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Analysis of Different Types of Attentional Interference Compared to Working Memory

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Abstract

Previous studies have shown a relationship between working memory (WM) and the Color-Word Stroop Task (CWS). Newer Stroop-like tasks such as the Color-Block Stroop-like Task (CBS) have been shown to cause interference but the nature of the interference is unclear. This study attempted to compare CWS and CBS to tests of working memory, specifically the Digits Span Backward task (DB) and an Operation Span (OSPAN) task. The first experiment involved no auditory stimuli. No significant correlation was found between WM and CWS. This led to a second experiment with the digit span administered auditorily. Again, no significant correlation between CWS and WM was found. Inadequate "attentional load" is believed to be the most probable cause for the lack of correlation. Results of other findings are discussed in light of these results and suggestions for future research are put forth.

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Chapter One

Introduction

There is much that science still does not know about how the brain works and how it processes information. Examples such as Phineas Gage have led psychologists to link cognitive function with anatomical location. In particular, the cognitive abilities of planning, reasoning, problem solving, self-ordered memory, and attentional set-shifting have all been linked to the prefrontal cortex (Robbins, 1996). However, knowing where a mental process happens has only limited value. Understanding *how* a mental process works does more to improve our psychological theories and advance the field as a whole than knowing where it takes place (Engel, 1999). Unfortunately, how the prefrontal cortex engages in the way we store and process information is still a mystery (c.f., Gerhand, 1999). This study hopes to compare different known psychological processes like working memory and cognitive interference and attempt to discover to what extent they are related.

Researchers have been studying memory storage, selective attention, effortful versus automatic processing as well as the mutual constraints that these processes put on each other (c.f., Cowan, 1988). Recent studies have focused on improving our understanding of the brain associated with executive functioning. In particular, many studies have examined the connection between working memory and cognitive interference (e.g., Kiefer, Ahligian, & Spitzer, 2005; Postle, Brush, & Nick, 2004). The theoretical framework for this connection can be found in Baddeley's (1999) model of working memory. Baddeley describes working memory as having three components. These components include a phonological loop, visuo-spatial sketchpad, and a central executive.

The phonological loop is the part of working memory that receives and sends auditory stimuli. This part of working memory attends to all forms of auditory stimuli. Most importantly, this is the part of working memory tied to language. This includes written as well as verbal information. While reading may at first appear to be a visual task, Baddeley, for instance, believes that we subvocalize everything that we read to help us attend to the information (Baddley, 1995). Three separate studies led Baddeley to conclude that the phonological loop exists. The first was the Baddeley (1966) study in which he found that subjects had more trouble remembering auditory stimuli that sounded similar as opposed to stimuli that had different sounds. This leads us to believe that sometimes distinguishing stimuli involves more than just our phonological loop. If people are taking longer to find the answer and are sometimes making mistakes then there must be more demand on a secondary decision making system, such as the central executive. The second source of support came from studies by Salamé and Baddeley (1982, 1989). They found that subjects decrease accuracy on memory tasks when they are asked to ignore an irrelevant audio stimulus, particularly a spoken stimulus. This indicated that the stimuli were still being encoded at some level before the subject could use executive functioning to ignore it. Finally, Baddeley, Thomson, and Buchanan (1975) found that subjects had trouble remembering longer words just as people have trouble remembering more than seven plus or minus two numbers (c.f., Miller, 1956). They also found that when subjects were prevented from subvocalizing that their memory for shorter words became similar to the memory for longer words. The auditory loop seems to be especially good at retaining the order in which information is given.

The visuo-spatial sketchpad is the part of working memory that takes in visual stimuli and helps us navigate the space around us. Not only does the sketchpad enable us to process the environment around us but we are also able to *imagine* the environment and mentally manipulate what we see. A clear example of this is a person's ability to navigate within their home when the lights are out. We can also mentally manipulate objects. We can imagine what a puzzle might look like when put together and we can "zoom in" on certain objects. For example, we can focus on the whiskers of the cat instead of the whole creature. Another role that the visuo-spatial sketch pad plays in our memory process is that imagining objects, events and concepts is a powerful heuristic and helps us to retain and recall information in long term memory.

The "central executive" part of working memory delegates limited amounts of attention to the phonological loop and the sketch pad and then relays that information to the long term memory. The diagram below helps to illustrate this concept.

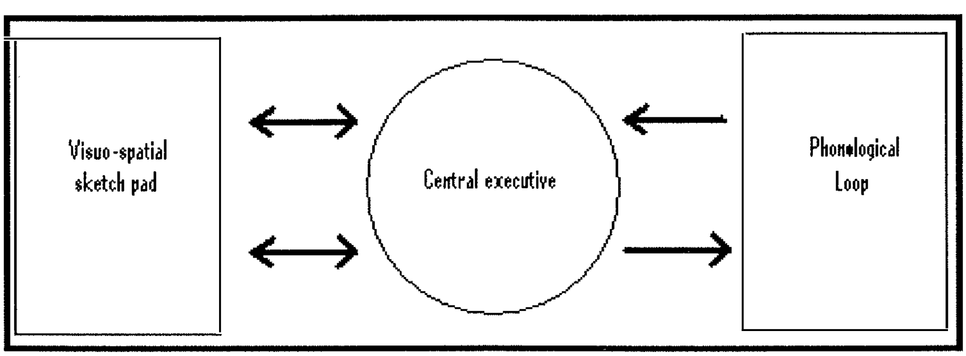

Figure 1. Baddeley's model of working memory (from Baddeley, 1999)

The central executive is the most complex and least understood of the three parts of working memory. It not only delegates attention but it seems to be able to screen out erroneous information to facilitate clear understanding. Furthermore, studies have found that executive functioning correlates highly with tests of general intelligence.

Despite a sound theory, there is still much confusion regarding which parts of the brain working memory taps into and what other cognitive systems it is connected to. Many recent studies have looked at the relationship between working memory and executive functioning (Andres, 2003; Bull & Scerif, 2001; Cantrill, 2003; Daniels, 2003; de Jong, & Das-Small, 1994; Engle, 2002; Raduly-Zorgo & Boglarka, 2004; Jin & Chen, 2001; Kindlon, 1999; Koch, Gobell, & Roid, 1999; McCarthy, 1995; Roncadin, 2003; Schelstraete & Hupet, 2002; Schooler et. al., 1997; Wolfe & Bell, 2004). Most believe that the executive decision making tied into the central executive of working memory is connected to the prefrontal executive decision making process that is commonly studied in tasks such as the Color-Word Stroop task. Kane and Engle (2003) compared working memory capacity, goal neglect, response competition, and task set to Stroop interference. In their study, Kane and Engle compared the results of working memory tasks and attentional tasks and found that working memory is one of the best predictors of executive functioning on attentional tasks. They also observed that the region of the brain that controls working memory is located in the prefrontal dorsolateral region of the prefrontal cortex. However, they noted that future pre-frontal cortex studies and studies on cognitive control should focus on determining whether the working memory capacity system is a single structure lying in a discrete point in the prefrontal cortex or if it is located in multiple systems throughout the brain. Kane and Engle (2002) provided evidence suggesting that the dorsolateral prefrontal cortex is the main site for working memory processing. They also concluded that a person with a low working memory performance span will do worse on an executive functioning task than a person with a high working memory performance span. They also concluded that when someone with a high working memory performance span has his memory taxed by having to remember high loads of information that he will perform as poorly as a person with a low working memory performance span or a person with dorsolateral pre-frontal cortex damage. This discovery led them to believe that executive functioning and working memory must access the same networks within the brain.

Kane and Engle (2003) also compared working memory with performance on the classic Color-Word Stroop task. All of these processes appear to access the dorsolateral prefrontal cortex. However, the Color-Word task only examines one type of cognitive interference in regard to executive functioning. This leaves us with the question of whether or not other types of cognitive interference would also produce similar results. There are many other "Stroop-like" tasks available to us that present different types of interference to the subject. Interference refers to the difficulty in attention that the brain experiences when it is forced to perform two tasks simultaneously (MacLeod, 1991).

The Color-Word Stroop task utilizes the colors and words to create incongruent stimuli by having a color word like "BLUE" written in red ink. Participants show increased response time (RT) and error rate when naming the color of the ink presumably because the incongruent color-word interferes with naming the color of the print. When compared to Baddeley's model, we can see how the central executive would struggle with interfering information. The visuo-spatial sketchpad is attending to the color while the phonological loop is attending to the written language. This creates a significant lag in reaction time when compared to congruent stimuli. However, other Stroop-like instruments have been developed that also present subjects with tasks that cause cognitive interference and a lag in RT. Many of these tasks only present the subject with information through one side of the working memory model though (i.e., solely through the sketch pad or solely through the phonological loop). One such task is the Color-Block task (Koch & Kubovy, 1996) in which two color blocks are presented next to each other. Response times are significantly longer when the color blocks are presented in incongruent compared to congruent colors. In the present study, I will replicate parts of the Kane and Engle (2003) study but I will also incorporate the Color-Block task and compare it to the results from the Color-Word task. In addition to comparing my results to the results from Kane and Engle's research, I also wish to determine if "Stroop-like" tasks other than the classic Color-Word Stroop task also utilize this dorsolateral prefrontal cortex region.

The first two tasks included in my study will be the digits forward (DF) and the digits backward (DB) tasks. These are almost identical to the subtest from the Wechsler Adult Intelligence Scale. DF requires the subjects to perform rote recall of a series of one digit numbers. The series starts at two numbers and gradually gets longer. The test continues until the subject misses two trials within an item or successfully completes all eight trials. This test is a simple measure of short-term memory. DB has the same format as DF but instead of rote recall, the subject must recall the numbers in the reverse order that they were given. This test is a simple measure of working memory. DB requires the subjects to manipulate the data prior to submitting the data. Any manipulation of stimuli utilizes working memory.

Operation span (OSPAN) is another task that assesses working memory (Turner & Engle, 1989). This task interweaves short series of words to be recalled with simple equations to be solved. This is an excellent test of working memory because it requires the subject to maintain a list of words and their spatial location on a computer screen while processing competing mathematical information.

The Color-Word Stroop task is an excellent test of executive functioning. As mentioned above, this test presents the subject with competing information from both the phonological loop and the visuo-spatial sketch pad which forces the central executive to screen out extraneous stimuli. Since the central executive is the core component of working memory, Stroop data should be highly correlated with the other measures of working memory.

The last test to be used is the Color-Block Stroop task. This test also elicits Stroop-like interference by pairing two colored blocks and requiring the participant to name one block (e.g., the upper block) in the pair. Since this task does not include words, it does not utilize the phonological loop in the same way as the Color-Word Stroop task. For this reason, it is currently unknown whether or not the Color-Block task uses the same attentional mechanism as the Color-Word Stroop task.

Currently unpublished work by Koch and Pritchard (1998) suggests that, unlike the Color-Word task, the Color-Block task is not related to digit span. Fifty-four undergraduates participated in the Koch and Prichard study. Each participant was administered the DF, DB, Golden's Color-Word Stroop task and the Color-Block task.

They found no correlation between the Color-Block interference and the digit span measures. Similarly, a study by Hall and Koch (in preparation) found that the Color-Block task was not correlated with the Color-Word task.

The current study examines the relationships between short-term memory, working memory and two types of executive functioning. It will attempt to replicate the previous finding that people with higher level working memory performance spans will do better on executive functioning tasks than those with a low working memory span. Along with comparing working memory to executive functioning, I will also assess the relationship between working memory and executive functioning. Since we believe the same system of the brain controls both working memory and executive functioning, it is assumed that the scores on working memory tasks and executive functioning tasks should rise and fall together. This experiment will specifically analyze the relationship between short-term memory, working memory and how well the central executive responds to various types of interference in the working memory process.

Hypotheses

Based on the work of Kane and Engle as well as others (Baddeley, 1986; Baddeley, 1993; Conway, & Kane, 2001; Engle, 2002; Engle, Kane, & Tuholski, 1999; Kane, M.J., Bleckley, Conway, & Engle, 2001; Kane, & Engle, 2000; Long, & Prat, 2002; Miller, 2000; Rosen & Engle, 1998; Tuholski, Engle, & Baylis, 2001; West, & Alain, 2000) we would expect that the scores on the Color-Word task would correlate with the DB and OSPAN. The question of interest is, "Will the Color-Block performance scores be correlated to the Color-Word Performance scores?" Along the same line of thought I would also wonder if the Color-Block task will correlate with the DB and

OSPAN scores. We know that the Color-Block task produces a Stroop-like type of cognitive interference. However, the Color-Block task enters the working memory in a different way and therefore there is the possibility that it will be processed in a different way. Additionally, the research of Koch and Prichard (1998) suggest that Color-Block performance is not related to digit span performance. This may also lead us to find that the Color-Block Task is not correlated with OSPAN performance as well.

This has dramatic implications. A positive correlation between the Color-Block task and the Color-Word task would suggest that both tasks utilize the same processing resources. Similar reaction times may indicate the same areas of the cortex are in use. It would also indicate that they access the working memory in similar ways.

However, if the results of the two Stroop-like tasks were not positively correlated then it would imply that block interference is processed differently than the traditional Color-Word interference. This may indicate that the Color-Block task does not utilize the dorsolateral prefrontal cortex as the Color-Word task does. This could further lead us to assume that the mechanism for selective attentional processing for that task does not solely lie in the dorsolateral prefrontal cortex. If the results of the Color-Block task were not correlated then we would speculate that the Color-Block task is not tied into working memory in the same way as the Color-Word task or it may be possible that the Color-Block task is not tied into working memory at all. Significantly different performance would indicate that they tap different regions of the brain. It is possible that the cognitive interference is occurring within the perceptual stream of processing instead of the response selection stage of processing. It is our hope that this experiment can help science differentiate between various cognitive tasks.

Chapter Two

Method: Experiment I

Participants

Fifty-five undergraduates from George Fox University, a private liberal arts university, volunteered to participate in the experiment for class credit. There were 14 males and 41 females. Participants were between the ages of 18 and 22. Two subjects were discounted for color-deficiency.

Materials and Design

The study included five tasks that measure various cognitive abilities: one short-term memory (STM) task, two working memory (WM) tasks and two cognitive interference tasks. Supplemental questionnaires were also included to account for potential individual differences. Each task took approximately 10 to 15 minutes.

Memory tasks. These tasks consisted of a digits-forward (DF) and a digits-backwards (DB) tasks similar to the Digit Span task found in the Wechsler Adult Intelligence Scale and the Wechsler Memory Scale (Wechsler 1997). The DF task served as a measure of STM capacity while the DB served as one measure of working memory. The only way that this task is different from the Wechsler tests is that the items are given visually instead of auditorily and the responses are made via keyboard input instead of spoken aloud. DF measures short-term memory and DB measures working memory.

These tasks have been shown to be reliable and valid measures (see the WAIS-III Technical Manual; Wechsler, 1997).

An operation span (OSPAN) task was included as a second measure of working memory. This task involved remembering sequences of words that increase in length while managing interference from being forced to solve arithmetic problems.

Cognitive interference tasks. Inhibition and attentional control were examined using the Color-Word Stroop (CWS) task as well as the Color-Block Stroop task (CBS). The CWS task consisted of 80 items. Forty items were neutral (string of "X"s in a consistent color) and 40 were incongruent (i.e., a word written in a color font that did not match the word). The CWS has been repeatedly shown to be a reliable and valid measure of cognitive interference (c.f., MacLeod, 1991). The CBS task contained 80 items. Thirty-two items were congruent (2 blocks that matched in color) and 42 items were incongruent (blocks of different color). The computer recorded response time and accuracy of information.

Supplemental measures. The participants completed a short demographic questionnaire in order to obtain information regarding age, sex, handedness as well as the existence of prior ADHD or learning disability diagnosis. Color vision was checked using a 10-item Color Vision Screening Inventory. This measure was shown to be a reliable and valid, non-equipment based screener for vision impairment by Coren and Hakstian (1988). Visual acuity was screened using a Landolt-C. The participants also took the 21-item Beck Depression Inventory, version 2 "BDI-II" (Beck, Steer, & Brown, 1996). The BDI-II is a reliable measure with a test-retest correlation of .93 (p = <.001). It has also shown strong validity when compared to other depression inventories and when tested on clinically depressed populations (c.f., Beck, Steer, & Brown, 1996). The 40-item State-Trait Anxiety Inventory "STAI" (c.f., Spielberger, 1984) was also included to examine state anxiety levels before completing the study. Lastly there was the 7-item Morningness-Eveningness Scale (M/ES; Adan & Almirall, 1991).

Procedure

The participants received the testing under supervised laboratory conditions. Participants with normal or corrected to normal vision completed the selected tasks. In order to account for order effects, the participants were randomly assigned to one of four test orders differing in order in which the digit span, operation span and two Stroop tasks were administered. Participants were tested four at a time and the testing took approximately 45 minutes.

Results and Discussion

Four participants produced outlying RTs for the CWS and CBS tasks and were, therefore, eliminated from the analysis. Additionally, seven participants' operation spans were removed due to response errors. No participants were removed from the study form depression or anxiety scores. Therefore, all analyses were done with a sample of 44 participants. Table 1 presents the descriptive statistics for the supplemental, memory and Stroop-like measures.

Results from the supplemental measures did not identify any correlations that were contrary to the existing body of research. The BDI-II was positively correlated with the State/Trait Anxiety measure (r (49) = .46, $p < .05$). The BDI-II was also negatively correlated to performance on the OSPAN (r (42) = .32, $p < .05$) suggesting that increases in depressive symptoms decrease accuracy on this working memory task. The BDI-II, STAI, and M/ES, were not correlated with any of the other performance tasks. The OSPAN and the Digit Backward scores were correlated with each other. DF was correlated with OSPAN (r (41) = .38, p < .05). DB was correlated to OSPAN (r (41) = .45, p <.05). These correlations were expected since digits backwards and operation span are both measures of working memory.

The results for Experiment 1 were not entirely expected. The objective of the experiment was to compare the relationship between the Color-Word Stroop task and working memory test to the Color-Block Stroop task and the working memory tasks. Similar to Kane and Engle (1999), it was hypothesized that there would be a relationship between the Color-Word Stroop task and the working memory tasks. However, there was no correlation between the Color-Word Stroop task and either working memory task (i.e., DB and OPSAN). Thus we were faced with a new problem that had to be resolved before we could begin to understand the Color-Word, Color-Block working memory relationships. The CWS and CBS are correlated with each other. We found a significant difference between the RT for the control versus the *incongruent* CWS items (t (47) = 6.53, p < .001). There was also some delay in the response times for the congruent and incongruent CBS items. However, what was most interesting is that the RT between the control CWS items and the incongruent CBS items is highly significant (t (42) = 6.35, p < .001. We believe that the greater difference in reaction times between control CWS items and incongruent CBS items is due to the fact that the congruent CBS items still expose the subject to two blocks of color whereas the control CWS items are a single series of colored X's. This indicates that multiple items on the screen create a higher level of "attentional load", even if the items are the same.

This is particularly interesting since it contradicts the Hall and Koch (2005) study in which they found no significant correlation between the CWS and CBS tasks. We believe that this is due to the nature of their experimental design. Their study only had subjects differentiate between two different colors in their version of the CBS. Our CBS required subjects to identify one of four different colors. We believe that the greater number of colors created more interference and increased the level of "attentional load".

Since we could not replicate the correlation between working memory and the Color-Word Stroop task, we attempted to discover any confounding variables or methodological differences that could account for the current findings. Several variables were considered that might account for the lack of correlation. Gender differences as well as population demographics were considered. There were more women subjects than male. However, the Stroop test and working memory tasks are considered to be gender neutral and no prior studies have found gender differences with either type of task (Golden, 1974; MacLeod, 1991). The fact that we used an undergraduate college population was also considered but that too was dismissed because most of the prior experiments had used college populations as their sample pool as well. No clear confounding variables in the testing environment were identified. One immediately apparent potential problem with our study was the way we administered the Digit-Span task. We had administered the test items visually and the respondents answered by tapping keyboard keys. However, the test was standardized using auditory stimulus and verbal responses. In order to rule out this variable as the cause of our lack of correlation we conducted Experiment 2 to partially replicate Experiment 1 using verbal presentation of the DF and DB tasks.

Chapter Three

Method: Experiment II

Participants

Forty-seven undergraduate from George Fox University participated in the study for class credit. There were seven males and 40 females. Ages ranged between 18 and 22 except for one 34-year-old female participant.

Materials and Design

This second study was an abbreviated version of Experiment 1. Rather than using all the previous tests, subjects were only given the color vision questionnaire, the Color-Word Stroop test (CWS), the Color-Block Stroop-like test (CBS) and the Digit Span Forward (DF) and Digits Span Backwards (DB) tests. The major difference this time was that the digit span tasks were administered in the standardized way with the stimulus given verbally and the responses spoken aloud by the subjects and recorded by the administrators.

Procedure

The participants received the testing under supervised laboratory conditions. Participants with normal or corrected to normal vision completed the selected tasks. Participants were tested individually for the Digit Span portion and four at a time for the rest of the tests. The entire test battery took 20-30 minutes. All subjects took the Digit

Span task first, then the CBS followed by the Stoop tasks. Subjects alternated the order they took the CBW and CWS with 50% taking CWS first and 50% the CBS.

Results and Discussion

The overall Digit Span scores between the first and second groups were not significantly different. However, scores on the Forward Digit Span tasks for our second experimental group were significantly better than the scores from the Forward Digit Span of the first experimental group (Group1 $M = 9.43$ (2.01) Group2 $M = 10.83$ (2.24); $t(100) = 3.35$, $p < .001$ $d = 0.63$). This may be explained by the theory that short-term memory is primarily auditorily stored (c.f., Frick, 1984). If this is true, then we can guess that a visual presentation of short-term memory stimuli would take longer to process because the material must be converted to auditory stimuli before it can be stored. This would give the auditory stimuli group a slight performance edge over the visual group.

To our surprise, we found that there was not a significant difference between the scores of the Reverse Digit Span when administered auditorily versus visually (Group1 $M = 7.44$ $SD = 2.34$; Group2 $M = 7.35$ $SD = 2.01$; $t(100) = .21$, NS). This suggests that the higher cognitive demand required for the working memory task may outweigh the auditory performance benefit. We also did not find any correlations between the auditory Digit Span task and the Stroop tasks. This led us to believe that the lack of correlation between the Digit Span working memory task and the Color Word Stoop task was not due to the way the Digit Span was administered. Therefore, we feel confident that the Reverse Digit Span is an effective measure of working memory whether administered auditorily or visually.

Chapter Four

Discussion

Experiment 1 was conducted to replicate the findings of Kane and Engle (2003) regarding Stroop interference and working memory while determining whether or not the color-block version of the Stroop is similarly related to working memory. The results, however, show that not only was the color-block Stroop not related to two working memory tasks, the standard color-word Stroop task was also not correlated with working memory as well. Several reasons for this failure to replicate previous findings were considered. Experiment 2 was conducted to determine if a methodological difference in the delivery of the digit span tasks between the two studies could have accounted for the failed replication. However, results from Experiment 2 showed no difference in performance on the DB task whether presented visually or verbally and no relationship with Stroop interference. Kane (personal communication) suggests that the cause for the lack of correlation may lie in the proportion of color-word congruent and color-word incongruent items. It may be that appropriate "cognitive loading" of the items as well as requiring the Color-Word test to have many more items than were used on our test may be the key to finding the correlation with the working memory tasks. Restuccia, Marca, Marra, Rubino, and Valeriani (2005) found that activity in the right frontal lobe only occurs during high attentional load tasks. This corroborates the notion that a certain level of demand must be placed on the brain before the central executive activates.

While this theory seems to be the most plausible explanation at this time, it is entirely possible that another variable exists that would better account for the correlation or lack thereof. WM probably accounts for some of the variance between Color Word Tasks and Color Block Tasks but there are probably other factors to better account for the remainder of the variance. We recommend that future research focus on this idea of cognitive loading. Perhaps, the experiment could vary the amount of congruent and incongruent items between groups of subjects to see which groups had a correlation with the working memory items. We propose that a future study expose subjects to one of 5 CWS tasks that vary in the amount of congruent items. We suggest groups of 0%, 20%, 40%, 60% and 80% congruent items. This would allow us to more specifically identify the proper amount of congruent items needed to build sufficient "attentional loading". Having congruent (AKA neutral) items of sufficient quantity has been reported to be very important to create the right amount of "attentional loading" (M. J. Kane, personal communication, February, 2006) to show a correlation between WM and the Stroop effect (c.f., Unsworth & Engle, 2005). Of course, we are assuming that at some level of congruence that the WM CWS correlation would reassert itself. We may find that this is not the case but since it has been clearly found in several other studies, we would assume that it will appear under the proper conditions. Once the proper percentage of congruent items is identified, then the original experiment can be repeated to compare levels of correlation between CWS and CBS.

Some of the data we gathered support the idea of attentional loading. The CBS and CWS scores were correlated in both experiments. Furthermore, when we compared the congruent and neutral items to the incongruent items in a paired samples t-test we found several significant results. The neutral CWS items were correlated to the incongruent CWS items (r (46) = .842) and the congruent CBS items were correlated with the incongruent CBS items at r (42) = .892. However, the most significant correlation was between the neutral CWS items and the incongruent CBS items (r (41) = .533). This shows that there is indeed interference occurring in the CBS task.

Since there is more difference between neutral and incongruent blocks than congruent and incongruent blocks, we are led to believe that there is some level of attentional loading with two items compared to one item on the screen. The more that a task is purely sensory, the less it draws upon the executive functioning systems of the central executive. The more complex and less sensory a task is, the more involved the executive functioning system becomes. This higher level of functioning leads to slower reaction times and correlates more with working memory, which we also assume to be a frontal lobe task. While the current study cannot make any definitive conclusions about the relationship between WM and Stroop-like tasks, we are able to point to "attentional load" as the critical variable that determines how connected they are.

Lastly, we made the surprising discovery that there does not seem to be any significant difference between a verbally or a visually administered Backwards Digit Span task. Further research should be devoted to confirm these results but the ramifications are exciting. It could mean that the way that the brain processes numerical information is independent of the visual or auditory regions of the brain. Or it could mean that the attentional demand placed on the subject overshadows the benefit one would gain from congruent sensory stimuli. It could also change the way that we do memory testing. It may be that many memory tasks are equally valid using computer administration, especially working memory tasks. Clearly, this would require a great deal of further study before such claims could be stated conclusively. Many tests of memory separate memory into visual and auditory sub-categories. It would be interesting to conduct future studies comparing standardized and computerized administrations of some of the most widely used memory tests (such as the WRAML and the WMS) and see if there is a difference in the scores received.

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Appendix A

Curriculum Vita

Joel Gregor MS, MFT

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Dundee, OR 97115 E-mail: jogregor@georgefox.edu

Education

2005- 2007 George Fox University APA accredited doctoral program
(Projected grad. date) Doctor of Psychology (Psy.D.) program

2001-2005 George Fox University
Masters of Arts in Psychology

1998-2001 Fuller Theological Seminary APA accredited program
M.S. Marital and Family Therapy

May 1998 Willamette University
B.S. Psychology, minor Religion

Supervised Clinical Experience

Oct. 2005-Present Practicum position at Providence Newberg Hospital, Newberg, Oregon
Clinical supervision provided by Mary Peterson Ph.D.

Administrative Coordinator for pain management services Providence Newberg Hospital—Helped to develop and establish a new pain management program. Conducted psychological pain assessments. Co-facilitated group therapy sessions. Served as liaison between hospital staff, George Fox University and Patients

Jun. 2005 – Present Practicum position at Providence Newberg Hospital, Newberg Oregon.

Clinical supervision provided by Mary Peterson Ph.D. and Donnell Campbell RN
Behavioral Health Practicum Student—Participated in multidisciplinary team meeting. Met with inpatients to conduct mental status examinations and provide brief counseling to the patient and/or family. Common issues addressed included depression, anxiety and concerns raised by the onset of dementia.

Aug. 2004- May 2005 Practicum Position at George Fox University Health and Counseling Center Newberg, OR
Clinical Supervisor was Dr. William Buhrow Psy.D.

Management Practicum Student—Conducted individual and couples counseling with undergraduate and graduate level students. Administered and interpreted testing for learning disabilities, and ADHD. I reviewed clinical reports, treatment plans and session notes for other practicum students and I determined all room assignments. I also led 2 clinical trainings. I was peer supervisor for 3 other students.

Jan. 2004 – Jun. 2004 Practicum position at Multnomah County Corrections Counseling Department
Clinical Supervisor was Dr. Stephen Huggins Psy.D. CCHP

Psychology Student Intern—Conducted individual Counseling with inmates at Inverness Jail as well as facilitated two weekly psychoeducational groups with inmates. I also performed cognitive and personality assessments of various inmates. Participated in clinical team meetings.

Jun. 2000- Jun. 2001 Practicum Position at Glen Roberts Child Study Center. Primary clinical supervisor was Dr. Jennifer Thomas Psy.D.

MFT Trainee—Worked with a variety of high need clients from ages 3 years to 18 years. Treatment focused on the use of play therapy, systems theory, developmental theory and psychoanalysis.

Mar. 1999- Jun. 2001 Practicum Position at Olive Crest Foster Family agency. Los Angeles, CA
Clinical supervisor was Teri O'Hair MFT

Therapist trainee—Worked with foster children and families who were dealing with issues related to foster care. Treatments focused on the use of play therapy, systems theory and object relations theory.

Sept. 1997- Jun. 1998 Undergraduate Practicum position at Walker Middle School, Salem, OR supervised by Master's level school counselors

Intern to the School Counselor—Worked with several at-risk boys as a mentor. I also assisted the counselor in various activities including clubs and community service projects. Supervised by Master's level school counselors.

Work Experience

Aug. 2004- Present Behavioral Health Specialist, Providence Newberg Hospital, Newberg, OR

- Part of a 5-person On-Call psychological response team
- Responsible for conducting psychological

  assessments to aid MD's in diagnosis and treatment.

May 2005- Present Individual Therapist, George Fox University, Newberg, OR

- Weekly individual therapy with a 14 year old male in the community
- Supervised by Wayne Adams Ph.D. ABPP at George Fox University

- Treatment plan focus on enuresis, reading learning disability and processing his parents' separation

Aug. 2001- Dec. 2003 Child and Family Therapist, RiverBend Youth Center, Oregon City, OR (503) 656-8005

- **Conducted individual and family therapy with adolescents at a residential psychiatric facility.**
- Facilitated educational and process groups with the youth at the facility
- Facilitated educational and support groups for the parents of the youth
- Performed all needed case management for my clients utilizing resources in counties throughout Oregon
- Trained in the CPI method of non-violent crisis intervention and became certified as a QMHP

1996 summer only Jr. High Youth Activities Director, Gilroy Presbyterian Church

- Coordinated all Jr. high activities for the summer
- Talked one on one with youth and gave bible study lessons
- Worked closely with the church staff

1994, 1995 summers Camp Counselor, Mount Hermon's Redwood Camp, Mount Hermon, CA

- Supervised cabins of boys ranging from grades 1-8
- Managed children's activities, played with them, and had many opportunities to talk about childhood and adolescent issues

Research Experience

Research Team Member

George Fox University, Newberg, OR

Meet bi-monthly to discuss and evaluate progress, methodology, and design of group and individual research projects. Areas of focus include memory, cognitive

interference, intelligence and personality traits of college athletes
Supervisor: Chris Koch, Ph.D.

Dissertation

Analysis of Different Types of Attentional Interference Compared to Working Memory
George Fox University, Newberg, OR
Proposal Approved: May 2005
Status: Data Analysis

This is a correlational study that will compare the response times from a typical Color-Word Stroop task to a "Stroop-like" Color-Block task. These response times will also be compared with 2 working memory tasks and one short-term memory to identify possible correlations. Final Oral Defense anticipated by 2/06. Chair: Christopher Koch, Ph.D.

Grants

2004 **Richter Scholars Grant for Independent Student Research**
$914 granted for dissertation supplies for research on the impact of working memory on various types of attentional interference.

Presentations

Koch, C., Gregor, J. (April 15, 2005). *Psychometric Examination of the Everyday Memory Questionnaire.* Poster presentation at the Western Psychological Association's annual convention, Portland, OR

The Question of Suicide: Subtle Signs, What to Ask & When to Refer. Presented by the George Fox University Crisis consultation team to the staff at Providence Newberg Hospital in April, 2005

Membership and Professional Affiliations

11/01-Present **Graduate Student Affiliate**, American Psychological Association

11/04- Present **Student Affiliate**, Western Psychological Association

6/05- Present **Student Member**, Oregon Geriatric Association

1996-1998 **Psi Chi**, Student Member

Additional Clinical Training

10/04 Acceptance and Commitment Therapy (ACT). Vijay Shankar, Psy.D., and Anne Shanker, MSSW, Newberg, OR

6/04 WISC-IV: An Overview and Discussion of Changes. Jerome Sattler, Ph.D., ABPP/CL, Newberg, OR

6/04 Disability Determination Assessment. Robert Henry, Ph.D. Newberg, OR.

5/04 Domestic Violence In-service for Clinicians. Patricia Warford, Psy.D. Newberg, OR.

10/03 Dialectical Behavioral Therapy: An Introduction. Brian Goff, Ph.D., Newberg, OR

5/03 Current Guidelines for Working with Gay, Lesbian, and Bisexual Clients. Carol Carver, Ph.D., Newberg, OR

3/03 Using Psychological Knowledge and Skills to Consult with Businesses. Steven T. Hunt, Ph.D., Portland, OR

2/03 Counseling Issues of the Soul: Guilt, Loneliness and Despair. William C. Buhrow, Jr., Psy.D., Newberg, OR

10/02 Assessment and Treatment of Traumatized Children. Sophie Lovinger, Ph.D., Newberg, OR

10/02 Integration of Religion and Psychotherapy: Explicit, Implicit, or What? Robert Lovinger, Ph.D., Newberg, OR

4/02 Post-colonial PTSD in Native Americans. Joseph B. Stone, Ph.D., Thomas J. Ball, Ph.D., Newberg, OR

Relevant Coursework from George Fox Doctor of Psychology Program

Core Courses:
Ethics For Psychologists
History and Systems of Psychology
Learning, Cognition and Emotion
Psychometrics
Research Design
Social Psychology
Theories of Personality and Psychotherapy
Child Development

Statistics
Multicultural Psychotherapy

Clinical Theory and Practice:
Cognitive/Behavioral Psychotherapy
Human Sexuality and Sexual Dysfunction
Biological Basis of Human Behavior
Psychopharmacology
Gender Issues in Psychotherapy
Psychodynamic Psychotherapy
Integrative approaches in Psychotherapy
Rural Psychology
Professional Issues in Psychotherapy
Business, Administrative and Regulatory Issues

Clinical Assessment:
Cognitive and Intellectual Assessment
Comprehensive Psychological Assessment
Neuropsychological Assessment
Personality Assessment
Projective Assessment
Clergy Assessment
Child Psychopathology & Assess

Relevant Coursework from Fuller Theological Seminary Marriage and Family Therapy Program

Core Courses:
Family Systems I
Family Systems II
Child and Family Development
Moral and Ethical Issues in Professional Life
Research Methods Statistics and Design
Legal issues in Family Practice
Psychopathology and Family systems
Advanced Issues in Clinical Practice

Clinical Theory and Practice:
Clinical Foundations
Family Therapy I

Family Therapy II
Marital Therapy
Addiction and Family Treatment
Gender and Sexuality
Divorce and the Reconstituted Family
Brief Therapy
Cultural and Ethnic Issues in Marriage and Family Therapy
Child and Adolescent Therapy

Clinical Assessment:
Introduction to Assessment

<u>Assessment Experience with:</u>

Achenbach Youth Self-Report Inventory
Behavior Assessment Scale for Children 2nd edition (BASC-2)
Booklet Category Test-Adult Version
Boston Naming Test-II
Brief Pain Inventory-short form (BPI)
Brown ADD Scales
Coping Strategies Questionnaire-revised (CSQ-R)
Conner's ADHD Rating Scale
Controlled Oral Word Association (FAS)
Child/Adolescent and Family Assessment Scale (CAFAS)
Child Autism Rating Scale (CARS)
Child Behavior Checklist (CBCL)
Children's Apperception Test (CAT)
Children's Depression Inventory (CDI)
Developmental Test of Visual-Motor Integration (VMI)
Delis-Kaplan Executive Functioning Scales (D-KEFS)
Finger Recognition Test
Finger Tapping Test
Finger Tip Number Writing Test
Gilliam Asperger's Disorder Scale (GADS)
Grip Strength Test
Grooved Peg Board
Hare PCL:YV
House-Tree-Person Test (HTP)
Millon Clinical Multi-Axial Inventory-III (MCMI)
Millon Behavioral Medicine Diagnostic (MBMD)

Mini Mental Status Examination (MMSE)
Minnesota Multiphasic Personality Inventory (MMPI-2)
Minnesota Multiphasic Personality Inventory for Adolescents (MMPI-A)
Pain Appraisal Inventory (PAI)
Personality Assessment Inventory (PAI)
Personality Inventory for Children 2nd edition (PIC-2)
Peabody Picture Vocabulary Test-III (PPVT-III)
Rey-Osterrieth Complex Figure Test
Roberts Apperception Test for Children (RATC)
Rorschach Inkblot Test
Rotter Incomplete Sentences
Sixteen Personality Factors Test (16PF)
Stroop color and Word Test
Structured Assessment of Violence in at-Risk Youth (SAVRY)
Tactile, Auditory and Visual Screening
Tactual Performance Test
Thematic Apperception Test
Trail Making Test
Trauma Symptom Checklist for Children (TSCC)
Vineland Adaptive Behavior Scales
Wechsler Adult Intelligence Scale-III (WAIS-III)
Wechsler Individual Achievement Test-II (WIAT-III)
Wechsler Intelligence Scale for Children-III and IV (WISC-III & IV)
Wechsler Memory Scale-III (WMS-III)
Wide Range Achievement Test-III (WRAT-3)
Wide Range Assessment of Memory and Learning (WRAML)
Wide Range Intelligence Test (WRIT)
Wisconsin Card Sort
Woodcock-Johnson Test of Achievement, revised (WJ-R)