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The ecological and concurrent validity of processing speed measures

Jeffrey Alan Sordahl Jr.
George Fox University

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The Ecological and Concurrent Validity of Processing Speed Measures

by

Jeffrey Alan Sordahl, Jr.

Presented to the Faculty of the
Graduate Department of Clinical Psychology
George Fox University
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of the requirements for the degree of
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in Clinical Psychology

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The Ecological and Concurrent Validity of Processing Speed Measures

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has been approved

at the

Graduate School of Clinical Psychology

George Fox University

As a Dissertation for the Psy.D. degree

Approval

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Chris Koch, PhD
Processing speed is a construct that has been present since Sir Francis Galton first used it as a rudimentary measure of individual differences in intelligence in the late 1800s. More recently, it has been introduced on Wechsler Intelligence Scales as an index which contributes to Full Scale IQ. Although processing speed has been alleged to contribute to various cognitive processes, such as memory, attention, and learning, little has been done to explore how this construct relates to “real-world” tasks. The purpose of this study was to evaluate the concurrent and ecological validity of common processing speed measures. The 50 participants chosen were divided into older (60-85 years) and younger (18-35 years) groups in order to examine possible disparity between age groups who have been reported to perform differently on processing speed measures. Each group was given a battery of processing speed tasks which included 6 formal neuropsychological measures, and 8 ecological tasks that were created for this study to reflect processing speed in everyday tasks. It was predicted that the younger group would perform better than the older on all processing speed measures, and that correlations between ecological and
formal neuropsychological measures would be greater for the older than younger group. As predicted, the younger group performed significantly better than the older on most processing speed tasks. The correlations between ecological and neuropsychological measures were significant and comparable between both groups. Substantial correlations between ecological and neuropsychological measures suggest that the construct of processing speed does play a role in performing real-world, everyday activities.
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Chapter 1

Introduction

History of Processing Speed

Processing speed is a curious construct that is dispersed throughout cognitive and neuropsychological literature. Although processing speed has only recently begun to receive attention from the research community, a form of this construct was studied long before. The late 1800s were characterized as the “brass instruments” era and generated new and creative ways to scientifically measure reaction time and the speed of completing many “cognitive” tasks. One notable contributor of this period was Sir Francis Galton. Not only did Galton create the well-known statistical concept of correlation and a method for its calculation, he also believed that performance on sensory tasks could be explained by differences in intelligence (O’Brien & Tulsky, 2008). Galton’s measures were heavily dependent on speed and reaction time. His colleague, James McKeen Cattell, brought this research to United States where it was openly received. Like Galton, Cattell collected voluminous amounts of data from mental tests that were comprised of various reaction time and sensory measures thought to quantitatively measure individual differences in intelligence (O’Brien & Tulsky, 2008). However, in 1901, Clark Wissler, a doctoral student, discredited Cattell’s work. Wissler’s dissertation research found no significant correlation between students’ grades and Cattell’s mental tests. As a result, this research interest in the speed at which tests were performed fell dormant. The next fifty years of research concentrated on various complex measures of intelligence. Processing speed’s empirical rebirth occurred in the 1970s and can be credited to Arthur Jensen. Jensen was a self-proclaimed
“Galtonian” who produced controversial research that looked at differences in intelligence across various racial groups. Although his work was scorned by peers, “The advent of Arthur Jensen’s ‘Choice Reaction Time’ paradigm resulted in renewed excitement and support for a connection between speed and mental abilities in the 1980s” (O’Brien & Tulsky, 2008, p. 10). Choice reaction time consists of both “decision time” and “movement time.” Choice reaction time added a cognitive component to the standard simple reaction time task, which in turn, correlated significantly better to intelligence. Although choice reaction time studies provided a wealth of information on speed and intelligence (Deary, Der, & Ford, 2001), another measure, “inspection time,” was offered as a purer alternative to determining mental speed. O’Brien & Tulsky (2008) defined inspection time as, “the duration of exposure to a stimulus necessary to make a simple visual discrimination with certain accuracy” (p. 10) Inspection time is deemed to be more informative than simple reaction time because it provides a measure of “higher-order cognitive processes” (O’Brien & Tulsky, 2008, p. 11).

Recently, the term “processing speed” has made its way into cognitive assessment. For instance, the Wechsler Scales of intelligence first incorporated the term in 1991. In their most recent forms, the Wechsler Scales (Wechsler, 1991, 1997, 2004, & 2008a) include two subtests (Coding and Symbol Search) within the domain of “Processing Speed,” contributing 20% of the overall Full Scale IQ. Wechsler’s Processing Speed Index was serendipitously discovered during the revision of the Wechsler Intelligence Scale for Children - Third Edition (WISC-III) (Wechsler, 1991). During the development of the WISC-III, the subtest “Symbol Search” was created in hopes to strengthen a factor called “Freedom from Distractibility” (Tulsky, Saklofske, & Zhu, 2003). Instead, a subsequent factor analysis showed the Symbol Search subtest loaded
with the Coding subtest, formerly included as part of the Verbal IQ measures, thus creating a new aggregate fourth factor known as Processing Speed.

**Processing Speed Assessment**

Processing speed measures come in a wide array. Within the domain of cognitive psychology, the Wechsler and Woodcock-Johnson intelligence tests are two prominent measures that incorporate processing speed into Full Scale IQ. The Wechsler Processing Speed Index (PSI) is found on both the WISC-IV and WAIS-IV, and, as noted above, includes Coding and Symbol Search subtests. According to the Sattler (Sattler & Ryan, 2009), Coding measures “the ability to learn an unfamiliar task involving speed of mental operation and psychomotor speed” (p. 110), and Symbol Search measures “speed of visual-perceptual scanning and discrimination” (p. 103).

The Woodcock-Johnson Test of Cognitive Abilities, Third Edition (WJ-III; Woodcock & Johnson, 1989) is based on the Cattell-Horn-Carroll theory of intelligence that includes a processing speed component. Processing speed is explicitly represented in two subtests, Visual Matching and Decision Speed, and contributes to the overall cognitive score composite. This measure is discussed in more detail below.

The field of neuropsychology has also made use of processing speed measures because of their sensitivity to neurological damage. For example, those who suffer from multiple sclerosis (Kail, 1998), Parkinson’s disease (Lee, Grossman, Morris, Stern, & Hurtig, 2003), Attention Deficit Disorder (Goth-Owens, Martinez-Torteya, Martel, & Nigg, 2010), or traumatic brain injury (Madigan, DeLuca, Diamond, Tramontano, & Averill, 2000) demonstrate especially poor performance on processing speed tasks. Some of the most commonly used neuropsychological tests for which processing speed is considered a significant contributor to overall performance,
include the Stroop Test (Stroop, 1935), Symbol Digit Modalities Test (Smith, 1991), Trail Making Test (Reitan, 1955) and the Paced Auditory Serial Addition Test (Gronwall & Sampson, 1974). While these various tests use different formats, processing speed is “captured” because of a timed component each employs to determine quality of overall performance (i.e., faster performance provides a better score).

**Processing Speed and the Conceptualization of Intelligence**

The concept of processing speed has evolved considerably since its inception. As already noted, measuring speed of task performance was thought in the mid-1800s, to be one of the soundest methods for evaluating individual differences in cognition (O’Brien & Tulsky, 2008). Throughout the late 1800s, simple processing speed and sensory tasks were thought to represent mental abilities, a position now considered far too simplistic to accurately portray the complexity of human intellect. One currently accepted theory of mental ability is the Cattell-Horn-Carroll theory of intelligence. This theory divides intelligence into three hierarchical mental groupings: general intelligence, broad abilities, and narrow abilities. Included in the broad abilities grouping of this model are two processing speed constructs: Cognitive Processing Speed (defined as “the speed of executing overlearned or automatized cognitive processes” (Gregory, 2007, p. 180), and Decision/Reaction Time or Speed (“the ability to make decisions quickly in response to simple stimuli” (Gregory, 2007, p. 180). Although processing speed is no longer considered the sole determinant of an individual’s cognitive ability, it is widely accepted (as evidenced by its inclusion in the WAIS-IV, WISC-IV, and Woodcock Johnson cognitive test) as an integral component to the conceptualization of intelligence.
Recently, genetic influences were found to have a large effect on the relationship between processing speed and general cognitive ability (Lee et al., 2012). Although processing speed has recently made a successful re-emergence into research interests, and gained support clinically for its role in intelligence, there exist at least two issues concerning the validity of this construct: providing theoretical clarification of the processing speed construct (Martin & Bush, 2008), and identifying processing speed’s ecological role, that is, what everyday tasks or accomplishments depend significantly upon processing speed, as currently measured.

**Problems Concerning the Conceptualization of Processing Speed**

Processing speed goes by many names, some of which are mental speed, reaction time, inspection time, perceptual speed and cognitive processing. Along with the variable terms relating to this construct, there also are a number of equally variable definitions such as these three:

1. “Speed of processing has been defined as, the rate at which information once made available to the senses, is processed and understood at the cognitive level.” (Ball & Vance, 2008, p. 244)

2. “Speed of (information) processing is the speed with which subjects can perform basic cognitive operations, including, but not limited to, perception, allocation of attention, chunking, rehearsal, long-term memory retrieval, response selection, and long-term memory storage.” (Posthuma & de Geus, 2008, p. 79)

3. “Processing speed can be conceptualized as the rapidity and efficiency of performing simple mental operations in working memory.” (Oh, Glutting, & McDermott, 1999, p. 363)
Processing Speed Measures

The definitions appointed to processing speed vary in their descriptions, as demonstrated by the three shown. Processing speed to some is the speed at which one becomes aware of information in the environment, while others allot it a closer relationship to working memory and higher order processes. One of the current frustrations in understanding this construct relates to the several definitions assigned to it. Sattler & Ryan (2009) unintentionally illustrates some of the confusion surrounding the term in his own somewhat convoluted description of processing speed; “The term processing speed describes a hypothesized processing speed ability underlying processing speed” (p. 48). Using the many definitions that have been suggested, one may find it difficult to understand what processing speed is. Is it related to most or all cognitive processes or just operating within working memory? Is it a component of intelligence, or simply a pacing measure of cognitive activity? That is, thinking fast verse slowly has little impact on the quality or complexity of the mental activity. These are appropriate questions to ask when confronted by the number of puzzling definitions assigned to this construct.

Some researchers have attempted to provide clarity. A study by Chiaravalloti, Christodoulou, Demaree and Deluca (2003), addressed the construct’s meaning by examining how processing speed measures relate to each other and how they influence higher cognitive processes. Using a mixed medical group of participants, these authors administered verbal learning, visual learning, working memory, and processing speed measures. The processing speed tasks included a single reaction time task, a choice reaction time task, and the Levin adaption of the Paced Auditory Serial Addition Tests (PASAT; Levin et al., 1987). Using a factor analysis, it was shown that the processing speed measures did not load on a single factor, but two. It was found that the simple and choice reaction time tasks formed a separate factor
from that of the PASAT and similar measures that require added attention/concentration processes. The two factors were labeled “simple processing speed” and “complex processing speed” (Chiaravalloti et al., 2003). Simple processing speed was described as the “basic elements of attention and concentration, requiring the recognition of a stimulus” (p. 496). Simple processing speed is measured by both reaction time and choice reaction time tasks and demand little from cognitive or attentive faculties. Complex processing speed tasks demand greater cognitive involvement and higher levels of concentration, such as the verbal working memory required on the PASAT. Furthermore, this study also found that complex processing speed tasks share a common variance with measures of new learning abilities. This could suggest that processing speed dysfunction can impair learning. Salthouse (1996) theorized that deficits in complex processing speed could impair other cognitive abilities by means of a “limited time mechanism” or a “simultaneity mechanism.” Both mechanisms can be defined as follows:

The limited time mechanism hypothesis asserts that the time spent on more basic cognitive functions will impact on the ability to complete more complex cognitive functions that are needed later in a cognitive sequence when a time limit is imposed. The simultaneity mechanism hypothesis asserts that cognitive actions performed early in a complex task will be “lost” by the time more complex cognitive tasks are (or should be) taking place, whether or not a time limit is imposed. (O’Brien & Tulsky, 2008, pp. 19)

Kalmar, Bryant, Tulsky, & DeLuca (2004) demonstrated complex processing speed impairment in persons with multiple sclerosis (MS). Using the Letter-Number Sequencing subtest from the WAIS-III (a working memory measure) and the PASAT (a complex processing speed measure), the researchers compared impairment on working memory and processing speed. Their results
indicated that performance was significantly worse on the PASAT, suggesting that a processing speed measure may be a better indicator of information processing dysfunction within the MS population. Furthermore, this study supported the limited time mechanism proposed by Salthouse (1996), that posits that processing speed impairment can affect performance on timed tasks when cognitive aptitude to complete the task is still functioning (i.e., MS subjects had the working memory capacity to complete the PASAT (demonstrated by average performance on LNS), however, lacked the capacity to keep up with the speeded pace).

With respect to the current findings in processing speed research, DeLuca (2008) proposes the following conceptual definition for processing speed: “Processing speed refers to either the time required to execute a cognitive task or the amount of work that can be completed within a finite period of time” (p. 266). This classification best represents the construct of processing speed because performance on processing speed measures is dependent upon either speed of completion or quantity of correct responses within a given time. That is, although most measures of processing speed also require use of other cognitive faculties, such as attention or working memory, they share in common a paced component that makes speed an integral factor to predicting performance. For these reasons, this study will use DeLuca’s definition of processing speed, which highlights the paced component of processing speed tasks.

**Purpose and Hypotheses of the Present Study**

The purpose of this study was to evaluate the concurrent and ecological validity of common processing speed measures. Building on the work by Chiaravalloti et al. (2003), this research used a similar battery of measures so that a variety of Processing Speed tasks are represented. Six processing speed measures were selected, creating a range between simple and
complex processing speed. Along with these measures, eight ecological tests were created to reflect real-world tasks. Both younger and older adults were utilized in order to examine the universality of the commonly reported disparity in processing speed between extreme age groups who. Significant correlations found between traditional measures of processing speed and ecological tasks will prove helpful in providing validity to the currently ill-defined construct of processing speed. Specifically, the following hypotheses were investigated in this research:

1. There will be a significant relationship between processing speed measures and this relationship will hold for both younger and older adults.

2. Measures of processing speed will correlate significantly higher within the older group as compared to the younger group because the older group is anticipated to produce a wider array of performance within tasks, as well as maintain consistent performance across tasks. That is, scores obtained on a single processing speed task for the older group will have a larger range than the younger group, and furthermore, individuals in the older group will perform consistently across tasks (i.e., slow performance on Coding predicts slow performance on Trails A). This assumption is supported by WAIS-IV (Wechsler, 2008c) normative data which shows that norms age bands between the ages of 16 and 35 require similar raw scores on measures of processing speed to achieve an average scaled score (10), whereas the raw scores needed to achieve a scaled score of 10 for older adults (60-85 years) dramatically decreases from age band to age band. Therefore, more variability on task performance is expected within the older group, even though the performance level for each individual in this group is anticipated to be fairly consistent across processing speed tasks. Statistically, if the data distributions for individual tasks
have a wider range, and performance across tasks is consistent, then correlations are expected to be higher.

3. Measures of complex processing speed (i.e., PASAT and Trails B) will correlate significantly better than simple processing speed measures (i.e., RT and CRT) on ecological tasks that are more cognitively demanding. This prediction is made because complex processing speed tasks require the integration of cognitive faculties, such as processing speed, attention, and working memory, and these processes better reflect performance demands of daily activities.

Measures of simple processing speed (i.e., RT and CRT) will correlate significantly better than complex processing speed measures (i.e., PASAT and Trails B) on ecological tasks that are less cognitively demanding, because simple processing speed measures require less integration of other cognitive abilities, such as, working memory and executive functioning, and therefore better resemble simple real-world tasks.

4) The older group will demonstrate significantly lower performance on all processing speed measures as compared to the younger group. According to the WAIS-IV, average adults between the ages of 18-35 perform about one standard deviation better than older adults between the ages of 60-85 when raw score comparisons are made using the standardization norms related to PSI tasks.
Chapter 2

Methods

Participants

The participants consisted of 19 males and 31 females. Participants were selected for two age groups: Younger (18-35 years) and older (60-85 years). These two age ranges were chosen to allow examination of processing speed at clearly different developmental stages of life. Specifically, the younger group likely represents maximum processing speed and stability, while the older group represents its deterioration. As shown in Figure 1, processing speed performance as measured by the Wechsler Adult Intelligence Scale 4th -Edition (Wechsler, 2008b) is stable between the ages of 16-35 years and begins to deteriorate after 40-45 years of age. Figure 1 illustrates the raw scores required to achieve a standard score of 10 (average ability) across age groups on the subtests comparing processing speed on the WAIS-IV.

To insure the representativeness of the data obtained, participants assigned to each group were selected to match respective demographics found in the 2000 US census. Table 1 provides the demographic information that was used to assign individuals to each group.

Participants were volunteers obtained through advertisement and solicitation on college campuses, retirement homes, community bulletin boards, and by word of mouth (Appendix A illustrates the volunteer flyer). Those who were interested in taking part in the research were screened for eligibility.

The screening process was conducted at the time of the initial phone or email contact, and participants were assessed for visual, verbal, hearing, or motor impairments that could negatively
Figure 1. Average performance raw scores on the subtests comprising the WAIS-IV Processing Speed Index, Coding (CD), Symbol Search (SS) and Cancelation (CA) across age.

Demographic information was also collected at this time to insure compliance with census proportions (Age, gender, education). Those who did not meet the criteria (respond “yes” to any of the health related screening questions or are unable to correctly answer all of the mental status questions) were excluded from participating in the study, but thanked for their interest. To reduce possible confounding variables, participants with the following ailments were excluded: history of stroke, seizures, head injury resulting in loss of consciousness, color blindness, as well as psychological disorders of bipolar, depression, attention deficit disorder and schizophrenia, dementia, medications that may negatively affect cognition or concentration and drug or alcohol abuse (past or present).

Those who met the screening criteria and agreed to participate were eligible for testing and an appointment and location was set. Participants were also asked to provide a contact number (if possible) where they could be reached in case a scheduling conflict arose. The
examiner also informed participants that they would be contacted 24-hours prior to their scheduled appointment for confirmation.

Table 1

<table>
<thead>
<tr>
<th>Census Category</th>
<th>Sub Category</th>
<th>Group</th>
<th>Number of Participants</th>
<th>US Census %</th>
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<tr>
<td>Sex</td>
<td>Male</td>
<td>Young</td>
<td>15</td>
<td>49.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Old</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Young</td>
<td>15</td>
<td>50.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Old</td>
<td>16</td>
<td></td>
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<tr>
<td>Race</td>
<td>White</td>
<td>Young</td>
<td>23</td>
<td>75.1</td>
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<td></td>
<td></td>
<td>Old</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-White</td>
<td>Young</td>
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<td>24.9</td>
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<td></td>
<td>Old</td>
<td>8</td>
<td></td>
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<tr>
<td></td>
<td>Some high school, no diploma, high school diploma, GED</td>
<td>Young</td>
<td>14</td>
<td>48.2</td>
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<tr>
<td></td>
<td></td>
<td>Old</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some college/no degree or associates degree</td>
<td>Young</td>
<td>8</td>
<td>27.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Old</td>
<td>9</td>
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<tr>
<td></td>
<td>Bachelors degree/ graduate/ professional degree</td>
<td>Young</td>
<td>7</td>
<td>24.4</td>
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<tr>
<td></td>
<td></td>
<td>Old</td>
<td>7</td>
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</table>

*Note. GED = General Education Degree.*

Prior to beginning the study, the project was submitted to and received approval from the George Fox University Human Subjects Committee. Upon arrival to the study, the procedure was again described to participants who were then asked to sign a consent form, which can be found in Appendix D. All participants agreed to participate, and were assigned an identification number, which was labeled on all of their materials. Thus, using this method, participants
remained anonymous and confidentiality was maintained on all record forms and data collection forms. Before administering any tests, the participants completed the questionnaire found in Appendix C, asking for: age, gender, years of education, handedness, occupation, and degree or area of interest in school. Information collected from the questionnaires was used to assess for variables that may relate to processing speed performance.

Measures

This experiment used six processing speed measures that are commonly used in cognitive and neuropsychological assessment. The purpose for using six measures was to examine the consistency between formal and normed cognitive assessments that are routinely used to evaluate processing speed. Performance on these neuropsychological measures was also compared to those used to measure performance on everyday tasks seemingly comprised of a significant portion of processing speed. Therefore, the following measures were included: Coding and Symbol Search subtests from the Wechsler Adult Intelligence Scale 4th – edition (Wechsler, 2008a), Trails A & B (Reitan, 1955), Paced Auditory Serial Addition Test (Gronwall, 1977) and a reaction time and choice reaction time measure that was administered on a computer. Eight other measures were created to represent everyday tasks that require processing speed. These tasks include the following: Stone Sort, Phonebook Search, “THE” Word Search, Verbal Fluency, File Sort, Math Fluency, Reading Fluency, and Copy Task. These measures were included because they have been deemed to require processing speed and are tasks that may be carried out in real life, such as reading, speaking, sorting, or solving simple math. A short 21-question Anxiety measure (Beck Anxiety Inventory) was also included to assess participant’s anxiety levels at the midway point of testing (after seven measures were given).
**Reaction Time.** Reaction Time (RT) was measured with a computer-based task, which was created using Super Lab software. Participants were asked to monitor a computer screen and, as quickly as they can, press a key marked ‘X’ on the keyboard with their dominate hand whenever an X appeared on the screen. Xs appeared in variable positions on the screen and never emerged in the same location. Intervals between stimuli varied between 1 and 6 seconds, so that the participant would not be able to predict the appearance of an X. Each participant responded to 30 stimuli (X’s) and response time was recorded in milliseconds. Upon finishing the task, average response time was calculated using the following: Sum of Response Time/30 = score. This task took approximately 5-minutes to administer.

**Choice Reaction Time.** Choice Reaction Time (CRT) was measured using a computer-based task created with Super Lab. Participants were asked to monitor a computer screen and press a key marked “X” if an X appeared on the screen and a key marked “O” if any other letter appeared. Intervals between stimuli were variable ranging between 1 and 6 seconds, so that participants would not be able to predict the appearance of stimuli. Stimuli appeared centered on the screen for all trials. There were 30 stimuli presented, consisting of 15 Xs and 15 other alphabet letters. For the purposes of this study, stimuli remained on the screen until a correct response from the participant was made. Therefore, participants were allowed to self-correct their responses, however, at the cost of adding time. Response time was recorded in milliseconds. Upon finishing the task, average response time was calculated the following way: Sum of Response Time/30 = score. This task was estimated to take 5 minutes.

The purpose of using both a RT and CRT task in this study was to provide a measure of simple processing speed. In a similar study, both a computerized RT task (“Press a button when a
cross appears on the screen”) and a CRT task (“Press a button when a circle appears on the screen and do nothing if an X appears”) factored together under a domain labeled “simple processing speed” (Chiaravalloti et al., 2003). Therefore, the RT/CRT tasks have been considered to be measures of simple processing speed.

**WAIS-IV: Coding.** The Coding subtest is one of two subtests that contribute to the Processing Speed Index. The Coding subtest may be administered to those between the ages of 16 and 90 years. This subtest requires the participant to copy symbols each of which has been paired with one integer from 1 - 9. In 120 seconds, the client is asked to copy as many corresponding symbols associated with integers that themselves are randomly arranged in horizontal rows. Totaling the number of correct symbols copied in the 120-second time limit constitutes the raw score for the test. Raw scores were collected to evaluate performance difference between the two age groups.

Coding’s test-retest reliability has been found at or above $r = .84$. The purpose for using this subtest is that it is a processing speed measure that substantially contributes to the Processing Speed Index found on both the child and adult versions of the Wechsler Intelligence Scales, commonly used intelligence measures in the US. See Appendix E to review the content of this subtest and the verbatim directions used for administration.

**WAIS-IV: Symbol Search.** The Symbol Search subtest of the WAIS-IV is the other core measure contributing to the Processing Speed Index, and can be administered to those between the ages of 16 and 90 years. The subtest requires the participant to indicate whether or not either of two target symbols can be found within a horizontal array of five symbols. The subtest raw
score is the number of correct identifications made per array, minus incorrect identifications made within a 120-second time limit.

The Symbol Search’s test-retest reliability has been found at or above $r = .75$. The reason for selecting this test is that it contributes to half of the processing speed index score of the WAIS-IV, which is a commonly used intelligence scale. See Appendix F to review the content of this measure as well as the verbatim directions used for administration.

Both the Coding and Symbol Search subtests were administered in their standardized formats.

**Trail Making Test A & B.** The Trail Making Test (TMT) is said to measure “attention, speed, and mental flexibility” (Strauss, Sherman, & Spreen, 2006, p. 655). The adult version may be administered to those between the ages of 15 and 89 years. Part A of the TMT requires the participant to draw lines between encircled numbers 1-25 in sequence as quickly as possible. Part B requires the participant to draw lines between the encircled numbers 1-13 and encircled letters A-L in alternating sequential order (e.g., a line from 1 to A, 2 to B, 3 to C). The administration of the TMT takes approximately 5 minutes. Scoring is based on time (in seconds) to successfully complete each sequence. Test-retest reliability for the TMT fluctuates with age, ranging between $r = .55$ (trial A) to .75 (trial B) for young healthy adults (Bornstein, Baker, & Douglas, 1987) and .53 (trial A) to .67 (trial B) in older adults (Mitrushina & Satz, 1991). This test has been included because it is commonly used in neuropsychological assessments and considered a measure of processing speed (Royan, Tombaugh, Rees, and Francis (2004).

**PASAT: Short Form.** Gronwell and Sampson (1974) designed the Paced Auditory Serial Addition Test (PASAT) to “provide an estimate of speed of information processing” (Strauss,
The test is also said to measure working memory and divided attention (Strauss, 2006). The test requires the participant to listen to a series of numbers between 1 and 9 that are presented singly in random order. The participant is instructed to add each number read aloud by the examiner to the number read aloud that immediately preceded it. There are four differently paced trials with fifty numbers presented in each trial. With each new recitation the 50 numbers are presented with shorter time increments between the recited digits, beginning with 3 seconds, then proceeding to 2.4, 2.0, and 1.6. Scoring of the PASAT is based on total number of correct responses given during each trial of 50 numbers. Its internal reliability ranges from .9 in adults (McCaffrey et al., 1995) to .96 in adolescents (Egan, 1988). For the purposes of this study, the short form will be used to conserve time. The PASAT short form uses Trials 1 and 2 only (2.4 and 2.0 seconds). Diehr et al. (2003) has demonstrated that the PASAT short form correlates well with the longer version ($r = .867 - .825$) and accounts for 90% of the variance of the longer form. The PASAT is a cognitively demanding measure, which stresses sustained attention, working memory and processing speed ability. The purpose for its use is because the PASAT has been deemed a measure of “complex processing speed” in the neuropsychology literature (Chiaravalloti et al., 2003). A complex processing speed measure assesses one’s ability to complete a task that demands heavily upon, not only processing speed but, another cognitive domain, such as working memory and attention. In this fashion, processing speed is evaluated within an integrated construct. The PASAT short form administration time is approximately 10-minutes.
Ecological Tasks

The following measures have been deemed to represent tasks which significantly require processing speed ability, according to a survey given to a convenience sample (N = 18) of clinical psychology graduate students in a neuropsychology class. Only those tasks receiving more than xx% agreement were utilized in this investigation.

**Stone Sort.** In 60 seconds, the participants were asked to sort stones by color into corresponding bowls “as fast as you can” while seated at a table. The stones were mixed randomly inside a box measuring approximately 12 inches x 6 inches x 2 inches. The box was placed on a table approximately 6 inches from the participant’s midline when seated. Three bowls were placed on the table as shown in Figure 2. There were three different colors of stones (red, blue, and grey) which were identical in size and shape. The participants were asked to sort as many stones according to color as quickly as possibly until told to stop. That is, match the color of the stone to the bowl that has the same color. Participants were asked to only use their dominant hand and to place the stones in the bowls one at a time. Furthermore, they were allowed to utilize any strategies that they spontaneously created to sort the buttons (i.e., sort all reds then blues then yellows). Scoring was based on the number of correct stones sorted in a 60-second time limit. A complete description of the stone sort task, including the directions is found in appendix G. This task was estimated to take 3 minutes.

**“THE” Word Search.** The participant was asked to search and circle the word “the” found within a 339-word story written at the 8th grade level. Participant score was the number of correctly circled “the’s” completed at the end of 60 seconds. A full description of the Word
Search task, including instructions is found in Appendix I. A copy of the Word Search protocol can be found in Appendix H. This task was estimated to take 3 minutes.

**Phonebook Search.** Participants were asked to lookup three company names in a phonebook and copy their numbers down. The examiner gave each participant a list of three names to search for with space provided under each company name for recording the correct phone number. Timing began once the examiner finished instructing the participant to begin searching and ended once the last number was written down. This task was estimated to take x minutes.

**Filing Sort.** The filing task required participants to sort twenty 9.25” x 11.75” cards alphabetically as quickly as possible. The participants were presented with twenty cards that were labeled with fictitious last names. They were then asked to file the cards into an open filing box alphabetically according to first letter of last name. The researcher began timing at the moment the participant touched the first card. The task ended as soon as the participant declared
that all of the files all were correctly placed or until ten-minutes had elapsed. If the participant had filed all folders in alphabetical order, but had done so backwards from Z–A, the task was still deemed complete. Scoring for this task was based on total time elapsed for completion. A description of the Filing task, including directions, can be found in Appendix K. This task was estimated to take approximately 5 minutes.

**Verbal Fluency.** In this task, the participant was asked to tell a story about their favorite or dream vacation. Timing started once the participant began his/her story, and ended after 45 seconds had elapsed. The participant’s story was recorded so that the audio could later be referred to when counting the total number of words spoken by the participant in the 45-seconds. The score for this task was the number of words spoken in 45 seconds. A description of the Verbal Fluency task, including directions, can be found in Appendix L. This task was estimated to take approximately 2 minutes.

**Math Fluency.** This task was created to resemble the Math Fluency subtests of commonly used tests of achievement, such as on the Woodcock Johnson III – Tests of Achievement or the Wechsler Individual Achievement Test – 3rd Edition. On this task, the participant was given a sheet of 30 arithmetic problems. All the problems required simple addition of two single integers. Each participant was asked to calculate as many sums as they could in 30-seconds. Timing began once the participant was handed the sheet of paper with the problems on it and ended after 30 seconds had elapsed. A description of the Math Fluency task, including directions, can be found in Appendix M. This task was estimated to take approximately 2 minutes.
Reading Fluency. In this task, the participant was asked to read a short paragraph. Timing began once the participant was handed the paragraph to read. The examiner followed along with a separate copy of the paragraph and recorded any reading errors (words missed, words added, words changed) made by the participant. A description of the Reading Fluency task, including directions, can be found in Appendix N. This task was estimated to take approximately 2 minutes.

Copy Task. For this task, the participant was asked to copy the first two sentences of the Reading Fluency Task. Timing began once the participant’s pen touched the paper and ended once the last word was written down. A description of the Copy Task, including directions, can be found in Appendix P. This task was estimated to take approximately 2 minutes.

Procedure

All participants began by filling out a brief questionnaire (found in Appendix C). The questionnaire requested demographic information (including, date of birth, gender, years of education, handedness, ethnicity, occupation) and two questions regarding the participant’s perceived processing speed ability. After filling out the questionnaire, the participant’s proceeded with the administration of all 14 measures. The administration order of tasks for each participant was randomized, thus controlling for possible order or effects. Randomization was achieved by assigning each task a number 0-14 and then using a random # table to order the tasks. After the participants completed 7 of the 14 measures, they were given the Beck Anxiety Inventory (BAI), a 21-question survey, to assess their recent level of anxiety. After the completion of all measures, each participant was awarded a $10 gift certificate along with being
entered into a drawing to potentially win a one hundred dollar gift certificate at the conclusion of the study. The estimated time to complete all 14 tasks was approximately 45-60 minutes.

**Statistical Analysis**

The intention of this study was to determine whether common neuropsychological measures of processing speed could predict performance on ecological tasks that were deemed to have a processing speed component. Pearson correlations were calculated between each group (younger and older) on ecological tasks, neuropsychological measures, demographic information, and data from the Beck Anxiety Inventory. To determine whether correlations between groups were significant t-tests and analyses of variance were performed to evaluate differences between group means.

Table 2

<table>
<thead>
<tr>
<th>Task</th>
<th>Time in Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction Time</td>
<td>5</td>
</tr>
<tr>
<td>Choice Reaction Time</td>
<td>5</td>
</tr>
<tr>
<td>Coding</td>
<td>4</td>
</tr>
<tr>
<td>Symbol Search</td>
<td>4</td>
</tr>
<tr>
<td>Trails A &amp; B</td>
<td>5</td>
</tr>
<tr>
<td>PASAT</td>
<td>10</td>
</tr>
<tr>
<td>Stone Sort</td>
<td>3</td>
</tr>
<tr>
<td>Word Search</td>
<td>3</td>
</tr>
<tr>
<td>Copy Task</td>
<td>2</td>
</tr>
<tr>
<td>File Sort</td>
<td>5</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>3</td>
</tr>
<tr>
<td>Math Fluency</td>
<td>2</td>
</tr>
<tr>
<td>Reading Fluency</td>
<td>2</td>
</tr>
<tr>
<td>Phonebook Search</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note. PASAT = Paced Auditory Serial Addition.*
Chapter 3

Results

“Younger” and “Older” groups were formed by contacting 50 individuals to participate. 26 (52%) of the younger and 24 (48%) of the older group were contacted and all were eligible and agreed to participate. Table 3 shows demographic information regarding both groups, and Table 4 provides the raw score means and standard deviations for each group on each task associated with the study.

Table 3

Demographic Information for Younger and Older Groups

<table>
<thead>
<tr>
<th></th>
<th>Younger Group (n = 26)</th>
<th>Older Group (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Age (Years) and (SD)</td>
<td>24.12 (4.8)</td>
<td>74.20 (7.3)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12 (46%)</td>
<td>7 (29%)</td>
</tr>
<tr>
<td>Female</td>
<td>14 (54%)</td>
<td>17 (71%)</td>
</tr>
<tr>
<td>Handedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>23 (89%)</td>
<td>20 (83%)</td>
</tr>
<tr>
<td>Left</td>
<td>3 (11%)</td>
<td>4 (17%)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>18 (69%)</td>
<td>24 (100%)</td>
</tr>
<tr>
<td>Asian</td>
<td>7 (27%)</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>1 (4%)</td>
<td>0</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some High School/High School/GED</td>
<td>10 (38.5%)</td>
<td>5 (21%)</td>
</tr>
<tr>
<td>Some College</td>
<td>6 (23%)</td>
<td>8 (33%)</td>
</tr>
<tr>
<td>College Degree/ Graduate School</td>
<td>10 (38.5%)</td>
<td>11 (46%)</td>
</tr>
<tr>
<td>Business/Finance</td>
<td>1 (4%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Health/Medical/Social</td>
<td>6 (23%)</td>
<td>6 (25%)</td>
</tr>
<tr>
<td>Education</td>
<td>3 (12%)</td>
<td>8 (33%)</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arts/Sports/Media/Entertainment</td>
<td>4 (15%)</td>
<td>0</td>
</tr>
<tr>
<td>Legal occupations</td>
<td>0</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Engineering/Architecture</td>
<td>0</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Other</td>
<td>12 (46%)</td>
<td>6 (25%)</td>
</tr>
</tbody>
</table>
Note. “Some High School” = had not obtained a high school diploma or were currently attending high school; “Some College” = having taken a college course, but not received a degree; “Occupation” = participant’s current status of employment, or employment prior to retiring; GED = General Education Degree

Table 4

<table>
<thead>
<tr>
<th>Measure</th>
<th>Younger Group Mean (SD)</th>
<th>Older Group Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coding (raw scores)</td>
<td>88.04 (21.52)</td>
<td>57.29 (13.27)</td>
</tr>
<tr>
<td>Coding (scaled scores)</td>
<td>12.92 (3.85)</td>
<td>11.96 (2.26)</td>
</tr>
<tr>
<td>Symbol Search (raw scores)</td>
<td>41.54 (9.82)</td>
<td>24.71 (7.47)</td>
</tr>
<tr>
<td>Symbol Search (scaled scores)</td>
<td>13.03 (3.85)</td>
<td>10.92 (2.84)</td>
</tr>
<tr>
<td>Trails A (sec)</td>
<td>21.88 (7.57)</td>
<td>42.21 (21.86)</td>
</tr>
<tr>
<td>Trails B (sec)</td>
<td>57.07 (27.7)</td>
<td>123.91 (77.02)</td>
</tr>
<tr>
<td>PASAT 1 (total correct)</td>
<td>42.88 (7.63)</td>
<td>33.08 (11.88)</td>
</tr>
<tr>
<td>PASAT 2 (total correct)</td>
<td>42.07 (6.84)</td>
<td>32.63 (12.11)</td>
</tr>
<tr>
<td>Reaction Time (msec)</td>
<td>392.78 (72.96)</td>
<td>435.56 (79.88)</td>
</tr>
<tr>
<td>Choice Reaction Time (msec)</td>
<td>184.24 (59.78)</td>
<td>297.09 (123.38)</td>
</tr>
<tr>
<td>Stone Sort (total/min)</td>
<td>62.03 (7.82)</td>
<td>51.58 (9.18)</td>
</tr>
<tr>
<td>Word Search (total/min)</td>
<td>42.27 (8.3)</td>
<td>32.50 (8.53)</td>
</tr>
<tr>
<td>File Sort (total sec)</td>
<td>77.73 (27.99)</td>
<td>106.67 (38.15)</td>
</tr>
<tr>
<td>Reading Fluency (total sec)</td>
<td>24.65 (2.99)</td>
<td>27.75 (3.57)</td>
</tr>
<tr>
<td>Math Fluency (total/30-sec)</td>
<td>27.57 (11.39)</td>
<td>27.79 (7.89)</td>
</tr>
<tr>
<td>Copy Task (total sec)</td>
<td>75.0 (21.68)</td>
<td>95.17 (25.43)</td>
</tr>
<tr>
<td>Verbal Fluency (total words)</td>
<td>111.31 (29.08)</td>
<td>97.63 (17.09)</td>
</tr>
<tr>
<td>Phonebook Task (total sec)</td>
<td>70.88 (27.81)</td>
<td>117.13 (59.65)</td>
</tr>
<tr>
<td>Beck Anxiety Inventory (total score)</td>
<td>29.15 (5.79)</td>
<td>28.16 (5.51)</td>
</tr>
</tbody>
</table>

Note. PASAT = Paced Auditory Serial Addition Test; msec = milliseconds.
Although there were fewer males than females participating in this study, especially in the older group, equality of means was found between genders on most processing speed tasks by conducting independent sample $t$-tests using $z$-scores for each age group. The older group demonstrated inequality of means between genders on one task, Math Fluency ($t(22) = 2.91, p < .01$), with males obtaining significantly higher scores than females. This difference was not observed in the younger group. These results suggest that on most processing speed tasks used in this study, males and females perform comparably to each other and the disproportionately low number of males in the older group was not problematic. A review of literature on gender differences in processing speed ability revealed that females are faster at paced tasks that use digits or the alphabet, while males are faster performing reaction time and other paced motor tasks (Roivainen, 2010). The results obtained in this study do not support such dissimilarity in performance between genders, but rather, suggests that males and females perform equivalently on most processing speed tasks.

Figure 3 illustrates a histogram of the combined participant sample’s scaled scores obtained on the Coding and Symbol Search tasks. These two formal measures of processing speed were chosen to illustrate the normalcy of the sample collected.

Skew and kurtosis were examined to determine the normalcy of the performance on these tasks. The coefficients for both tasks were between ± 1.0 (Coding: skew = .351, kurtosis = -.144, Symbol Search: skew = .551, kurtosis = -.111), suggesting that each distribution approximates a normal distribution. A bivariate correlation between the obtained Coding and Symbol Search scaled scores for the combined group was .71, which appears comparable to the .65 correlation reported in the WAIS-IV *Technical and Interpretive Manual* (Wechsler, 2008c) for the
Figure 3. Frequency distributions for Coding and Symbol Search subtest scaled scores.
combined standardization sample, thus suggesting that the sample obtained for this study was similar to the standardization sample obtained for the WAIS-IV norming effort. However, sampling differences were found; the mean scaled scores for the combined age groups were greater than an average scaled score of 10 for Coding \((t(49) = 5.43, p < .01)\) and Symbol Search \((t(49) = 4.04, p < .01)\) tasks. This was also true for the younger age group alone (Coding \((t(25) = 3.87, p < .01)\); Symbol Search \((t(25) = 4.02, p < .01)\), and for older age group it was found true just on the Coding subtest \((t(23) = 4.25, p < .01)\).

To evaluate the hypothesis that the younger group would perform significantly better than the older group on all processing speed measures, an independent t-test was performed with each processing speed task to determine if an age group difference existed. T-tests were performed because raw scores were used to evaluate differences between age groups for each processing speed task and, in most instances, the tasks had different raw score metrics. Results of those analyses are found in Table 5 within the end column labeled “Test of Equality of Means.”

As anticipated, mean differences on all formal and ecological processing speed tasks between the younger and older groups were highly significant, with one exception, namely RT which was significant at \(p = .055\) level. Figure 4 illustrates the magnitude of these age differences by showing the percentage difference between the groups’ performances for each processing speed task.

A significant age difference favoring the younger group was obtained for each task, other than performance on the Math Fluency task, which may reflect the rehearsed/over-learned aspect of this task. Furthermore, this result appears to be consistent with what has been shown in the Manual of the Wechsler Individual Achievement Test – Third Edition (Wechsler, 2009);
Table 5

*Significance Levels Using Raw Score Performance on Formal and Ecological Tasks, Younger vs. Older Groups*

<table>
<thead>
<tr>
<th>Levene’s Test (Equality of Variance)</th>
<th>Test of Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td><strong>Formal Processing Speed Measures</strong></td>
<td></td>
</tr>
<tr>
<td>Coding</td>
<td>3.916</td>
</tr>
<tr>
<td>Symbol Search</td>
<td>1.606</td>
</tr>
<tr>
<td>Trails A</td>
<td>8.798</td>
</tr>
<tr>
<td>Trails B</td>
<td>13.476</td>
</tr>
<tr>
<td>PASAT 1</td>
<td>7.796</td>
</tr>
<tr>
<td>PASAT 2</td>
<td>9.988</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>1.112</td>
</tr>
<tr>
<td>Choice Reaction Time</td>
<td>8.346</td>
</tr>
<tr>
<td><strong>Ecological Measures of Processing Speed</strong></td>
<td></td>
</tr>
<tr>
<td>Stone Sort</td>
<td>.103</td>
</tr>
<tr>
<td>Word Search</td>
<td>.050</td>
</tr>
<tr>
<td>File Sort</td>
<td>.408</td>
</tr>
<tr>
<td>Reading Fluency</td>
<td>.162</td>
</tr>
<tr>
<td>Copy Task</td>
<td>.444</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>6.517</td>
</tr>
<tr>
<td>Phonebook Task</td>
<td>6.583</td>
</tr>
<tr>
<td>Math Fluency</td>
<td>6.102</td>
</tr>
</tbody>
</table>

*Note.* PASAT = Paced Auditory Serial Addition Test; Sig. = statistical significance.

Specifically, Math Fluency performance has a comparable raw score for younger (18-year-olds) and older (50-year-olds) adults.
Figure 4. Percent difference younger exceeds older group for each processing speed task. Younger group > Older group statistically significant (p < .05) for each task, other than Math Fluency.

To confirm this apparent age effect on processing speed performance, a two-way analysis of variance was conducted between the two age groups and the sixteen processing speed tasks. Raw scores for each task were converted into z scores to provide a common metric for comparison. Figure 5 illustrates the two groups’ performance after the z-score transformation. Results confirmed the age effect found by the t-test ($F(1, 48) = 36.17, p < .01$), although there also was a significant interaction effect, with performance on the Math Fluency task being the one exception to this overall age difference ($F(1, 48) = 2.99, p < .01$). Figure 5 illustrates this one discrepant age finding.
It was also anticipated that the older group would perform with a wider range of ability on each task than the younger group. However, values for Levene’s test for equality of differences, which is found in Table 4, shows that on only 8 of the 16 tasks, the variance was significantly different between age groups at the \( p < .05 \) level and that on 6 of the 16 tasks the older group demonstrated more variability. Interestingly, the older group produced more variability on formal measures of processing speed, which is consistent with what is shown in the
WAIS-IV normative data (Wechsler, 2008b), and the younger group performed with more variability on ecological tasks. These results may indicate that older individuals perform paced tasks with less variability when the task is more familiar. An illustration of the equality and inequality of variance between groups can be seen in Figure 6, depicted by the varying distributions of data points (i.e., tightly versus widely clustered data arrangements).

To test hypotheses regarding the inter-relationships between processing speed tasks, raw scores were converted into $z$ scores so that a standard unit of measurement could be used to compare performance across the varied tasks with different means and standard deviations. Bivariate correlations were then calculated for both age groups separately since age differences in correlations were possible. Table 6 shows the inter-correlations for both age groups across all processing speed tasks; the bolded and italicized numbers represent the older group’s correlations, and the correlations in regular font represent the Younger group’s.

Summarizing Table 6, Table 7 lists each processing speed task along with the corresponding percentage of the other tasks with which it is significantly correlated at or beyond the .01 level; 58% (69 of 120) of the Younger group’s correlations and 48% (58 of 120) of the older group’s correlations were at or beyond the .01 level of significance. Correlations reported in Table 6 ranged between .006 to .946 with a large majority of the lower inter-correlations contributed by RT and CRT. This finding supports the distinction between simple and complex processing speed constructs, as demonstrated by RT and CRT’s limited ability to correlate with other processing speed tasks (Table 7).

To determine if the magnitude of correlations between processing speed tasks significantly differed between the older and younger groups, the average correlation was
calculated for each group and a t-test was performed to examine whether there was a significant age difference. No significant age differences were found. Table 8 shows results from the independent t-test between the younger and older group’s correlations on processing speed tasks.
### Table 6: Correlations Between Processing Speed Tasks for Younger (top score) and Older (bottom score) Age Groups

<table>
<thead>
<tr>
<th>Trails A</th>
<th>Trails B</th>
<th>PASAT 1</th>
<th>PASAT 2</th>
<th>RT</th>
<th>CRT</th>
<th>Stone Sort</th>
<th>Word Search</th>
<th>File Sort</th>
<th>Reading Fluency</th>
<th>Copy Task</th>
<th>Verbal Fluency</th>
<th>Phoneme Task</th>
<th>Symbol Search</th>
<th>Coding</th>
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</table>

**Note.** PASAT = Paced Auditory Serial Addition; RT = Reaction Time; CRT = Choice Reaction Time.
Table 7

For each Processing Speed Task, the Percentage of Significant Correlations with other 15 Processing speed Tasks for Younger and Older Groups.

<table>
<thead>
<tr>
<th>Task</th>
<th>Younger Group</th>
<th>Older Group</th>
<th>Younger Group</th>
<th>Older Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Fluency</td>
<td>80%</td>
<td>40%</td>
<td>87%</td>
<td>67%</td>
</tr>
<tr>
<td>Stone Sort</td>
<td>60%</td>
<td>67%</td>
<td>87%</td>
<td>80%</td>
</tr>
<tr>
<td>Word Search</td>
<td>73%</td>
<td>47%</td>
<td>80%</td>
<td>87%</td>
</tr>
<tr>
<td>File Sort</td>
<td>93%</td>
<td>47%</td>
<td>93%</td>
<td>87%</td>
</tr>
<tr>
<td>Reading Fluency</td>
<td>80%</td>
<td>20%</td>
<td>87%</td>
<td>80%</td>
</tr>
<tr>
<td>Copy Task</td>
<td>60%</td>
<td>47%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Verbal Fluency</td>
<td>13%</td>
<td>47%</td>
<td>27%</td>
<td>67%</td>
</tr>
<tr>
<td>Phonebook Task</td>
<td>60%</td>
<td>80%</td>
<td>73%</td>
<td>93%</td>
</tr>
<tr>
<td>Symbol Search</td>
<td>80%</td>
<td>20%</td>
<td>80%</td>
<td>53%</td>
</tr>
<tr>
<td>Coding</td>
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<td>40%</td>
<td>80%</td>
<td>60%</td>
</tr>
<tr>
<td>Trails A</td>
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<td>80%</td>
<td>87%</td>
</tr>
<tr>
<td>Trails B</td>
<td>73%</td>
<td>87%</td>
<td>80%</td>
<td>93%</td>
</tr>
<tr>
<td>PASAT 1</td>
<td>60%</td>
<td>67%</td>
<td>67%</td>
<td>87%</td>
</tr>
<tr>
<td>PASAT 2</td>
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<td>87%</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>7%</td>
<td>0%</td>
<td>53%</td>
<td>7%</td>
</tr>
<tr>
<td>Choice Reaction Time</td>
<td>0%</td>
<td>40%</td>
<td>13%</td>
<td>67%</td>
</tr>
</tbody>
</table>

Note. PASAT = Paced Auditory Serial Arithmetic Test.
Table 8

Independent t-test Between Younger and Older Group Correlations

<table>
<thead>
<tr>
<th></th>
<th>Levene’s Test</th>
<th>Test of Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>All Correlations</td>
<td>.872</td>
<td>.351</td>
</tr>
<tr>
<td>Ecological Task Correlations</td>
<td>.560</td>
<td>.458</td>
</tr>
<tr>
<td>Neuropsychological Task Correlations</td>
<td>.000</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Note. Sig. = statistically significant.*

The degree of interrelationship between processing speed tasks was found to be equivalent for younger and older groups. Likewise, when comparing the mean correlations between the younger and older groups’ performance on the two types of processing speed tasks (i.e., ecological and neuropsychological tasks), results again indicated non-significant differences between groups. Therefore, each age group demonstrated equivalent magnitude of relationship with neuropsychological as well as ecological processing speed tasks. Furthermore, an analysis of the correlations’ variability between groups was also conducted, and again no significant differences were obtained, thus indicating that the degree of relationship amongst processing speed measures was comparable for the older and younger groups.

**Additional Analysis**

In addition to examining the hypotheses of the study, further analyses were conducted to evaluate the relationship between processing speed tasks and several demographic variables, as well as the BAI.
In order to examine if anxiety played a role in performance on processing speed measures, BAI scores were computed for each participant. The mean BAI score for the older group was 28.2 ($SD = 5.5$); for the younger group it was 29.2 ($SD = 5.8$), a difference that was not found significant ($t(48) = .617, p > .05$). In order to examine the relationship between anxiety and processing speed performance, total BAI scores for each group were correlated with z scores for all processing speed measures. Significant correlations ($p < .01$) between BAI score and processing speed task were found in the younger group only on the Verbal Fluency ($r = -.529$) and File Sort tasks ($r = .582$). No significant correlations were found between BAI and Processing Speed scores for the older group. These results suggest that, overall, anxiety level (as measured by the BAI) had minimal or no effect on processing speed performance.

Correlations were computed between all processing speed task raw scores and demographic variables, which included handedness, age, education, number of traffic violations acquired in the past three years, and two Likert scale self-reports regarding perceived mental and motor speed. The only significant correlations found were between processing speed tasks and both Age (in years) and Education (broken into four levels as shown in the questionnaire); those $r$ values are reported in Table 9.

Results indicated that Education is significantly correlated with only Math Fluency ($r = .51$). Moreover, a two-way repeated measures analysis of variance examining educational level and zscore performance on processing speed tasks was conducted. No significance was found for education or processing speed tasks. However, a significant interaction was found ($F(2, 42) = 1.62, p < .05, Eta = .073$), indicating that on 3 of the 16 processing speed tasks the high
school/GED group performed significantly worse. Because the effect size of this interaction is very small, the clinical significance of this finding is negligible.

Table 9

Correlations Between Processing Speed Tasks and Demographic Information

<table>
<thead>
<tr>
<th>Task</th>
<th>Age</th>
<th>Education</th>
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</thead>
<tbody>
<tr>
<td>Coding</td>
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<td>.226</td>
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<tr>
<td>Symbol Search</td>
<td>.676**</td>
<td>.215</td>
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<tr>
<td>PASAT 2</td>
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<td>.103</td>
</tr>
<tr>
<td>Reaction Time</td>
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<td>.262</td>
</tr>
<tr>
<td>Choice Reaction Time</td>
<td>.566**</td>
<td>.272</td>
</tr>
<tr>
<td>Stone Sort</td>
<td>.526**</td>
<td>.075</td>
</tr>
<tr>
<td>Word Search</td>
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<td>.247</td>
</tr>
<tr>
<td>File Sort</td>
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<td>.142</td>
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<tr>
<td>Reading Fluency</td>
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<td>.162</td>
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<td>Math Fluency</td>
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<tr>
<td>Verbal Fluency</td>
<td>.267</td>
<td>.069</td>
</tr>
<tr>
<td>Phonebook Task</td>
<td>.499**</td>
<td>.030</td>
</tr>
</tbody>
</table>

Note. *Indicates correlation is significant at the .05 level; ** Indicates correlation is significant at the .01 level; PASAT = Paced Auditory Serial Addition Test.
A two-way repeated measures analysis of variance was conducted on scores of processing speed tasks for left and right-handed participants; no significant main effect or interaction differences were obtained for handedness. Also, using number of traffic violations acquired in the past three years (groups of none, 1-2, and 3 or more), an additional two-way repeated measures ANOVA using processing speed task z-score performance, showed no main effect or interaction differences related to traffic violation subgroups.

An additional analysis was conducted to examine the consistency of participant error rate made across multiple processing speed tasks; that is, the question was asked, are individuals who produce errors on one task more likely to generate errors on another? Figure 7 illustrates the average number of errors made for each group on tasks for which errors were possible and Table 10 shows the results from the bivariate correlational analysis that was conducted on the total sample using tasks for which errors was a recorded variable.

Figure 7. Average number of total errors for older and younger adults, on processing speed tasks
Table 10

*Correlations Between Errors on Processing speed Tasks*

<table>
<thead>
<tr>
<th>Coding</th>
<th>Symbol Search</th>
<th>Trails A</th>
<th>Trails B</th>
<th>Choice Reaction Time</th>
<th>File Sort</th>
<th>Reading Fluency</th>
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<tbody>
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<td>0.021</td>
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<td>0.111</td>
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<tr>
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<td>0.459**</td>
<td>0.381**</td>
<td>0.376**</td>
<td>0.051</td>
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<tr>
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<td>0.066</td>
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<tr>
<td>Reading Fluency</td>
<td>0.127</td>
<td>0.134</td>
<td>0.234</td>
<td>0.111</td>
<td>0.098</td>
<td>0.250</td>
</tr>
</tbody>
</table>

*Note.* ** Indicates correlation is significant at the .01 level.

Significant correlations of a low moderate magnitude were found among the error rates of CRT, Symbol Search, Trails A and Trails B. These results suggest that individuals who produce errors on one processing speed task are likely to produce errors on others. Moreover, it shows that there is consistency among processing speed measures that record error production.

Furthermore, a significant difference was found between younger and older groups’ error rates for the Trails B task ($t(48) = 2.80, p < .01$); although this difference was found statistically
significant, the average errors produced in the older group was 1 and therefore may be clinically negligible for interpretation.
Chapter 4

Discussion

The intention of this study was to evaluate the concurrent and ecological validity of common processing speed measures. This was done by administering a battery of processing speed measures to two age groups (older and younger) that are known to perform differently on processing speed tasks. Furthermore, the battery of measures was chosen to include processing speed tasks that are used regularly in neuropsychological assessment, as well as everyday tasks that “experts” deemed to substantially reflect processing speed. Also, within the literature, the construct of processing speed has been bifurcated into simple and complex types, thus distinguishing between processing speed tasks that require little cognitive effort and those which demand the integration of other faculties, such as attention and working memory (Chiaravalloti et al., 2003). Accordingly, this study included neuropsychological processing speed tasks that have been deemed simple (i.e., RT and CRT), as well as those labeled complex (i.e., PASAT).

The data collected were used to evaluate several hypotheses that are reiterated and discussed here. The first hypothesis predicted that there would be a significant relationship between processing speed measures and that this relationship would hold for both younger and older adults. Results from this study indicated that neuropsychological measures of processing speed significantly correlated with ecologically-anchored processing speed tasks, with the correlations ranging from .006 to .946. This finding was true for both the younger and older group, with the younger group’s correlations ranging from .011 to .804, and the older group’s
ranging from .006 to .946. These results add to the predictive and ecological validity of the processing speed construct by demonstrating that formal measures of processing speed relate well to paced tasks that are performed in everyday activities. Furthermore, these findings support the concurrent validity of processing speed measures by demonstrating their significant inter-relatedness across tasks. Clinically, this is an important finding because it supports the use of neuropsychological testing to identify deficits in speed of task completion, which consequently may impact level of adaptive functioning in daily life.

The second hypothesis of this study predicted that the older group would demonstrate significantly greater correlations across processing speed measures as compared to the younger group. This was anticipated because it has been shown that older adults perform with increasingly slower performance on processing speed tasks after the age of 45 (Wechsler, 2008b), and therefore, are likely to produce more variability on tasks. Statistically, a group that produces a wider data distribution on single processing speed tasks and also performs consistently across tasks will create larger correlations. However, results indicated that, overall, there was no difference between groups and their inter-correlations across processing measures. This finding is interesting in that it supports the predictive validity of processing speed measures across tasks and age groups.

A third hypothesis was that complex neuropsychological processing speed tasks would correlate greater with complex ecological tasks and similarly, simple neuropsychological processing speed tasks would correlate greater with simple ecological tasks. Because this study included only 50 participants, a factor analysis could not be used as a means to demonstrate differentiation between simple and complex processing speed tasks. Instead, magnitude of
correlation between complex vs. simple and ecological vs. neuropsychological processing speed tasks was compared. This was done by calculating the percentage of tasks that correlated with other tasks at or beyond a .05 level. Those tasks deemed simple processing speed in the neuropsychological literature (RT and CRT; Chiaravalloti et al., 2003) produced the lowest number of significant correlations with other tasks (combining age groups, RT produced 9 and CRT produced 12 significant correlations with other tasks), compared to more complex tasks which produced more than twice the number of significant correlations (combining age groups, PASAT produced 28 significant correlations with other tasks). This finding supports the differentiation of processing speed into complex and simple forms, illustrated by the limited degree to which RT and CRT correlated with other tasks. Interestingly, these findings imply that the ecological tasks used in this study relate better to complex forms of processing speed measures, such as the PASAT or Trails B. This finding may be made more clear by bearing in mind that complex processing speed incorporates new learning, memory, and concentration (Chiaravalloti et al., 2003), while simple processing speed tasks require minimal attention or cognitive manipulation. Considering that in real world activities it is rare for an individual to accomplish a task that does not involve multiple cognitive faculties simultaneously employed, it is then understandable that the ecological tasks used in this study more highly correlated with complex processing speed measures which draw upon working memory, sustained attention, and executive functioning.

The fourth hypothesis of this study predicted that the older group would produce significantly lower scores on all processing speed measures compared to the younger group. Results confirmed this hypothesis, which was highly expected and has been shown in both past
research (Salthouse, 1996) and in the raw scores produced for processing speed subtests of cognitive assessment tools, such as Coding and Symbol Search on the WAIS-IV (Wechsler, 2008a). One exception to this age difference was found on the Math Fluency task. The non-significant results found with this task may reflect the familiarity, simplicity, and over-learned nature of the content of this particular task, namely calculating the sums of two single integers.

One theory proposed by Salthouse (1996) explains how complex processing speed can impact performance on tasks that require higher cognition, particularly in older adults who typically show age-related decline in their processing speed abilities. Specifically, two mechanisms have been identified: a “limited time mechanism,” and a “simultaneity mechanism.” Simply stated, the “limited time mechanism” suggests that, with slower processing speed, an individual will process less information in a given amount of time. Likewise, the “simultaneity mechanism” states that, with slower processing speed, earlier processed information will not be accessible or will be irrelevant at a later stage of processing. These mechanisms may account for the significant discrepancy seen between younger and older adults. For instance, when older adults attempt to complete the PASAT, their slower processing impacts them in two ways. First, they are unable to produce as many correct responses (limited time mechanism) because the task is going too fast for them to keep up, and therefore they can only respond intermittently. Secondly, slower processing prevents older adults from accurately encoding and/or retrieving the correct information (simultaneity mechanism) that will be required to produce the next correct response (adding previous number heard to the next one said aloud) resulting in more errors.

When comparing this study’s results to the current literature, corroborative evidence is found that supports other investigations (Chiaravalloti et al., 2003; Verhaeghen & Salthouse,
1997). For example, similar to Chiaravalloti et al. (2003), the current study utilized a variety of formal neuropsychological processing speed measures to investigate their concurrent validity. Similar to their findings, the current study observed a difference between RT/CRT tasks and more complex processing speed tasks such as Trails A and B. That is, RT and CRT tasks were not as inter-correlated with other processing speed measures.

In a meta-analyses conducted by Verhaeghen and Salthouse (1997) looking at the relationship between age and cognition, a mean correlation of .52 between age and processing speed task was found. In the present study, a mean correlation between age and processing speed task was .45, with correlations ranging between .015 (Math Fluency) and .676 (Symbol Search). Therefore, the current study’s findings regarding the relationship between age and processing speed performance, are comparable to what literature has shown.

Furthermore, this study was able to expand upon those studies by including measures that are more reflective of real world tasks, thereby providing consensual validation to the construct of processing speed generally, as well as to the WAIS-IV subtests specifically purporting to measure this construct. These results provide empirical support to the often-used processing speed definition of “time required to execute a cognitive task or the amount of work that can be completed within a finite period of time” (DeLuca, 2008, p. 266). As a result of this investigation, there is an empirical basis for WAIS-IV users to expect a relationship between the test’s Processing Speed Index and performance on everyday tasks, such as how quickly one can read, write, file something alphabetically, use a phonebook, as well as complete simple math calculations. Although the task demands of looking something up in a phonebook and completing the WAIS-IV Coding subtest seem rather different, the inter-correlations between
these tasks are indeed significant (in the older group, the correlation between the phonebook task and Coding was .74), greater than the inter-correlation given in the test’s Technical and Interpretive Manual (Wechsler, 2008c) between the ostensibly similar two subtests comprising the WAIS-IV Processing Speed Index (.65). Given the significant inter-correlations found between neuropsychological and everyday measures of processing speed, this study provides strong supporting evidence for a construct of processing speed; no supporting evidence is provided in the WAIS-IV test Technical and Interpretive Manual (Wechsler, 2008c).

**Limitations and Future Research**

One of the limitations of this study was an insufficient sample size to compute a factor analysis using all processing speed tasks. The importance of this statistical procedure is that it could have provided additional support for simple and complex processing speed domains (i.e., RT and CRT performance load on separate factors than PASAT and Trails B). Furthermore, it would have been interesting to see how everyday processing speed tasks factored in relation to the neuropsychological measures. Therefore, replication of this study with a significantly larger sample size would be worthwhile because a factor analysis could be completed.

Another limitation to this study was the sampling procedure. Although precautions were taken to select participants that would closely match demographic census criteria of age, gender, education, and ethnicity, the sample was not reflective of the census proportions. Specifically, because of difficulty finding and enlisting them, there were relatively few participants who had either not finished high school or had only obtained a general education degree. This limitation may limit the generalizability of the results to those within the population who have lower educational achievement.
A third limitation to this study was the exclusion of discriminant validity tasks. That is, it would have been beneficial to have included tasks that were not expected to relate with processing speed measures, such as spelling or perceptual reasoning ability. Inclusion of such tasks and finding lower correlations with them, would have aided in more soundly establishing the construct validity of processing speed.

A fourth limitation was the above average mean scaled score obtained on the Coding (12.92) and Symbol Search (13.03) subtests within the younger group. This presents a limitation in that the younger sample obtained may over-represent an above average group and therefore generalize less to the normal population. Furthermore, because Coding and Symbol Search represent a domain of intelligence (Wechsler, 2008a), this result may also suggest that the differences seen in processing speed performance between age groups may be more reflective of a discrepancy in IQ. To address this, an analysis of covariance (ANCOVA) was performed using Coding as the covariate. Results indicated that age groups still performed significantly differently across tasks. Therefore, an aspect of intelligence is unlikely the factor contributing to differences in processing speed performance.

As processing speed is further evaluated, future research should continue to explore how this peculiar construct, which has been deemed to be both a major component in aging (Birren & Fisher, 1995) as well as a mediating factor in the development of general intelligence in adolescence (Coyle, Pillow, Snyder, & Kochunov, 2011), relates to real world performance. Much like what has been pointed out in the executive functioning literature (Barkley, 2011), little research has been conducted on the ecological validity of formal processing speed measures. In addition, as processing speed continues to become noticed as an integral part of higher order
cognitive functions, research would benefit from further delineating the underlying mechanisms by which processing speed operates and interacts with other cognitive faculties, such as working memory, attention and executive functioning. Furthermore, although the definition of processing speed that DeLuca has suggested, “Processing speed refers to either the time required to execute a cognitive task or the amount of work that can be completed within a finite period of time” (DeLuca, 2008), was preferred in this study, its definition would benefit from continued refinement, particularly in light of it’s simple and complex domains.
References


Appendix A

Volunteer Form
VOLUNTEERS WANTED

GET A $10 GIFT CARD

Those who participate will also be entered into a drawing for a chance to win a $100 GIFT CARD

Are you interested in participating in research that will benefit the field of clinical psychology? If “YES,” please read the following information:

- Are you between the age of 18 – 35 or 60 – 80?
- Have about 1-hour of free time?
- If so, please call the number below.

Contact Jeff Sordahl at (555) 555-0125
Appendix B

Screening Form
**Age:**___________  **Gender:** M F  **English Primary Language:** Yes No

**Education**

- [ ] Some high school/no diploma
- [ ] High school diploma, GED
- [ ] Some college/no degree or associates degree
- [ ] Bachelors Degree/ Graduate/ Professional Degree

<table>
<thead>
<tr>
<th>Screening Questions (To be asked upon first contact of participant)</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have difficulty reading the size print found on newspapers?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Do you have difficulty hearing what others say to you at home or in a store?  
(Examiner should take note if participant is having a significantly difficult time hearing or understanding the questions being asked. If yes, exclude the participant from testing.) | | |
| Do you have any difficulty when doing things like tying your shoes or writing? | | |

**Have you ever had**

- Stroke?
- Seizure?
- Head injury?

**Do you have**

- Bipolar disorder?
- Schizophrenia?
- Dementia?
- Drug or Alcohol Abuse

**Are you currently on any medications that sometimes negatively affect your ability to think clearly or concentrate?**

<table>
<thead>
<tr>
<th>Mental Status Questions</th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
</table>
| What is the 3rd month of the year?  
(March) | | |
| What are the 1st and 7th letters of the alphabet?  
(A & G) | | |
| How much is 5 + 6 = ?(11) | | |
Appendix C

Questionnaire
Questionnaire

**Name:** ________________________________

**Date of Birth** __________   **Age:** __________   **Today’s Date** __________

**Gender** [ ] Male   [ ] Female   **Handedness** [ ] Left   [ ] Right

**Ethnicity** [ ] Latino/Latina   [ ] African American   [ ] Caucasian   [ ] Asian
   [ ] Native American/First Nations   [ ] Other

**Education** [ ] Some high school/no diploma   [ ] High school diploma, GED
   [ ] Some college/no degree or associates degree
   [ ] Bachelors Degree/ Graduate/ Professional Degree

**Occupational Field** [ ] Business/Finance   [ ] Legal Occupations
   [ ] Health/Medical/Social Services   [ ] Education/ Teaching   [ ] Art, Sports, Media, & Entertainment
   [ ] Engineering/Architecture   [ ] Computer Sciences   [ ] Other ______________________

**Number of traffic violations in the past 3 years (including accidents or speeding tickets that were or were not your fault)** _______

---

<table>
<thead>
<tr>
<th>Please respond to the following question with the best of your knowledge</th>
<th>Slower</th>
<th>Average</th>
<th>Faster</th>
</tr>
</thead>
<tbody>
<tr>
<td>How fast “mentally” are you compared to those your age? (e.g., Time it takes you to think through a problem or remember something from past knowledge)</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How fast do you move compared to others your age in doing things like preparing a meal or walking to the mailbox?</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D

Consent Form
George Fox University
Graduate Department of Clinical Psychology

INFORMED CONSENT FORM

You are being asked to participate in a research study conducted by Jeff Sordahl, M.A. You will be asked to perform a number of tasks that will take approximately 50 minutes to complete. You are asked to participate due to meeting qualifications for this study. Your identity will be kept confidential. There are no anticipated discomforts or risks participating in this study. However, there is always the chance that there are some unexpected risks, such as fatigue. If you feel uncomfortable or distressed, please tell the researcher and he/she will ask you if you want to continue. If you find some of the language difficult to understand during the instruction, please ask the researcher about this form.

By agreeing to the informed consent you will be consenting to participate in the study. At any time, you have the freedom to withdrawal or not respond, but for the purposes of the adequate data collection, the researchers ask for your full participation. Participants who complete this study have an opportunity to receive a summary of the results after the study is completed. If interested, email Jeff Sordahl at jsordahl08@georgefox.edu. If you have any concerns about the testing process, you may contact Dr. Wayne Adams of the George Fox University Graduate Department of Clinical Psychology. Dr. Adams is available at (503) 554-2370 or waadams@georgefox.edu.

The collection of results from this research may be used for scientific or educational purposes. It may be presented at scientific meetings and/or published in professional journals or books. The results of the study, if presented at a professional forum or if published, will have no identifying information that would connect you to the specific results.

By completing your participation in this research you will be rewarded with a $10 gift card and your name will be entered into a drawing to win an additional $100 gift card to Target that will be chosen at the conclusion of this project. If your name is drawn for the $100 gift card, we will mail it to the destination you designate below.

If you consent to participating in this research, please sign the following.

___________________________  _____________________________  ______________
Please print name  Please sign name  Date

If you wish to have your name entered into the $100 Target gift card drawing, please fill out the following so that we may mail it to you if your name is drawn.
Name________________________
Address to mail gift card
Appendix E

Coding Directions and Sample
Coding Directions

The Coding subtest is on the back of the Response Booklet (page 8). Turn the Response Booklet over so the Coding subtest is visible and place it in front of the examinee. Ensure that the examinee sees only Coding. Point to the key at the top of the page and say, Look at these boxes. Each box has a number in the top part (point across the numbers from 1 to 9) and a special mark in the bottom part (point across the symbols). Each number has its own mark (point to 1 and its symbol, then to 2 and its symbol).

Point to the demonstration items and say, Down here, the boxes have numbers in the top parts but are empty in the bottom parts. You are to draw the marks that belong in the empty boxes, like this.

Point to the first demonstration item (6) and say, Here is a 6. The 6 has this mark (point to the key to show its corresponding symbol), so I draw that mark in the box, like this (write the symbol).

Point to the second demonstration item (8) and say, Here is an 8. The 8 has this mark (point to the key to show its corresponding symbol), so I draw that mark in the box (write the symbol).

Point to the third demonstration item (3) and say, Here is a 3. The 3 has this mark (point to the key to show its corresponding symbol), so I draw that mark in the box (write the symbol).

Proceed to Sample Items.

Hand the examinee a #2 pencil without an eraser and say, Now you do these (point to the sample items). Stop when you get to this line (point to the heavy line that separates the sample items from the test items).

Allow the examinee to work alone on the remaining sample items. If a left-handed examinee partially blocks the key with his or her left hand while completing the sample items, stop the administration. Place an extra Response Booklet, opened to the Coding subtest, to the right of the examinee’s Response Booklet. Position it so the extra key is aligned with the key the examinee’s hand is blocking. Have the examinee complete the remaining sample items using the extra key, so he or she will be accustomed to the arrangement when completing the test items.

If the examinee completes the sample items correctly, offer praise such as Yes or Right and, finally, Now you know how to do them.
Say, When I say go, do these the same way. Start here (point to the first test item), go in order, and don’t skip any. Work as fast as you can without making mistakes until I tell you to stop. Are you ready?

Explain further if necessary, then say, Go. Begin timing and allow 120 seconds. If necessary, remind the examinee to go in order and continue working. Give no further assistance.

If the examinee is still working at 120 seconds, stop timing and say, Stop. Record the completion time as 120 seconds.

Remove the Response Booklet and pencil from the examinee’s view before proceeding to the next subtest.

Coding Sample
Appendix F

Symbol Search Directions and Sample
Symbol Search Directions

**Sample Items**

1. Hand the examinee the pencil without an eraser. Point to Sample Items, and say, "Now do these here. Go ahead."
   Allow the examinee to work on the sample items.
   - The first and third sample items contain a matching symbol in the search group.
   - The second sample item does not.
   - The examinee should mark the matching symbols on the sample items.

2. Correct responses:
   - Check the correct responses immediately, as follows:
   - If the examinee does not mark the NO box on both target symbols, note that.
   - If the examinee does not mark the NO box on both target symbols, note that.
   - If the examinee marks the NO box on both target symbols, note that.

**Test Items**

- Correct responses:
  - Draw a diagonal line through the NO box.
  - If the examinee marks the NO box on both target symbols, note that.
  - If the examinee does not mark the NO box on both target symbols, note that.

**Administration Items**

- Place the Response Booklet in front of the examinee, and ensure the examinee sees the Demonstration Item. One of these shapes (point to each target symbol). This shape is the same as one of these shapes (point to each target symbol) on the search group.
- If the examinee marks the NO box on both target symbols, note that.
- If the examinee does not mark the NO box on both target symbols, note that.
- If the examinee does not mark the NO box on both target symbols, note that.
- If the examinee marks the NO box on both target symbols, note that.

- Place the Response Booklet in front of the examinee, and ensure the examinee sees the Demonstration Item. One of these shapes (point to each target symbol). This shape is the same as one of these shapes (point to each target symbol) on the search group.
- If the examinee marks the NO box on both target symbols, note that.
- If the examinee does not mark the NO box on both target symbols, note that.
- If the examinee does not mark the NO box on both target symbols, note that.
- If the examinee marks the NO box on both target symbols, note that.
Symbol Search Sample
Appendix G

Stone Sort Task
Stone Sort Task

Arrangement

• Place box of stones approximately 6” from participants midline on table
• Place the 3 cups approximately 3” behind the stone box and spread 6” apart from one another. The cups should be placed parallel with the table and in the following order from the participants left to right, red, blue and gray. The blue cup should be approximately 3” above the stone box. See Figure 3 for example.

Directions

• Examiner reads aloud, “In front of you is a box full of three different color stones, red, blue and gray. For this task, I would like you to place those stones (examiner grabs a red button) into the bowls that match their color (put red button into red cup) as quickly as you can. You may only move one stone at a time, using your dominant (right/left) hand. Make sure that each stone is placed into the matching colored bowl because misplaced stones will not count. For practice, place one stone from each color into their matching bowl. “

(If correct) “When I say “go” begin placing the stones as quick as you can and stop when I say, “Stop.” Are you ready? GO” (Begin timing once the participant has touched the first stone)

(If no) Demonstrate to the participant how to place each colored stone into their appropriate cup (red button to red cup, blue button to blue cup). Have the participant do one practice placement to assure understanding. Once participant understands the task, continue with instructions above.

During Administration
• Make sure participant is placing stones one at a time. (If not) say “Please place the stones one at a time.”

• If participant becomes distracted and slows down the examiner should say the following, “Please work as quickly as you can.”

• If the participant forgets the directions during the administration the examiner should say, “Remember that the stones need to be placed into the bowl that matches their color.” The examiner does not need to remove any incorrectly placed stones, but should not count them when scoring.

Scoring

• After 60 seconds has elapsed, count the number of stones that were correctly placed in each cup and record the number.

• Score = number of correctly placed stones within 60 seconds

• Misplaced stones should be discarded from scoring.
Appendix H

Phonebook Search
Phonebook Search

Arrangement

• Place the Phonebook approximately 6” from the participant’s midline on the table in front of him/her.

• Place the list of names on the table to the participant’s writing hand side.

Directions

• Examiner should place the Phonebook and list of names in front of the participant.

• Examiner reads aloud, “In front of you are a phonebook and a list of three names. Below each name listed is a space for you to fill in the phone number associated with the name. When I say, “go,” search the phonebook for the three listed names and record their phone number in the given space (Examiner points to space next to each name). The correct names in the phonebook are highlighted in yellow so that you will know you have found the correct name to record the number. Are you ready?

• (If yes) “Begin searching and let me know when you have found all the correct numbers. The examiner should begin timing and end timing once the participant has found all five numbers.

• (If no) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During Administration

• If the participant attempts to record a name that hasn’t been highlighted say, “Remember that the correct names have been highlighted in yellow.”
• If the participant takes longer than 5-minutes to complete the task, stop timing, record the number of correct numbers found and move onto the next subtest.

**Scoring**

• Record the trial time in seconds between the examiner’s “Go” and the participant finding all three names.

• If the participant goes beyond 5-minutes, record the number of correct numbers found.
Appendix I

Word Search Task
“THE” Word Search

Arrangement

• “THE” Story Search should be placed on table in front of participant. Allow him/her to position it so writing comfortably.

Directions

• Examiner reads aloud, “In front of you is a Story. The objective of this task is to identify the word “THE, T-H-E” within the story (point to the example “THE” on the top of the sheet). Read the story from the beginning to end, and when you find a “THE,” circle it with your pen. You will have 1-minute to find as many “THE’s” as you can. There are 56 “THE’s” total in the story, let me know if you have found them all, otherwise, I will ask you to stop after 1-minute. Are you ready?

• (If yes) When I say, “Go,” begin your search, remember to circle each “THE” you find. Ready? Go.” (Examiner should begin timing on the word “go” and stop once 60-seconds has elapsed or the participant has found all THE’s).

• (If no) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During Administration

• If the participant believes they are finished, but actually are not, the examiner should say, “There are still more to find, please keep looking.”

• If the participant begins to circle words other than “THE,” tell them “Remember you are trying to find the word “THE” (point to the example “THE” on the top of the page).
Scoring

• The participant’s score is calculated by the total correctly circled “THE’s” identified (A maximum of 56 “THE’s”).

Circle “The, the”

The orange cat chases the mouse around the kitchen as the cat’s owner cooks dinner. The mouse dashed under the table towards the small hole in the wall, but the orange feline is too quick and the mouse quickly maneuvers towards the cracked door leading outside to the tiny rodents’ freedom. As the mouse approaches the gap in the door, the cat’s owner takes notice of the chase in pursuit and quickly flings the backdoor open to allow the mouse more space for escape. The mouse scurries across the linoleum floor towards the sunlight beaming through the open door. The orange cat follows close behind the little gray mouse. The mouse’s tail wiggles left to right with every step towards freedom, only furthering the cat’s curiosity towards the little creature. As the mouse crosses the threshold of the backdoor, he leaps into the sunlight towards the blades of grass below him. The cat watches as the mouse lifts off the ground and is carried through the air towards the maze of green outside. In an attempt to foil the mouse’s relentless effort, the orange cat takes on his tiger like instincts and pounces towards the mouse with the speed of a cheetah and the force of a lion. With claws extended and fangs bared, the feline predator hurls towards its prey. The cat feels the air rushing past his whiskers and sees the wormy tail of the little gray mouse floating in the air just ahead of him. In a last ditch effort; the cat unloads his air assault clasping his paws together like a steel bear trap. The cat hits the floor with a thud, paws still closed with vice grip strength. After a split second to recover from
the plummet, the cat quickly looks at his paws to view his prize. Unclasping his sore red paws, the cat’s ears droop in disappointment to find a little wormy tail, but no gray mouse attached. Looking outside, the cat sees a jostling tower of grass in the distance.
Appendix J

Filing Task
File Sort

**Arrangement**

- Place the filing container on the table approximately 6” from the participant’s midline.
- Take the 20 (9.25”x 11.75 ”) cards, with fictitious last names written in the upper right hand corner and order them accordingly:

<table>
<thead>
<tr>
<th>Jackson</th>
<th>Adams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vogel</td>
<td>Willis</td>
</tr>
<tr>
<td>Smith</td>
<td>Crones</td>
</tr>
<tr>
<td>Hanson</td>
<td>Davis</td>
</tr>
<tr>
<td>Tibbles</td>
<td>Bailey</td>
</tr>
<tr>
<td>Evans</td>
<td>Green</td>
</tr>
<tr>
<td>Fredrick</td>
<td>Lorenson</td>
</tr>
<tr>
<td>Nicholson</td>
<td>Kelly</td>
</tr>
<tr>
<td>Monroe</td>
<td>Peterson</td>
</tr>
<tr>
<td>Orson</td>
<td>Renolds</td>
</tr>
</tbody>
</table>

- Place the cards name-side down on the table between the filing container and the participant, or approximately 3” from the container and the participant
- Examiner should stand to the left or right of participant during administration
Directions

• Examiner say’s the following; “In front of you are 20 files with last names written on them. Behind those files is a container for them to go into. The object of this task is for you to place the files into the container in alphabetical order beginning with names that start with the letter A and progressing to B and so forth. For practice, file these three cards with the names ADAM, RYAN and DEXTER into the container one at a time alphabetically (give example cards to the participant and allow them to file).

• (If the participant files the example correctly) “Good. Now I would like you to file the rest of the cards into the container. When I say, “Go,” you may turn the cards over and begin filing them in alphabetical order one at a time. Remember that you must start with letters at the beginning of the alphabet and move onto the other letters in alphabetic order. You will have 5-minutes to complete this task, but if you finish early let me know. Ready, “Go.” Begin timing at the moment the participant touches the deck of cards and stop when either the participant has completed the task correctly from a-z /z-a (although direction call for a-z order, z-a will still be considered correct) or once 5-minutes has elapsed.

• (If the participant does not complete the example) “Watch me do it, I would put them alphabetically in the container in the following order: ADAM then DEXTER and lastly, RYAN. (Examiner should take out the folders and allow the participant to try again) Go ahead and try filing the folders in alphabetical order.” The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During administration
If the participant forgets how they are supposed to file the cards say, “**remember they are to go in alphabetical order.**”

**Scoring**

- The score for this task will be the total time it took for the participant to correctly file the cards in alphabetical order (A-Z or Z-A) recorded in seconds.
- The examiner should also record the number of errors made (files placed out of alphabetic order).

### Correct File Ordering

<table>
<thead>
<tr>
<th>A – Z</th>
<th>Z – A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>Willis</td>
</tr>
<tr>
<td>Bailey</td>
<td>Vogel</td>
</tr>
<tr>
<td>Crones</td>
<td>Tibbles</td>
</tr>
<tr>
<td>Davis</td>
<td>Smith</td>
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Appendix K

Verbal Fluency
Verbal Fluency

Arrangement

- Have the participant seated at the desk.
- Examiner may be seated in front of them.
- Place audio recorder on the table between the participant and examiner and press play.

Directions

- The examiner should read the following aloud, “For this task I would like you to tell me a story about either your favorite vacation or your dream vacation. I will be recording your story so that I may play it back later. I will first give you 15 seconds to think about what story you would like to tell me. I will then say, “Begin” and you may start telling me your story. You will have 45 seconds to tell me the story in as much detail as possible, after which I will ask you to stop. Are you ready?”
- (If yes) Remember, when I say, “Begin,” start telling me your story and when I say, “Stop” you must stop telling your story. You now have 15 seconds to think about your story. The examiner will give the participant 15 seconds to think. After 15 seconds have elapsed say, “Begin” and start timing on the stopwatch. After 45 seconds have elapsed, the examiner should say, “Stop” and end timing.
- (If no) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During administration
• If the participant stops talking for a period longer than 15-seconds say, “You still have more time, tell me more if you can.”

• If the participant begins to tell you something obviously not related to their vacation (i.e., participant begins asking the examiner questions), the examiner should say, “Please only tell me about your vacation.”

Scoring

• Verbal speed Score = words spoken per second

• The examiner should listen to the recording of the participant’s response and count the number of words spoken within the 45 second time frame.

• Disregard filler responses from being scored, such as: umm, hmmm, “like” used incorrectly (i.e., “like, that is like, really neat.”)

• Score = # words spoken / 45 seconds
Appendix L

Math Fluency
Math Fluency

Arrangement
• Have the participant seated at the desk.
• Examiner may be seated in front of them.
• When presenting the Math Sheet, place it flat on the table approximately 3” from the participant.

Directions
• The examiner should read the following aloud, “For this task I will be giving you a page of simple addition problems. You will have 30-seconds to complete as many of the problems you can. If you can’t figure one out, skip it and go on to the next one. Begin once I hand you the sheet of paper with the problems on it and I will tell you to stop after 30-seconds. Do you have any questions?
• (If no) The examiner should place the sheet of math problems flat on the table in front of the participant approximately 3” away from the table’s edge. The examiner will begin timing once the participant’s pencil touches the paper. After 30-seconds have elapsed, the examiner should say, “Stop” and end the procedure and record the number of items correctly answered.
• (If yes) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During administration
• If the participant “gets stuck” on a problem, say “Skip that one if you don’t know how to do it.”
### Processing Speed Measures

**Scoring**

- Number of correctly solved math problems after 30-seconds

#### Math Fluency Sheet

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| 8  | +3 | +5 | +5 | +9 | +7 | +8 |

| 7  | +7 | +9 | +8 | +9 | +2 | +1 |

| 7  | +3 | +6 | +2 | +8 | +3 | +9 |

| 1  | +9 | +8 | +2 | +5 | +3 | +4 |

| 2  | +5 | +1 | +9 | +6 | +3 | +6 |

| 1  | +7 | +4 | +8 | +8 | +2 | +8 |
Appendix M

Reading Fluency
Arrangement

• Have the participant seated at the desk.
• Examiner may be seated in front of them.
• When presenting the paragraph, place it flat on the table approximately 3” from the participant.
• The examiner should also have a copy of the paragraph to record any errors made by the participant.

Directions

• The examiner should read the following aloud, “For this task I would like you to read a short paragraph to me. Begin reading immediately once I hand you the paragraph. Do you have any questions?”
• (If no) The examiner should hand the participant the paragraph. The examiner should begin timing once the participant begins to read. The examiner will circle any errors made on the examiners paragraph form. Errors include words missed, added, or changed. The examiner should stop timing once the participant has read the last word of the paragraph.
• (If yes) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During administration

• If the participant cannot pronounce a word and asks the examiner for help, the examiner should say, “Skip that word and continue.”
Scoring
• The examiner should record the total time in seconds to read the paragraph, as well as the number of errors made (words missed, added, or changed).

Reading Fluency Paragraph

Ben plans to go hiking on Sunday with three of his best friends. The hike will take 4-hours to complete and will be 6-miles round-trip. Ben hopes to stop for lunch at the top, which overlooks the surrounding valley. He has prepared a peanut butter and jelly sandwich to eat, but is worried that it may get smashed in his backpack. Ben decides that it would be best to take his plastic lunch pail. It will take up extra room in his backpack, but now his sandwich won’t be smashed.
Appendix N

Reaction Time
Reaction Time

Arrangement

• Have the participant seated in front of the computer.
• The computer’s keyboard should be placed within 3” of the table’s edge and centered in front of the participant.
• The computer monitor should sit 12” centered behind the keyboard.

Directions

• The examiner should read the following aloud, “For this task I would like you to watch the computer screen and press the button marked “X” as fast as you can whenever you see an X appear. Also, when you see an X appear on the screen, make sure to press the button using your right/left hand (participant’s dominant hand). Do you have any questions?”
• (If no) The examiner should begin the Reaction Time program and begin testing
• (If yes) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

During administration

• If the participant begins to use either both hands or their non-dominant hand say, “Only use your right/left (dominant) hand to press the button.”

Scoring

• The score for this test will be the average time in seconds to respond to the stimuli.
Appendix O

Choice Reaction Time
Choice Reaction Time

Arrangement

• Have the participant seated in front of the computer.
• The computer’s keyboard should be placed within 3” of the table’s edge and centered in front of the participant.
• The computer monitor should sit 12” centered behind the keyboard.

Directions

• The examiner should read the following aloud, “For this task I would like you to watch the computer screen and, as fast as you can, press the button marked “X” whenever you see an X appear and the button marked “O” whenever you see any letter other than X appear. For example, if you see the letter A, D, or J, you would press the button marked “O.” Do you have any questions?”
• (If no) The examiner should begin the Reaction Time program and begin testing
• (If yes) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

Scoring

• The average time in seconds to respond to the stimuli will be recorded, as well as number of errors made
• Choice Reaction Time score = CRT (avg/sec) – RT (avg/sec)
Appendix P

Copy Task
Copy Task

Arrangement

• Place the Copy Task Sheet in front of the participant flat on the table

Directions

• “For this task I would like you to copy these three sentences in the lines given below (The examiner should point to the three sentences and to the lines below each sentence for the participant to copy onto. When I say, “go,” quickly copy these sentences. Don’t worry about neatness, however, don’t leave out or misspell words. Do you have any questions?”

• (If no) The examiner should begin testing and timing once saying “go.”

• (If yes) The examiner should clarify any confusion the participant may have and begin testing once the participant understands the directions.

Scoring

• The score for this task is the time in seconds for the participant to copy (correctly) the three sentences and the number of correctly written words.

• If the participant has not finished after 5 minutes, end timing and record the number of correct words written.
Copy Task Protocol

Ben plans to go hiking on Sunday with three of his best friends. The hike will take 4-hours to complete and will be 6-miles round-trip. Ben hopes to stop for lunch at the top, which overlooks the surrounding valley.
Appendix Q

Curriculum Vitae
Jeffrey A. Sordahl

11425 SW Zurich St Apt #302 • Newberg, Oregon 97070 • PHONE (206) 661-5368
EMAIL jsordahl08@georgefox.edu

Education

2008 - Present  
**Student in Doctor of Psychology Program**  
Graduate Dept of Clinical Psychology (*APA-Accredited*)  
George Fox University, Newberg, OR  
Anticipated Date of Graduation, spring 2013

2010  
**Master of Arts**  
Graduate Dept of Clinical Psychology (*APA-Accredited*)  
George Fox University, Newberg, OR

2007  
**Bachelor of Arts, Psychology**  
University of Washington, Seattle, WA

Honors

2010  
**Special Commendation Award**  
Graduate Department of Clinical Psychology  
George Fox University, Newberg, OR

2009  
**Richter Research Scholar Grant Recipient**  
Richter Foundation ($1,000)  
“Ecological Validity of Processing Speed Measures”

Clinical Training

2010 – Present  
**Practicum II**  
Oregon Health and Science University  
Family Medicine at Richmond Clinic  
Portland, OR  
Responsibilities:

- Psychotherapy to a diverse group of patients, including the uninsured and those on Medicaid or Medicare, within an integrated Behavioral Health, Primary Care model
- Psychological assessment, typically including
  - ADHD
  - Memory
  - Learning Disorders
• Neuropsychological Screening

  Behavioral Health consultation to primary care physicians Conduct research related to the integration of behavioral health within a primary care medical setting

  **Supervisor:** Tami Hoogestraat, PsyD

2010 – Present

  **Supplemental Practicum**
  **George Fox Behavioral Health Clinic**
  **Newberg, OR**
  **Responsibilities:**
  • Conduct neuropsychological assessments for patients referred from Providence Newberg Medical Center

  **Supervisor:** Joel Gregor, PsyD

2010 – Present

  **Supplemental Practicum**
  **Providence Newberg Hospital**
  **Newberg, Oregon**
  **Responsibilities:**
  • As part of a 24/7 on-call team, provide risk assessments for the Providence Newberg Medical Center’s Emergency Department, Intensive Care Unit, and Medical/Surgical unit.
  • Consultation to hospital personnel, including physicians, nurses, and social workers, regarding patient safety and need for hospitalization.

  **Supervisor:** Mary Peterson, PhD

2009 – 2010

  **Practicum I**
  **New Urban High School**
  **North Clackamas, OR**
  **Responsibilities:**
  • Academic and cognitive assessment
  • Counseling services to high school students, including cognitive-behavioral therapy, career counseling, classroom observation, and in-take interviews

  **Supervisor:** Fiorella Kassab, PhD

2009

  **Pediatric Neuropsychology Volunteer**
  **Oregon Health and Science University**
  **Doernbecher Children’s Hospital**
  **Portland, OR**
  **Responsibilities:**
  • Organize patient referrals for research purposes
  • Create spread sheets for data collection
  • Observe clinical evaluations

  **Supervisor:** Robert Butler, PhD, ABPP-Cn
2008 – 2009  Pre-practicum  
George Fox University  
Newberg, OR  
Responsibilities:  
• Brief individual therapy with undergraduate students  
• Treatment planning  
• Weekly individual and group supervision, with videotape reviews  
Supervisor: Clark Campbell, PhD, ABPP

Research Experience

Presentations


Other Research Experience

2008 - Present  **Research Team Member:** George Fox University, Newberg, OR  
**Duties:** Meet bi-monthly to discuss dissertation progress and assist team members with research design and methodology.  
**Dissertation Topic:** Processing Speed Assessment An examination of the concurrent and ecological validity of processing speed.  
**Advisor:** Wayne Adams, PhD ABPP-CI

2008  **Research Assistant:** George Fox University, Newberg, OR  
**Duties:** Completed statistical analyses of WRAML2 index and subtest scores as well as academic achievement scores using SPSS. Tables of the correlations using Excel  
**Supervisor:** Wayne Adams, PhD ABPP-CI

2007  **Lab Assistant:** University of Washington, Seattle, WA
Mizumori Behavioral Neuroscience Lab

**Title:** Spatial Context Representations Across Neural Systems: Regulations by Dopamine  
**Duties:** Assisted in collecting and entering data, created stereotrodes for neural recording, trained rats to complete a radial arm maze with a differential reward system.  
**Supervisor:** Sherri Mizumori PhD, Katie Gill PhD

2005  
**Research Assistant:** Abilene Christian University, Abilene, TX  
**Title:** The Validity of the Trauma Symptom Checklist for Young Children  
**Duties:** Assist in running SPSS correlations and interpreting results.  
**Supervisor:** Jeffrey N. Wherry PhD

### Teaching Experience

2010 – Present  
**Teaching Assistant**  
*Cognitive Assessment*  
Graduate Department of Clinical Psychology  
George Fox University, Newberg, OR  
Duties include planning and teaching weekly labs on administering, and interpreting various cognitive tests including several related to IQ and academic achievement, as well as grading lab assignments. Guest lecturer on “The Woodcock Johnson.”

2011  
**Guest Lecturer**  
*Building a Neuropsychological Battery for Dementia*  
Family Medicine at Richmond  
Oregon Health and Science University, Portland, OR

### Volunteer Experience & Activities

2010  
**National Academy of Neuropsychology Conference**  
**Vancouver British Columbia**  
Student Volunteer, helped with the organization of and attended conference workshops

2009  
**Super Bowl Party for the Homeless**  
**Men's Burnside Shelter, Portland, OR**  
Served snacks and dinner to the homeless

2008 – 2011  
**Serve Day Volunteer**  
**Juliette’s House, McMinnville, OR**  
Provided building maintenance and yard work for a non-profit child abuse assessment center.

2006  
**Note Taker for Students with a Disability**  
**University of Washington, Seattle, WA**
Provided notes for a fellow student in a Biology course.

**Professional Affiliations & Leadership Experience**

2011 – Present  
American Psychological Association – Division 40 Association for Neuropsychology Students in Training

2009 – Present  
**Student Mentor**  
Mentored incoming George Fox University PsyD students

2009 – Present  
**ABPP Student Member**

2008 – 2010  
**Student Council Representative to Student Council of the Graduate Department of Clinical Psychology**, George Fox University, Newberg, OR

2008 – Present  
American Psychological Association – Graduate Student Affiliate  
- Division 40 Clinical Neuropsychology  
- Division 38 Health Psychology

2009 – Present  
**National Academy of Neuropsychology – Graduate Student Affiliate**

**Relevant Graduate Coursework**

**Theory/Practice:**  
- Cognitive Behavioral Therapy  
- Biological Basis of Behavior  
- Psychopathology  
- Theories of Personality  
  - Human Growth and Development  
  - Psychodynamic Intervention  
  - Object Relations Therapy  
  - Psychopharmacology

**Assessment:**  
- Psychometrics  
- Personality Assessment  
- Cognitive Assessment  
- Neuropsychological Assessment  
- Child and Adolescent Therapy and Assessment

**Research:**  
- Statistics  
- Advanced Research and Design

**Professional Issues:**  
- Ethics for Psychologists  
- Multicultural Therapy
Additional Professional Development

2011

*Primary Care Behavioral Health: Where Body, Mind (& Spirit) Meet*
Presented by: Neftali Serrano, PhD
Graduate Department of Clinical Psychology Colloquium Series, George Fox University

*Best practices in Multi-cultural assessment*
Presented by: Eleanor Gil-Kashiwabara, PhD
Graduate Department of Clinical Psychology Colloquium Series, George Fox University

*Child custody evaluations: not for everyone. Review of recent APA practice guidelines*
Presented by: Wendy Bourg Ransford, PhD
Graduate Department of Clinical Psychology Colloquium Series, George Fox University

2010

*Multi-cultural counseling: An alternative conceptualization*
Presented by: Carlos Taloyo, PhD
Graduate Department of Clinical Psychology Colloquium Series,

*Current Guidelines for Working with Gay, Lesbian, and Bisexual Clients; The new APA practice guidelines*
Presented by: Carol Carver, PhD
Graduate Department of Clinical Psychology Colloquium Series,

2009

*Recognizing the Symptoms and Understanding the Experience of Neuropsychological Disorders: A Workshop for Non-Neuropsychologists*
Presented by: Alfred W. Kaszniak, PhD, ABPP (CN),
At Crowne Plaza Portland Lake Oswego

*A Challenging Look at “Executive Functions” and the Frontal Lobes: Anything New after Thirty Years of Research?*
Presented by: Donald Stuss, PhD, ABPP-CN,
At the University of Washington

*Facilitating Development of Self-Regulation/Executive Functions and Associated Sense of Personal Identity in Children and Young Adults.*
Presented by: Mark Ylvisaker, PhD
At the University of Washington

*The MMPI-2-RF.*
Presented by: Yosef Ben-Porah, PhD
Graduate Department of Clinical Psychology Colloquium Series