will be informed of the necessity of administering the pre- and post-test stimulus materials. Additionally, they will be informed that most people who take this test have a sense of failure in performance and that this is expected. They will be asked to keep the procedures and purpose of the study confidential to avoid contaminating the results. They will be thanked, awarded their class credit points and dismissed.

"Thank you for your consistent cooperation in participating in this study. You have taken one of three neuropsychological tests we are reviewing. Your feelings regarding the test situation were evaluated with the pre- and posttest instruments we gave you on your first and last tests. The test itself was evaluated based on your performance over the four trials. This is often a difficult and stressful test. We appreciate your help in learning more about the three tests under evaluation."

For further information regarding this test, refer the student to Jeannine Mielke 542-8835.

Appendix J

PASAT Scoring Form

Patient ID# ___-___ ___ ___ Date ___ ___/___ ___/___ ___

2	2.4	2.0	1.6	1.2		2.4	2.0	1.6	1.2		2.4	2.0	1.6	1.2
7 (9)					9 (11)					2 (8)				
3 (10)					7 (16)					7 (9)				
4 (7)					6 (13)					5 (12)				
8 (12)					5 (11)					9 (14)				
1 (9)					8 (13)					2 (11)				
5 (6)					1 (9)					3 (5)				
6 (11)					4 (5)					9 (12)				
9 (15)					1 (5)					7 (16)				
1 (10)					2 (3)					4 (11)				
3 (4)					6 (8)					5 (9)				
6 (9)					3 (9)					7 (12)				
4 (10)					7 (10)					6 (13)				
3 (7)					5 (12)					8 (14)				
2 (5)					8 (13)					1 (9)				
7 (9)					3 (11)					3 (4)				
8 (15)					9 (12)					1 (4)				
5 (13)					1 (10)					9 (10)				
9 (14)					4 (5)					2 (11)				
4 (13)					8 (12)					5 (7)				
2 (6)					6 (14)					6 (11)				

	Total correct	Time/response
2.4 sec pacing	_____	_____
2.0 sec pacing	_____	_____
1.6 sec pacing	_____	_____
1.2 sec pacing	_____	_____
Total time		_____

Mean time _____

Appendix K

Spielberger State Anxiety Scale

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate value to the right of the statement to indicate how you feel *right now*, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

STAIS-AD Test Form Y

Appendix L

Face Sheet

Date: _____

#_____

Name: _____ Phone #:_____

Section #: _____ Instructor:_____

Date of Birth: _____ Education Level:_____

_____

(To be filled out by the experimenter)

1. PASAT/ASPAT: Is the volume level loud enough for you to clearly hear the numbers?
Yes _____ No _____
2. VSPAT: Can you see the numbers clearly?
Yes _____ No _____

Date and time of scheduled tests:

Test 1_____ Test 2 _____ Test 3 _____ Test 4 _____

Time_____Experimenter_____

I understand that it is important to the research project that all four tests be attended as scheduled.

Signature of participant:_____

Appendix M

Date and time of scheduled tests:

Test 1_________ Test 2 _________ Test 3 _________ Test 4 _________

Time ____________________

Experimenter ___________________________________

If you are unable to attend any of the scheduled tests, please call

Jeannine Mielke at 542-8835 to advise of cancellation and to reschedule.

Date and time of scheduled tests:

Test 1_________ Test 2 _________ Test 3 _________ Test 4 _________

Time ____________________

Experimenter ___________________________________

If you are unable to attend any of the scheduled tests, please call

Jeannine Mielke at 542-8835 to advise of cancellation and to reschedule.

Date and time of scheduled tests:

Test 1_________ Test 2 _________ Test 3 _________ Test 4 _________

Time ____________________

Experimenter ___________________________________

If you are unable to attend any of the scheduled tests, please call

Jeannine Mielke at 542-8835 to advise of cancellation and to reschedule.

Appendix N

Time Line

Date:

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Face Sheet	No testing	PASAT, ASPAT or VSPAT	No testing	PASAT, ASPAT or VSPAT	No testing	Spielberger State Anxiety Scale
Modified Medical Health Screening Questionnaire		Level of Effort Scale		Level of Effort Scale		
Consent Form						PASAT, ASPAT or VSPAT
Spielberger State Anxiety Scale						Spielberger State Anxiety Scale
PASAT, ASPAT of or VSPAT						Level Effort Scale
Spielberger State Anxiety Scale						
Debriefing						
Level of Effort Scale						

Appendix O

With over 2 million serious head injuries and as many as 750,000 mild Traumatic Brain Injuries (TBI) incurred each year (Lezak, 1995), it's not surprising that neuropsychologists have focused much of their attention on the assessment and evaluation of TBI. Additionally, these figures don't begin to estimate the many mild head injuries which go undiagnosed due to the lower severity of the trauma, failure to seek medical treatment or late onset of distressing symptoms.

Traumatic Brain Injury

Brain injuries can be divided into two distinct categories, open head injuries and closed head injuries. Open head injuries are those injuries which involve the penetration of the brain by a foreign object, such as a bullet, missile or flying debris. These injuries tend to result in concentrated tissue damage following the path of the foreign object (Lezak, 1995). After the removal of the object and damaged tissue, the wound usually produces a localized and focal deficit. More generalized damage may also be caused by the pressure and shock waves accompanying the penetration (Lezak, 1995). These injuries often produce specific behavioral deficits, dependent upon the region of the brain damage. Additionally, these injuries may produce global impairments associated with more generalized injury, i. e., deficits in

memory function, attention and concentration, general mental slowing and reduced ability to deal with life's everyday demands (Lezak, 1995).

Closed head injuries typically result in two stages of brain injury; primary injury which occurs at the time of impact and secondary injury which consists of the physiological effects set into motion by the primary injury (Lezak, 1995). The static injury causes one of the most common patterns of primary injury. It is caused by the force of impact from a blow to the head on a relatively still victim (Lezak, 1995). These injuries may result in both coup (the point at which the impact hits the head) lesions and contrecoup (the area of the brain opposite to the point of impact) lesions. This is due to the rebounding of the brain on its flexible stem in a liquid medium within the skull casing (Lezak, 1995). These lesions account for the specific and localized behavioral changes that accompany closed head injuries.

Another common type of primary injury, caused by motor vehicle accidents or a fall, results in a closed head injury which involves "...rotational acceleration of the brain within the bony structure of the skull" (Lezak, 1995, p.177). This is accompanied by rapid acceleration/deceleration. This action causes shearing effects and microscopic lesions throughout the brain (Lezak, 1995). If the impact is

strong enough it may result in fracture of the skull increasing the chance of infection and further tissue damage (Lezak, 1983).

Secondary injury involves the swelling of the brain within its solid, inflexible casing. The swelling is caused by hemorrhages or edema resulting from the primary injury to the brain. Hemorrhages can often result in a hematoma, a rapidly growing mass of blood which pushes against the softer brain tissue. Edema is the collection of fluid in and around damaged tissue. Both of these conditions result in additional tissue damage as they expand, compressing air and liquid filled spaces as well as brain tissue.

A subdivision of closed head injury is mild traumatic brain injury, MTBI. MTBI has been variously defined as an injury resulting in a posttraumatic amnesia of less then one hour, a Glasgow Coma Scale score of between 13 and 15, a hospital stay of less than three days, no hospital stay, a change in or loss of consciousness for less than two minutes or a combination of these criteria (Gronwall, 1991). Reitan (1994) prefers to use the definition of MTBI put forth by Rimel, Giordani, Barth et al. (1981) as a head blow causing a loss of consciousness of twenty minutes or less, a Glasgow Coma Scale score on hospital admission of 13 to 15, and a hospitalization of 48 hours or less, because of the general adoption of these criteria by other researchers.

In 1987 Rutherford defined MTBI as "an acceleration/deceleration injury to the head almost always associated with a period of amnesia, and followed by a characteristic group of symptoms such as headache, poor memory, and vertigo". In some cases, no loss of consciousness occurs, but rather an alteration of consciousness as in when a person is dazed or confused. No structural damage of either the brain or the skull is detectable (Binder, 1986). With the use of magnetic resonance imaging (MRI), physical evidence of brain damage has been found in some cases of MTBI (Gronwall, 1991). Damage may occur at the site of impact or coup, contrecoup, as diffuse tissue damage throughout the brain, or damage to the brain stem and its related structures (Gronwall & Samson, 1974; Van Zomeren, Brouwer, & Deelman, 1984).

The early symptoms of MTBI include confusion, disorientation, blurred vision, headache, dizziness, vomiting, nausea, drowsiness, retrograde amnesia and post-traumatic amnesia of various durations (Rutherford, 1989, Gronwall, 1991). Additional symptoms which may occur include momentary loss of consciousness, respiratory problems, mild ataxia, irritability, problems with concentration and memory, sensitivity to light and noise, feelings of depersonalization and derealization, lack of insight into one's condition, fatigue, malaise and

more sleep required then usual (Gronwall, 1976b, 1977, 1991; Wrightson, 1989; Reitan, 1994).

Most of the symptoms of MTBI resolve within the first three months, with post-traumatic amnesia usually ending within 24 hours of injury (Lezak, 1995). However, for some patients the symptoms can continue indefinitely, reported in research as long as fifteen years post concussion (Gronwall, 1991, p. 259). Particularly vulnerable are those who have suffered multiple TBI's. It has been found that multiple TBI's result in increased impairment, longer recovery times,and a decrease in information processing. Other factors affecting recovery rates are age, substance use, life stressors and psychological make up of the individual (Gronwall, 1989, 1991).

Assessment of Mild Traumatic Brain Injury

Given the difficulty in defining MTBI, it is not surprising that many different assessment tools have been employed in its diagnosis. Among these are general intelligence tests, such as the Wechsler Adult Intelligence Scale Revised (WAIS-R; Wechsler, 1981) and neuropsychological test batteries such as the Halstead-Reitan battery (Reitan, 1994). Tests of memory, attention and concentration have been employed, such as portions of the WAIS-R, specifically reverse Digit Span, and Digit Symbol (Gronwall, 1991) and the Wechsler Memory

Scale-Revised (WMS-Ṙ; Wechsler, 1987). To address information processing ability deficits, researchers and clinicians have used the Brown-Peterson test of auditory short-term memory (CCC), the Stroop Color and Word Test (Stroop, 1935), the Trail Making Test and the Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977). These tests have all been used to assess various aspects of MTBI.

The PASAT (Sampson, 1956) has proven to obtain significant results in differentiating between severe TBI and MTBI, as confirmed by the growing body of normative validation data on this subject (Gronwall, 1991). Additional research on the PASAT has shown consistent utility in MTBI assessment of attention and concentration and overall processing capabilities (Lezak, 1995; Deary, Langan, Hepburn & Frier, 1991). However, in a study by Stuss et al., in 1989, conflicting results were found regarding the ability of the PASAT to differentiate mild head injury subjects from controls. The PASAT was found to be sufficiently sensitive to differentiate mild head injury subjects from controls, but not at levels of significance. This may have been due to the criteria for inclusion in the mild head injury group, variability of symptoms, time since injury of persistent symptoms during repeated measures evaluation or inadequate statistical power due to the small sample.

PASAT

The PASAT (Gronwall & Sampson 1974; Gronwall, 1977; Gronwall & Wrightson 1974, 1978, 1981) was a modification of an earlier test, developed by Sampson (1956, 1958a, 1958b), the Visual Paced Serial Addition Task (VPSAT). The VPSAT was developed for use in testing the effects of duration and pace on stimulus response performance. The PASAT was developed to assess the effects of MTBI, specifically as a test of processing speed and capacity, memory, concentration and attention. Gronwall and her associates used the PASAT as a means of tracking the progress of MTBI patients within a clinical setting. It continues to be used as one measure of determining patient readiness for return to work. Its use has been extended to tracking the progression of brain lesions as well. The PASAT measures processing speed and capacity, memory, concentration and attention through the use of single digit numbers presented sequentially to be added in pairs. While the PASAT has proven very useful in assessing MTBI, it is not without its shortcomings. Evidence of practice effects (Sampson, 1961; Stuss et al., 1987), increased levels of anxiety during testing and significant correlations to IQ (Kanter 1984; Epperson & Cripe, 1985, as cited in Brittain et al., 1991) and arithmetic ability (Weber, 1988; Bateman & Hall, 1997) have been reported.

Studies linking performance on the PASAT to arithmetic ability highlight another potential problem. Gronwall and Sampson (1974) indicate that there is a low correlation, r=.24, of performance on the PASAT and arithmetic ability (Sampson, 1954, cited in Gronwall and Sampson, 1974). However, more recent studies by Weber (1988) and by Bateman and Hall (in press) report correlations between performance on the PASAT and arithmetic ability. In two studies by Weber, performance on the PASAT was found to highly correlate (r=.70 and .69 respectively, $p<.05$) with a self-developed "Adding Test". However, this adding test lacks the validity and reliability necessary to make further conclusions about arithmetic performance and the PASAT. Of more utility is the study by Bateman and Hall (in press) in which the authors compared performance on the PASAT, as well as two modified versions of the PASAT, the ASPAT and the VSPAT, with reliable and validated measures of arithmetic performance, the Arithmetic subtest of the WAIS-R, the Calculation subtest of the Woodcock-Johnson Psycho-Educational Battery-Revised (WJ-R), the Graded Difficulty Arithmetic Test (GDA), and a math score from the American College Test (ACT). Their research on university students demonstrated that a substantial number of the scores on the PASAT are significantly correlated with various measures of arithmetic ability. In fact, 16 of 20 correlations calculated were

significant when evaluated at the assigned alpha level ($p<.002$, Bonferroni correction; Bateman & Hall, in press). Thess high correlations may indicate that arithmetic ability is detracting from the purpose of the test which is to assess processing capacity, attention and concentration. By contrast, none of the arithmetic scores were significantly correlated with performance on either the ASPAT or the VSPAT at the $p<.002$ level. Thus, scores on the latter two tests appear to be uncontaminated with arithmetic ability.

Results of studies addressing the correlation between performance on the PASAT and IQ have been more variable. Egan (1988), Brittain, LaMarche, Reeder, Roth and Boll (1991) found significant correlation between PASAT scores and general IQ. In a 1991 study by Deary, Langan, Hepburn and Frier, the PASAT was found to be highly correlated with subjects' WAIS-R Full scale IQ scores, Verbal IQ, Performance IQ and Freedom From Distractibility scores, as well as all subtest scores. In an earlier study, Kanter, 1984 also found a "robust relationship" between PASAT performance and WAIS scores. The highest correlation of PASAT performance in this study was with Performance IQ, specifically the Digit Span subtest. Epperson and Cripe, 1985, found subjects with higher IQ scores consistently performed better on the PASAT than those subjects with lower IQ scores. These findings are in direct contrast to the findings

of Gronwall and Wrightson (1981), who found that the PASAT was "not significantly correlated with either general intelligence or arithmetic ability".

Practice Effects

In addition to the difficulties inherent in testing the subtle effects of mild TBI is the confounding problem of practice effects. Practice effects elevate scores artificially over subsequent testings, due to familiarity with the instrument, instead of as a result of the measures functioning as an objective index of the characteristic in question. This matter is germane to a variety of assessment situations.

It is apparent that the role of practice effects arising from repeated administrations of neuropsychological tests is important due to a variety of reasons. There may be the need for repeat testing to monitor the progression of a disease, to evaluate therapeutic efficacy of a drug or rehabilitation training program, or because of the demand for second opinions as litigation increases (Lezak, 1995). In litigation cases, as clinical psychologists present themselves to the courts as expert witnesses, the importance of estimating practice effects from previous test exposure has taken on renewed significance. Attorneys may refer their clients to a professional of their own choosing for repeated assessment and evaluation. This may result in several neurological

exams within a short time frame. The very nature of personal injury litigation virtually guarantees that in many cases the client will be examined multiple times (Putnam, Adams, & Schneider, 1992).

In a growing literature regarding practice effects and test-retest reliability, research efforts have focused on mainstays of clinical neuropsychological assessment, the Wechsler WAIS-R and WMS-R and the Halstead-Reitan Neuropsychological Test Battery (HRNB). Significant practice effects have been found on portions of the original WAIS and WMS, but the practice effects differ between neuropsychologically impaired participants and unimpaired individuals. They also differ across several other variables, including "age, severity of deficit, and type and progression of lesion" (Shatz, 1981). In normal and general clinical populations, the 1980 findings of Matarazzo, Carmody and Jacobs that estimate differences on the WAIS may be accepted as a general rule of thumb by clinicians (Shatz, 1981). The research results of these authors show potential practice effects from test to retest of a 3-5 point subtest score change and a 15 points or more change in IQ. On the WMS-R, practice effects have been repeatedly found on the Verbal Memory, Figural Memory and Paired Associates subtests (McCaffrey & Westervelt, 1995; McCaffrey, Ortega, Orsillo, Nelles & Haase, 1992; Shatz, 1981). However, practice effects within neuropsychologically impaired

populations have shown great variability and must be addressed on an individual basis (Shatz, 1981). Additionally, research by Shatz has shown that practice effects on the WAIS are minimal for younger individuals, whereas the effect for elderly individuals "... may be inversely proportional to length of test-retest interval." (Shatz, 1981, p. 16).

The HRNB has also shown practice effects on individual subtests. In research by Dodrill & Troupin (1975) in which 17 chronic seizure patients were given four administrations of the HRNB and the WAIS over an 18-29 month period, practice effects were found on the following HRNB subtests: the category test, TPT localization and impairment index, as well as on the WAIS Full scale IQ, Verbal IQ, and Performance IQ. Of particular note, the practice effects were found on the HRNB subtests considered most sensitive to brain dysfunction.

These trends were clinically, as well as statistically, significant. Dodrill noted that if cut-off points alone were used to determine normality of brain functions, twice as many patients would have been judged normal by the fourth administration of these tests as on the first. Given that six months had elapsed between the administrations, it would be reasonable to expect even greater practice effects if the evaluations were given more frequently or closer together (Dodrill & Troupin, 1975).

However, it should be remembered that the majority of neuropsychological test measures did not show significant practice effects even by the fourth administration (Dodrill & Troupin, 1975).

The PASAT and its predecessor the VPSAT have also shown evidence of practice effects (Sampson, 1956, 1958a, 1958b, 1961). Roman, Edwall, Buchanan & Patton wrote of the PASAT in 1991, that Gronwall and Sampson (1974) reported significantly improved performance from the first to the second PASAT administration in their control subjects, but found minimal improvements with subsequent administrations. In contrast, Stuss, Stethem, Hugenholtz, and Richard (1989), although not focusing on practice effects, also found significantly better performance from first to second administrations of the PASAT, but with steady improvements in the performance of their controls across three to four administrations and a leveling off of performance by the fifth trial. Practice effects still existed at the third and fourth trials and were different for different presentation rates. Performance at all presentation rates (2.4, 2.0, 1.6, 1.2s) were significantly different from each other, and performance decreased as presentation rate increased. The MTBI subjects always performed significantly worse than the controls (Stuss, et al., 1989, p. 149).

These variable findings illustrate the necessity for further research to expand the database on practice effects within neuropsychological testing. Of particular interest are tests outside the Halstead-Reitan Neuropsychological Test Battery and Wechsler tests which have received less study, such as the PASAT.

The client's level of anxiety may also play an important role in neuropsychological test performance. In addition to interpreting the role of practice effects on PASAT results when dealing with multiple administrations, clinicians need to assess the effects of anxiety the PASAT has been shown to cause (Lezak, 1995; Deary, Emeier, MacLeod, Dougall, Hepburn, Frier, & Goodwin, 1994; Stuss et al., 1989). Level of anxiety and its effects may also differ across administrations.

Anxiety

Anxiety, as defined by Spielberger (1983, p.1), ". . . is an unpleasant emotional state or condition". Spielberger further defines anxiety as two distinct states, State Anxiety and Trait Anxiety. State anxiety is a physiological reaction to a stressful situation at a given time and level of intensity. Trait anxiety refers to individual differences in anxiety-proneness which, for that person, remain relatively stable. That is the stable differences between people in their perception of stressful

situations as dangerous or threatening and their response to such situations results in short-term elevations in the intensity of their State anxiety reactions. Trait anxiety may also reflect individual differences in the frequency and intensity with which anxiety states have been experienced in the past, and in the probability that State anxiety will be experienced in the future. The stronger the anxiety trait, the more probable that the individual will experience more intense elevations in State anxiety in a stressful situation. In other words, if a person tends to perceive stressful situations as frightening, their level of State anxiety will tend to be higher then those who do not perceive most stressful situations as frightening.

Stress, (as measured by anxiety level) is associated with lower performance on neuropsychological tests and is also viewed as an agent in delaying recovery for mild TBI patients (Gronwall, 1977). Specifically, increased stress may cause a leveling off or regression of scores in repeated PASAT testing. In an earlier comparison of three MTBI assessment instruments, the Trail Making Test (TMT), Auditory Short Term Memory Test under Interference (CCC) and the PASAT, Stuss et al.(1989) found the PASAT sufficiently effective, but cautioned its use because it is stressful for patients. Stuss stated, "In our experience, the PASAT, although proven effective in identifying deficits after TBI, is

unnecessarily stressful. Our previous research also suggested that it is affected by level of education in normal subjects to a greater degree than either the TMT or CCC." (1989, p. 153). They suggested that if equally effective and less demanding tests exist, that are relatively independent of confounding by age and/or education, they should be used.

Lezak (1995) states regarding her own use of the PASAT in assessment:

> Unfortunately, patients experience this sensitive test as very stressful: most persons - whether cognitively intact or impaired - feel under great pressure and that they are failing, even when doing well. Since attentional deficits can be elicited in less painful ways, I do not ordinarily use the PASAT. However, I keep it available for those times when subtle attentional deficits need to be made obvious to the most hide-bound skeptics for some purpose very much in the patient's interest; and then I prepare these patients beforehand, letting them know that it can be an unpleasant procedure and that they may feel that they are failing when they are not. (p. 373)

In a study by Deary et al., 1994, comparing two groups of participants with Type I diabetes mellitus, the Spielberger State Anxiety scale was used to assess the anxiety levels of participants at rest and immediately after administration of the PASAT. Both of the diabetic groups, those with no severe hypoglycaemic episodes and those who had

five or more hypoglycaemic episodes, show a dramatic increase in anxiety level as reported on the Spielberger State Anxiety scale prior to and after completing the PASAT. This is the only study in the literature that makes a formal assessment of anxiety and PASAT performance. However, this study is based on a population with a serious, chronic medical illness. Results for a population of control participants in normal health may differ in regard to anxiety levels and PASAT performance.

Gender and age have also been debated as a factors in performance on the PASAT (Stuss, Stethem, & Poirier, 1987; Brittain, La Marche, Reeder, Roth, & Boll, 1991). In separate experiments opposing findings of better performance have been found for females versus males. Brittain et al. (1991), found that male gender was significantly correlated with higher scores on the PASAT, while Stuss et al.(1987), found a nonsignificant tendency for females to perform better on the PASAT. In more recent research, Bateman and Hall (1996) found no significant differences between the scores of male and females on the PASAT. Additional studies have found decreased scores in participants over forty (Gronwall, 1991). Gronwall cautioned against the PASAT's use with either children or adults over forty. The confounding variable of age will be addressed in this experiment by confining the age group to those

between 18 and 40. Gender will not be addressed due to the lack of confirmed evidence regarding differences in performance between males and females.