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A Meta-Analysis of Neuropsychological Tests Utilized in Evaluations for Post-Operative Cognitive Dysfunction in Adult Surgery Patients

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Abstract

Cognitive dysfunction post-surgery has a significant impact on patients' quality of life during recovery and afterward. Several studies have been completed on post-operative cognitive dysfunction (POCD), but since studies are varied in their methodologies and designs a meta-analysis is helpful to synthesize the current available research. The present study took a meta-analysis approach to examine neuropsychological tests most sensitive to POCD in adult surgery patients, and determine implications this would have for developing a battery of tests to evaluate for POCD pre and post-surgery. Although some assessment batteries have been proposed for certain populations (e.g., cardiac patients), little research has been completed on what tests are most sensitive within a general population of patients. Journal articles on POCD were located through medical and psychological research databases. Of the 109 articles that could potentially be included, 24 met inclusion criteria. 192 effect sizes were calculated, with 2,188 participants across all studies. Articles were coded for assessment measures and various factors for studies

that included both POCD and non-POCD patients, and effect sizes were determined for each of the neuropsychological tests included in each article using the software Comprehensive Meta-Analysis Professional Version 3. POCD effect sizes were significantly higher in Chinese studies, as compared with studies from other research centers and so Chinese studies were excluded from the final analysis. The final analysis found older adults have more severe cognitive decline due to POCD symptoms, that the most prominent time for symptoms is 7-14 days post-surgery, and that patients have the same pattern of POCD deficits after cardiac surgery as after non-cardiac surgery. The Mini-Mental State Examination (MMSE) was found to be very sensitive to identifying POCD, and tests measuring delayed recall, language, and processing speed were found to be moderately effective in detecting POCD. Implications of these results for post-surgery care of geriatric patients as well as the implications for neuropsychological testing for POCD symptoms are discussed.

Key Words: Cognitive Dysfunction, Postoperative, Surgery Patients, POCD, Neuropsychological Tests

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Chapter 1

Introduction

The potential of cognitive impairment following surgery is not necessarily well known by the general population of individuals who are preparing to undergo surgery (Jildenstål, Rawal, Hallén, Berggren, & Jakobsson, 2014). Bryson and Wyand (2006) note Post-Operative Cognitive Dysfunction (POCD) is a common complication for patients post-surgery in which anesthesia was used, and Hanning (2005) notes long-term and, at times permanent, neurological change can occur after undergoing surgery. The term *POCD* is used in the literature to encompass a noticeable decline in various neuropsychological domains, including memory and processing speed. Although POCD is not a term that currently appears in the *Diagnostic and Statistical Manual of Mental Disorders*, 5th Edition (*DSM-5*; American Psychiatric Association [APA], 2013) or the *International Classification of Diseases* (*ICD-10*; World Health Organization [WHO], 2016), it is a term that encompasses difficulty in various areas of cognitive functioning and is well-established in the literature (Tsai, Sands, & Leung, 2010). Monk et al., (2008) report rates of POCD at discharge from the hospital are between 36.6-41.4% depending on the age of the patient, with older individuals having higher rates of documented cognitive difficulty at discharge. POCD can resolve within days to weeks after surgery, but can also become a more permanent disorder with significant changes in level of functioning and quality of life for an individual (Deiner & Silverstein, 2009; Grape, Ravussin, Rossi, Kern & Steiner, 2012; Monk &

Price, 2011; Rundshagen, 2014). The current study aims to examine the literature that is available on POCD in order to provide a quantitative summary of the literature.

POCD Defined

According to Rasmussen (2006), preliminary review of literature indicates POCD is a term variably defined. Even so, some general consensus exists on how the issues are defined among studies that distinguish between postoperative cognitive dysfunction and other conditions that may develop after surgery, such as delirium and dementia.

Grape et al. (2012) state that, generally, POCD is defined as stability in consciousness but changes in cognition. Typically there are notable impairments of memory, concentration, language comprehension, abstract thinking, and social integration when compared to an individual's baseline and pre-operative functioning and ability (Grape et al. 2012). Tsaiet al. (2010) also offer a less specific definition of POCD as impairment of thinking, memory tasks, executive functioning, and processing speed after surgery has been completed. Rudolph, et al. (2010) define POCD as decline in an individual's cognitive functioning from pre-surgery abilities, and that this has been a frequent phenomenon after cardiac surgery. Most frequently measured cognitive domains include attention and memory, with motor skills less frequently evaluated. In their review of the literature relating to cardiac patients, they noted four ways of measuring POCD resulting from their study: percent decline, standard deviation decline, factor analysis, and analysis of performance on individual tests (Rudolph et al., 2010).

POCD is not currently a term included in the *Diagnostic and Statistical Manual of Mental Disorders*, 5th Edition (*DSM-5*; APA, 2013) or the *International Classification of Diseases* (*ICD-10*; WHO, 2016), but may be encompassed by other diagnostic descriptors by

some clinicians. For example, Monk & Price (2011) state some professionals may make a diagnosis of "neurocognitive disorder" with specifications regarding degree of severity.

It is important when defining POCD to distinguish the difficulties encompassed by this term from other phenomena, such as postoperative delirium and dementia that may develop post-surgery for some patients. Post-operative delirium is more transient than POCD, and is distinguishable in its acute development soon after operation (Deiner & Silverstein, 2009). It involves noticeable fluctuations in a person's orientation and attention capabilities, as compared to a more subtle change in cognitive functioning and a more stable and long-lasting change associated with POCD. The duration and severity of delirium is variable, typically occurring within the first four days post operation, and resulting in fluctuating mental status (Grape et al., 2012). Tsai et al. (2010) agree with this distinction between POCD and delirium, stating delirium is an acute state of confusion, evidenced through differences in attention and awareness of the person's own environment, and these symptoms can fluctuate rather quickly and result in disorientation. Patients with POCD, however, are typically fully oriented but experience a decline in their neuropsychological abilities as compared to their own baseline performance. Fewer studies seem to comment on the differential diagnosis of dementia and POCD, but this is nevertheless an important consideration, since some symptomatology may appear rather similar. A very clear distinction is that dementia differs from both of the diagnoses of POCD and delirium in that dementia is a longer chronic decline in a person's cognitive functioning, and has a different etiology than delirium or POCD (Tsai et al., 2010).

The Importance of POCD

It benefits psychologists to understand critical aspects of POCD, as it yields harmful effects on adaptive functioning and quality of life during recovery from surgery and after discharge from the hospital. POCD is a common occurrence after many surgeries (Grape et al., 2012; Monk et al., 2008), and as a result, it is an important consideration when working with patients who have had surgeries or are considering undergoing surgery. POCD results in numerous deficits including at least short-term and possible long-term changes in a patient's cognitive and behavioral functioning.

Short-term deficits can result in a poorer recovery process for patients, presenting with diverse manifestations in various domains. For example, Krenk, Rasmussen, and Kehlet (2010) found deficits in memory and processing speed in patients with POCD; this observation is significant due to the essential role of memory in daily functioning. Another area impacted within a short-term time frame is a patient's ability to follow detailed instructions for post-surgery care. Tsai et al. (2010) comment that it is very important to determine a patient's level of cognitive dysfunction early on, stating typically hospital staff give patients detailed instructions for such tasks as wound care, medication management, symptom monitoring, and daily activity levels post-surgery. However, if patients are experiencing POCD when this education is being provided, the patient's ability to understand what he or she is being told and remember what instructions were given may be impaired. The patient's ability to understand and recall instructions given at hospital discharge may also be difficult and put them at risk for complications occurring post discharge when they are recovering (Tsai et al., 2010). In addition, experiencing POCD has been linked with higher mortality rates (Rundshagen, 2014).

POCD also has long-term impacts on functioning that can prove harmful to a patient's quality of life long after surgery. Grape et al., (2012) state many patients are pursuing surgery as a means of addressing health difficulties affecting their quality of life, and surgery is a means by which they are hoping to improve their level of functioning. However, if POCD results from the surgery process the patient's quality of life may be the same as pre surgery, or possibly even worse. Tsai et al. (2010) comment that improving the measurement and understanding of POCD is beneficial to patients because more recent studies have confirmed POCD is related to lower levels of daily living skills, early resignation from the work force, and more dependence on government resources after hospital discharge.

Historical Origins of POCD

In 1955, Bedford published a review of research done with elderly patients who underwent general anesthesia during surgery. His observations indicated about 10% of the older adult patients were able to function independently but experienced some mild cognitive problems after surgical procedures. However, Bedford also noticed a small percentage of patients experienced more extreme symptoms that persisted until their deaths. This led him to conclude these problems were associated with anesthesia and hypotension. However, even though Bedford documented his observation of this phenomenon in the 50s, POCD remained relatively absent from the research until the 1990s (Monk & Price, 2011). Furthermore, Hanning (2005) comments that before the 1990s reports of POCD in non-cardiac patients were mostly anecdotal and were generally assumed to be a result of perioperative misfortunes.

Studies on post-operative cognitive dysfunction were first published in anesthesia and medical journals since the symptoms of POCD were first noted in hospitals when patients were

having cognitive difficulties after surgical procedures. Physicians and nurses began recognizing this constellation of cognitive impairment in post-surgery patients and it was termed "post-operative cognitive dysfunction." The first hallmark studies of POCD were completed in the 1990s. In 1994 the first systematic study, the International Study on Post-Operative Cognitive Dysfunction (n.d.; ISPOCD), coordinated by the University Hospital of Copenhagen, Denmark, was founded in order to gather data on POCD. The first study, ISPOCD-1, was developed out of the literature they had at the time and examined the incidence and causes of POCD. A second study, ISPOCD-2, was initiated to examine follow-up questions that came out of the first study.

One of the main purposes of the ISPOCD studies was to study the incidence and prevalence rates for POCD. The studies found 19-41 % of patients experienced POCD at one week post-surgery, and 10%-17% continued to experience these difficulties three months post-surgery. Incidence rates are typically higher after cardiac surgery as opposed to non-cardiac surgery procedures, with 43%-81% of post-cardiac surgery individuals experiencing difficulty seven days post-surgery, and 6%-39% three months after surgery. Several other studies have replicated these findings that both early and late POCD rates are considerably higher among post cardiac surgery patients as opposed to patients after other types of surgeries (Grape et al., 2012; Lewis, Maruff, & Silbert, 2005). Rundshagen (2014) recently summarized the incidence of POCD, noting approximately 40% of patients who are hospitalized for surgery and are also over the age of 60 meet criteria for POCD on discharge and about 10% of these individuals continue to have POCD at three months post-surgery. Bryson and Wyand (2006) reported in their review on POCD literature that POCD was present in approximately 15%-25% of individuals post-

surgery. Monk et al. (2008) found 30%-40% of adult surgery patients experience POCD at time of discharge from the hospital.

Although there is variation among these studies regarding the incidence rates of POCD, it is evident a significant number of surgery patients experience cognitive dysfunction after surgery. When 10%-40% of patients experience POCD symptoms, the need to continue research in this field in order to be able to improve the experience and recovery process of patients becomes clear. The rate of POCD is important not only in the recovery process for many patients, but also in the longer-term trajectory regarding quality of life post-surgery.

One caution in considering the POCD incidence rates mentioned by Monk and Price (2011) is that preoperative cognitive functioning may affect a patient's postoperative outcomes regarding cognitive abilities. They state studies have indicated preoperative events or impairments can increase a patient's risk for cognitive difficulty post-surgery. They further state a person's brain reserve, or level of healthy cognitive functioning prior to surgery, is a protective factor (Monk & Price, 2011). Furthermore, it is important to note some individuals, particularly older adults, may have subjective cognitive complaints that may be undiagnosed prior to surgery, and this would affect their post-surgery outcomes. Some studies have chosen to specifically examine the relationship between dementia patients or mild cognitive impairment patients and their outcomes post-surgery; however, it is noted it may not be a valid assumption all individuals participating in other studies do not have subjective undiagnosed complaints that could impact their outcomes. For these reasons, a within subjects design, i.e. with pre-post neuropsychological testing, should be preferred to a between-subjects research design.

Gaps in the Literature and Methodological Challenges

Even though a fair amount of research exists on POCD, there are still gaps, limitations, and discrepancies in the literature that warrant further examination. At this point it is most valuable to study what areas or gaps exist within the literature and focus on those areas in future research in order to add clarity for continuing research on POCD and enabling future studies to focus on the most beneficial endeavors.

One concern about POCD research, mentioned by Krenk et al. (2010), is that POCD studies frequently lack a control group. Having a control group in the study's design assists in considering potential practice effects of repeated testing that previous studies have used. Rasmussen (2006) also states the lack of control groups in these studies creates an additional challenge to interpreting the literature due to various methodological differences that can be found among available studies. Similarly, many POCD studies have small sample sizes.

A second gap in the literature, mentioned by Krenk et al. (2010), is although POCD is a rather significant problem after surgery, the etiology and physiological changes are not completely understood at this point. Grape et al. in their 2012 study also concur with this concern, that the pathophysiology of POCD is not completely understood.

A third concern about POCD research is that some studies do not distinguish well between the diagnoses of delirium, dementia and POCD. Further research is needed to standardize diagnostic processes for how POCD differs and is distinct from these other diagnoses. Standardizing the criteria and symptoms of POCD would help resolve this important issue and enable practitioners to tailor treatment and prognosis more accurately depending on the particular diagnosis. Along with this, Krenk et al. (2010) comment there is a lack of a consistent

international definition of what constitutes POCD, making it difficult and complex to compare between studies. Tsai et al. (2010) state the diagnostic criteria of POCD include a significant change in neuropsychological test scores of memory and executive functioning. Defining the phenomenon consistently has been a problem in the study of POCD. Studies most typically give a patient a diagnosis of POCD if the patient shows cognitive decline after surgery that is one standard deviation or more away from his or her baseline functioning, while others require a drop on two or three measures that were administered. Due to the inconsistency of POCD diagnosis and interpretation of test results, it can be difficult to know precisely how much cognitive loss is accounted for post-surgery (Grape et al., 2012; Tsai et al., 2010).

Grape et al. (2012) state that although there is a lack of consensus around standardized criteria for diagnosis, the following aspects are what the authors have found to have general consensus in the field: First, they recommend good research design be employed. Specifically, they say pre- and postoperative testing is necessary to diagnose POCD, thus providing a clear indication of changes from the individual's baseline testing (Grape et al., 2012; Rundshagen, 2014). Further, a control group should be used in study design in order to account for typical levels of age-related cognitive decline, as well as practice effects from testing an individual multiple times. They also recommend post-surgery testing should be conducted both seven days and three months post-surgery. They recommend a standardized process for choosing neuropsychological tests is necessary. Unlike for cardiac surgery, few statements exist for other subpopulations of surgery patients when considering test batteries to be administered. Interpretation of test results and giving a diagnosis of POCD is quite varied. For example, some studies give a diagnosis of POCD if a patient shows some cognitive decline after surgery equal to

or greater than one standard deviation on one or more tests, a patient shows decline on two or three tests, or a patient shows change in z-scores or percentages. There should be consistency in statistical methods utilized; for example, whether practice effects are being accounted for, among others. Lastly, Grape and colleagues (2012) recommended the "diagnosis" of POCD be more quantifiable or be based on a continuum (for example, a scale of 0-100) rather than in a way that indicates the disorder is "present" or "not present." These aspects are very similar to the consensus statement that already exists for cardiac patients (Murkin, Newman, Stump, & Blumenthal, 1995).

Bryson and Wyand (2006) state a weakness in the research, as well as an area for future research, is that most studies completed on POCD have used many differing assessment tools and have not been streamlined, making it difficult to compare studies (Bryson & Wyand, 2006; Rudolph et al., 2010). Similarly, Newfield (2009) notes the lack of a standard preoperative neurological exam and neuropsychological testing battery due to the infancy of POCD studies. Hanning (2005) states further research is necessary with more sensitive instruments for testing that maintain high test-retest reliability in order to improve the quality of studies completed. Rudolph et al. (2010) comment this heterogeneity in measurement of POCD may be impeding the progress of research by reducing the ability to compare results across studies about the causes and treatment of cognitive dysfunction after surgery.

Finally, another significant methodological consideration regarding POCD research is the considerable amount of variability in how studies evaluate change data for neuropsychological tests, even though evaluating this is not a new concept. Lewis, Maruff, Silbert, Evered, and Scott (2006) use the example of concussion evaluations, stating tests have been used to compare

cognitive performance before and after injury to guide decisions about athletes returning to play. Lewis and colleagues state they found reliable decisions about true cognitive change in a setting like this requires the researcher to take into account the number of tests used in the study as well as the statistical rule being used. These can be refined by the application of these rules to a matched control group where there has been no true cognitive change (Lewis et al., 2006).

Other Populations with Proposed Neuropsychological Batteries

Pre- and post-surgical neuropsychological assessment batteries have been proposed for assessing cognitive functioning for specific populations. For example, other than the proposed cardiac battery, battery was proposed more recently for bariatric patients. Gunstad, Mueller, Stanek, and Spitznagel (2012) note cognitive dysfunction is frequent in patients who are candidates for bariatric surgery with evidence of difficulties more than 1.5 *SD* below normative values. They found approximately a quarter of patients had clinically significant deficits on tests measuring learning new information and recognition memory tasks. Gunstad and colleagues found uncomplicated bariatric surgery does not typically result in cognitive impairment at 12 weeks post-surgery, with patients typically showing improvement in several cognitive domains, including memory, attention, and executive functioning. Patients consistently evidenced improvement in memory function 12 weeks post-surgery when compared to controls, even when controlling for improved abilities and potential practice effects (Gunstad et al., 2012). The American Society for Bariatric Surgery recently endorsed providing neuropsychological evaluations to bariatric surgery patients, and third party payers have begun to agree to pay for these services. However, the best neuropsychological tests to measure cognitive functioning for these surgery candidates have not yet been studied and established, and further research is

needed to find the most sensitive and predictive tests for this population. Gunstad et al. (2012) recommend a comprehensive preoperative neuropsychological battery, and suggest a minimal cognitive functioning screening battery for functioning after surgery. The proposed postoperative battery includes the Modified MMSE to measure global cognitive ability, and Digit Span to measure attention (Gunstad et al., 2012).

History of the Cardiac Battery

Cardiac surgery is associated with higher risk of cerebral complications post-surgery (Krenk et al., 2010). Rasmussen (2006) makes similar statements, noting while POCD is diagnosed after major non-cardiac surgery, it occurs at lower rates than individuals who have undergone cardiac surgery. Newfield (2009) also purports having a history of cerebrovascular accident, even when there are no evident impairments from it, can increase someone's likelihood of acquiring POCD and is an independent factor at three months post-operation. Rudshagen (2014) states cardiac or vascular disease is a risk factor, and Rasmussen (2006) mentioned although previously thought to improve cognitive functioning, carotid artery surgery does not seem to improve cognitive functioning levels.

Why the battery was developed. The Consensus Statement on Neurobehavioral Outcomes After Cardiac Surgery (1995) was developed to address this problem. The Consensus Statement was developed to outline criteria for assessing central nervous system outcomes post cardiac surgery, and includes guidelines for a core battery, timing of evaluation, and measures to assess additional comorbid conditions (Rudolph et al., 2010). The goal was to develop a statement that included contributions from various disciplines, including psychology,

neuropsychology, neurology, anesthesia, cardiovascular surgery, brain ischemia research, and others (Murkin et al., 1995).

Tests historically included in the battery. From the Consensus Statement, the core recommended neuropsychological battery includes the following: the Rey Auditory Verbal Learning Test, Trail Making A & B, and the Grooved Pegboard. The Consensus Statement presents these tests as the essentials of a neuropsychological battery, as well as delineate guidelines for conducting research with this population. For example, the authors recommend ensuring a measure of mood state is administered concurrently with measures of cognitive abilities. Furthermore, they include suggestions for test selection, controlling for practice effects, measuring individual change in pre- post-surgery test performance, addressing issues in study design, eliminating extraneous variables, inclusion of a neurologic exam, and accounting for practice effects (Murkin et al., 1995). However, Rudolph et al. (2010) comment these guidelines presented by the Consensus Statement have not been widely utilized for cardiac patients resulting in continued variability in study methodology.

The importance of test sensitivity. The development of standard criteria for measuring neuropsychiatric conditions in other areas of research (for e.g., delirium, Alzheimer's, depression) has advanced the clinical and scientific research in these areas. Developing and validating a standardized neuropsychological battery and criteria would aid in advancing the research conducted on POCD and improve the efficiency of evaluation, identifying at risk patients, and quantifying outcomes (Rudolph et al., 2010).

The Value of Meta-Analysis

Meta-analysis is a helpful method for examining and synthesizing the research that has been done on POCD. Meta-analysis is a methodology that aims to accumulate and quantitatively summarize knowledge from a field of research, and identifies the effect of an intervention or phenomena by combining the conclusions of several studies. It allows the researcher to review previously completed studies (Greco, Zangrillo, Biondi-Zoccai, & Landoni, 2013). A meta-analysis can be helpful in several ways, including determining whether scientific findings are consistent or can be generalized, picking up on patterns across studies, identifying areas of disagreement in the literature, and looking at other relationships that may become apparent when comparing multiple studies. By examining the effect sizes associated with previous research studies, a meta-analysis can highlight areas for future research and how future studies could be designed in order to ensure the study has the most individual power possible (Greco et al., 2013). Harrison (2011) states a meta-analysis provides a framework for synthesizing and comparing information gathered from research studies that have been done, and that this method can be helpful for topic areas where most experiments have been completed with smaller sample sizes. It allows a systematic review of research done in the field and of important hypotheses or theoretical assumptions (Harrison, 2011).

Research on POCD is one such area that has had several small studies completed, but is still in need of having a meta-analysis done to synthesize the results of these various studies. There is a lack of consensus on how POCD is defined or researched, and at this point the literature is rather scattered. There have been several small, more casual, studies that have been completed looking at POCD, its etiology, and various risk factors. Therefore, it is a valuable

endeavor to look at these studies more comprehensively to determine what is being found within the research looking at POCD. A quantitative review article, or a meta-analysis, is helpful in analyzing the current literature, synthesizing the findings, and determining where future research should focus its efforts.

The Present Study

The purpose of the present study is to examine and quantitatively summarize the POCD literature using a meta-analysis in order to determine neuropsychological tests that are more sensitive to cognitive dysfunction after surgery. A meta-analysis will highlight key findings, gaps in the literature, and the focus of future research. The cardiac battery presented in the Statement of Consensus on Assessment of Neurobehavioral Outcomes after Cardiac Surgery (1995) proposed a battery for cardiovascular surgery patients, and it is beneficial to examine the sensitivity of these tests to POCD to determine if this would be a beneficial battery to utilize with other surgery subpopulations as well.

Hypotheses

The following hypothesis was generated for the current study: The neuropsychological tests included in the core neuropsychological battery developed for cardiac patients will be more sensitive to POCD than other neuropsychological tests. Even though the literature on cardiac patients is variable, it is presumed the tests included in this battery would be sensitive to POCD and may be beneficial to utilize when evaluating other surgery populations.

Chapter 2

Methods

Selection of Studies

Studies were acquired by searching the following electronic databases until December, 2015: *Medline*, *CINAHL*, *PsychINFO*, *PsychArticles*, *Psychology and Behavioral Sciences Collection*, *Health Source – Consumer Edition*, *Central Register of Controlled Trials*, and *Academic Search Premier* for the years 1994-2015. The year 1994 was utilized because with the exception of Bedford's initial discovery, POCD research began in 1994. An attempt was made to post information about the present study on the listserv for the International Neuropsychological Society (INS) for information on work pertaining to POCD that may not yet be published. This was not a fruitful effort and the listserv administrator did not respond to inquiries. After they were identified, pertinent articles from reference lists were retrieved and read. Terms used when searching the databases can be seen in Appendix A, along with a summary of databases searched and number of articles found with each search. Authors of some journal articles did not include enough statistics to figure an effect size and were contacted via email to obtain data; these queries did not produce many results with authors offering a variety of reasons for their non-responses (i.e., no longer had data because of number of years passed, original study conducted in another language and article translated into English, etc.). No unpublished works were located to be included in the present study. Therefore, these efforts yielded 109 potentially eligible articles, which were checked by two authors for eligibility to be included in the present study.

Inclusion & Exclusion Criteria

In order to be included in the current analysis, studies had to include: (a) an empirical measure of cognitive functioning used to evaluate each patient for POCD, (b) written in English or had been sufficiently translated into English, and (c) completed with adult human participants. Additionally, each article needed to report either within-group design (e.g., pre and post-surgery comparisons) or a between group design (e.g., surgery and control group comparisons) sufficient to allow the calculation of an effect size.

In contrast, studies that did not include enough cognitive test data were not included. Additionally, studies were excluded if: (a) they used animal subjects for their sample, (b) did not differentiate between postoperative delirium and POCD, (c) did not use quantitative outcome measures, and (d) participants met criteria for pre-surgical cognitive dysfunction or medical conditions involving the brain (e.g., surgery to remove pituitary tumor).

Of the 109 potential studies identified in database searches, 24 studies met inclusion criteria for this meta-analysis. The remaining 85 studies were excluded for the following reasons: did not include enough test data for an effect size to be calculated, included subjects who were undergoing brain surgery or had pre-existing cognitive concerns, poor study designs or considerable methodological issues.

The final data utilized in this study included 24 studies, a total of 192 effect sizes, and 2,188 participants. The average sample size per effect size was $n = 88.52$, with the smallest sample size being $n = 8$ and the largest being $n = 508$. Most of the effect sizes were based on within-groups data. Specifically, 16 effect sizes were calculated from mean differences data found in 3 published papers; 111 effect sizes were calculated from pre-post surgery means

reported in 19 published papers; and 20 effect sizes were calculated from the *p*-values of paired-samples *t*-tests reported in one published paper. The four studies with between-groups designs (i.e., comparing means of surgery and non-surgery participants) resulted in the calculation of 45 effect sizes.

Coding of Study Characteristics

The factors of patient age (middle-aged or older adult), type of surgery (cardiac versus non-cardiac), whether the study was completed in China, study design (comparing between or within groups), and the neuropsychological test used were coded in the various articles that met inclusion criteria for the current analysis. Table 1 shows the studies included in the sample for this analysis.

Computation of Effect Sizes

The meta-analysis software, "Comprehensive Meta-Analysis v.3, Professional Version" (CMA; Borenstein, Hedges, Higgins, & Rothstein, 2009) was used for calculating the effect sizes. Using this software allowed for entering individual test data from each journal article, and the program calculated effect size (Cohen's d', Hedges g, etc.) based on the information entered. The program also provided calculations for standard error and *p*-values for each effect size. Hedge's *g* was used in this analysis in an effort to correct for bias in small samples (cf. Borenstein, 2009; Borenstein et al., 2009). The variance of each effect size was computed according to the formulae given by Borenstein (2009).

Table 1

Articles Located from Database Searches

	Authors	Year	Title	Study Design	Age of Participants	China	Type of Surgery
1.	Steinmetz, Funder, Dahl, & Rasmussen	2010	Depth of Anesthesia and Post-Operative Cognitive Dysfunction	Within	Older	No	Non-cardiac
2.	Hudetz et al.	2009	Ketamine Attenuates Post-Operative Cognitive Dysfunction After Cardiac Surgery	Within & Between	Older	No	Cardiac
3.	Lewis, Maruff, Silbert, Evered, & Scott	2006	The Sensitivity and Specificity of Three Common Statistical Rules for the Classification of Post-Operative Cognitive Dysfunction Following Coronary Artery Bypass Graft Surgery	Within & Between	Older	No	Cardiac
4.	Li, Shao, Wang, & Wang	2014	Relationship Between Post-Operative Cognitive Dysfunction and Regional Cerebral Oxygen Saturation and B-Amyloid Protein	Between	Older	Yes	Cardiac
5.	Gottesman et al.	2007	Early Postoperative Cognitive Dysfunction and Blood Pressure During Coronary Artery Bypass Graft Operation	Within	Older	No	Cardiac
6.	Maekawa, Baba, Otomo, Morshita, & Tamura	2014	Low Pre-Existing Gray Matter Volume in the Medial Temporal Lobe and White Matter Lesions Are Associated with Postoperative Cognitive Dysfunction after Cardiac Surgery	Between	Older	No	Cardiac
7.	Walzer, Herrmann, & Wallesch	1997	Neuropsychological Disorders After Coronary Bypass Surgery	Within	Older	No	Cardiac

Table continues

Table 1 continued

	Authors	Year	Title	Study Design	Age of Participants	China	Type of Surgery
8.	Tian, Zhao, Li, Guo, Wang, & Jiang	2015	Pre-emptive Parecoxib and Post-Operative Cognitive Function In Elderly Patients	Between	Older	Yes	Non-Cardiac
9.	Djaiani et al.	2007	Continuous-Flow Cell Saver Reduces Cognitive Decline in Elderly Patients After Coronary Bypass Surgery	Within	Older	No	Cardiac
10.	Rentowl & Hanning	2004	Odour Identification as a Marker for Postoperative Cognitive Dysfunction: A Pilot Study	Between	Older	No	Non-Cardiac
11.	Johnson et al.	2002	Postoperative Cognitive Dysfunction in Middle-Aged Patients	Between	Middle-Aged	No	Non-Cardiac
12.	Baar, Diephuis, Moons, Holtkamp, Hijman, & Kalkman	2003	The Effect of Zero-Balanced Ultrafiltration During Cardiopulmonary Bypass on S100b Release and Cognitive Function	Between	Older	No	Cardiac
13.	Hassani et al.	2015	Can Valeriana Officinalis Root Extract Prevent Early Postoperative Cognitive Dysfunction After CABG Surgery? A Randomized Double Blind Placebo Controlled Trial	Within	Middle-aged	No	Cardiac
14.	Lili, Zhiyong, & Jianjun	2013	A Preliminary Study of the Effects of Ulinastatin on Early Postoperative Cognitive Function in Patients Undergoing Abdominal Surgery	Within	Older	Yes	Non-Cardiac
15.	Zhu, Ji, Gao, Li, & Yang	2016	Association Between Perioperative Blood Transfusion and Early Postoperative Cognitive Dysfunction in Aged Patients Following Total Hip Replacement Surgery	Within & Between	Older	Yes	Non-Cardiac

Table continues

Table 1 continued

	Authors	Year	Title	Study Design	Age of Participants	China	Type of Surgery
16.	Ni et al.	2015	Cerebral Oxygen Saturation After Multiple Perioperative Influential Factors Predicts the Occurrence of Postoperative Cognitive Dysfunction	Within & Between	Older	Yes	Non-Cardiac
17.	Sirvinskas et al.	2014	Effects of Intraoperative External Head Cooling on Short-Term Cognitive Function in Patients After Coronary Artery Bypass Graft Surgery	Within	Older	No	Cardiac
18.	Hudetz, Gandhi, Iqbal, Patterson, & Pagel	2011	Elevated Postoperative Inflammatory Biomarkers are Associated With Short- and Medium-Term Cognitive Dysfunction After Coronary Artery Surgery	Within	Older	No	Cardiac
19.	Rappold et al.	2016	Evidence of an Association Between Brain Cellular Injury and Cognitive Decline After Non-Cardiac Surgery	Within	Middle-Older	No	Non-Cardiac
20.	Hudetz, Patterson, Amole, Riley, & Pagel	2011	Postoperative Cognitive Dysfunction After Noncardiac Surgery: Effects of Metabolic Syndrome	Within & Between	Older	No	Non-Cardiac
21.	Sato et al.	2015	Postoperative Structural Brain Changes and Cognitive Dysfunction in Patients With Breast Cancer	Within & Between	Middle-Older	No	Non-Cardiac
22..	Ilvan & Ozkose	2015	The Effect of Total Intravenous Anesthesia on the Postoperative Cognitive Functions of Young and Elderly Patients After Lumbar Disk Surgery	Within	Middle & Older	No	Non-Cardiac

Table continues

Table 1 continued

	Authors	Year	Title	Study Design	Age of Participants	China	Type of Surgery
23.	Postler, Neidel, Gunther, & Kirschner	2011	Incidence of Early Postoperative Cognitive Dysfunction and Other Adverse Events in Elderly Patients Undergoing Elective Total Hip Replacement	Within	Older	No	Non-Cardiac
24.	Mandal, et. al.	2011	Impact of General Versus Epidural Anesthesia on Early Post-Operative Cognitive Dysfunction Following Hip and Knee Surgery	Within	Older	No	Non-Cardiac

Chapter 3

Results

Outline of the Meta-Analytic Process

Klein (2005) describes an iterative approach to meta-analyses in which the following steps are undertaken. First, decide whether to combine results across studies. Second, estimate an average effect size. Third, examine the heterogeneity of effect sizes across studies. Fourth, estimate the potential for bias. This is the rough outline that this results section will follow. The raw data for each study, including the Hedge's g, Standard Error of Hedge's g and coding, appear in Appendix B.

Combining Results Across Studies

There are two common models of variance in meta-analyses, Fixed-effects models and Random-effects models. In Fixed-effects models the assumption is that all effect sizes are being sampled from a common treatment effect and therefore, would be expected to be the same except for variability across different studies. In Random-effects models, the assumption is that treatment effects across studies may arise from different sources. In the present analysis a Random-effects model was used.

Examining Moderator Variables

Several variables were investigated as moderators. These included (a) whether the participants were cardiac patients or not; (b) whether the study was conducted in China; (c) the number of post-surgery days when testing took place; and (d) patient age.

Cardiac patients. The weighted mean Hedges *g* for the studies with cardiac patients was significantly different from zero, Hedge's $g = .24$ ($SE = .10$), $z = 2.41$, $p = .02$. Similarly, the weighted mean Hedges g for the studies with non-cardiac patients also was significantly different from zero, Hedge's $g = .26$ ($SE = .08$), $z = 3.19$, $p = .001$. In fact, the weighted mean Hedges *g* did not differ for studies with cardiac and non-cardiac patients, therefore, this variable was not considered in subsequent analyses.

Chinese studies. The weighted mean Hedges *g* for the studies conducted in China ($n = 5$) was significantly different from zero, Hedge's $g = .52$ ($SE = .14$), $z = 3.79$, $p < .001$. Similarly, the weighted mean Hedges g for the studies conducted in other countries ($n = 20$) also was significantly different from zero, Hedge's $g = .19$ ($SE = .07$), $z = 2.83$, $p = .005$. The weighted mean Hedges *g* was significantly inflated for studies conducted in China. Therefore, the decision was made to include only non-Chinese studies in subsequent analyses.

The number of post-surgery days when testing took place. This variable was coded into three periods: less than one week, one to two weeks, and one to three months. Figure 1 shows the Forrest plot displaying the average effects for studies as a function of the number of post-surgery days when testing took place. The weighted mean Hedges *g* for the studies with multiple testing times was significantly different from zero, Hedge's $g = .39$ ($SE = .15$), $z = 2.57$, $p = .01$. The weighted mean Hedges *g* for the studies with testing times of less than 1 week was not significantly different from zero, Hedge's $g = .04$ ($SE = .16$), $z = 0.25$, $p = .80$. The weighted mean Hedges *g* for the studies with testing times between one to two weeks was significantly different from zero, Hedge's $g = .33$ ($SE = .08$), $z = 4.11$, $p < .001$. Finally, the weighted mean Hedges *g* for the studies with testing times of one to three months was not significantly different

from zero, Hedge's g = -.03 (SE = .17), z = -0.16, p = .87. These results suggest that the effects of POCD are most pronounced from 7-14 days after surgery. Because most studies (n = 18) in this analysis were conducted in this time frame, the decision was made to include only this time frame in subsequent analyses.

Patient age. The weighted mean Hedges g for the studies conducted on patients younger than 65 years old (n = 5) was not significantly different from zero, Hedge's g = -.07 (SE = .14), z = - 0.52, p = .61. In contrast, the weighted mean Hedges g for the studies conducted on patients who were older than 65 years was significantly different from zero, Hedge's g = .41 (SE = .08), z = 5.03, p < .001. These results suggest that the effects of POCD are most pronounced for older patients. Because most studies (n = 17) in this analysis were conducted with older participants, the decision was made to include only these studies in subsequent analyses.

Estimating an Average Effect Size

The weighted mean Hedges g indicated a small effect of POCD on patient's performance on neuropsychological tests, Hedge's g = .45 (SE = .05), z = 8.86, p < .001. Of the 54 effect sizes that qualified for the final analysis, 23 (42.59 %) were in the hypothesized direction, and 31 (57.41%) were negative or equaled zero. The effect sizes ranged from g = -.81 to g = 1.79, suggesting substantial variability. Statistical analysis also suggests there is considerable heterogeneity among these 54 effect sizes, Q (53) = 204.33, p <.001.

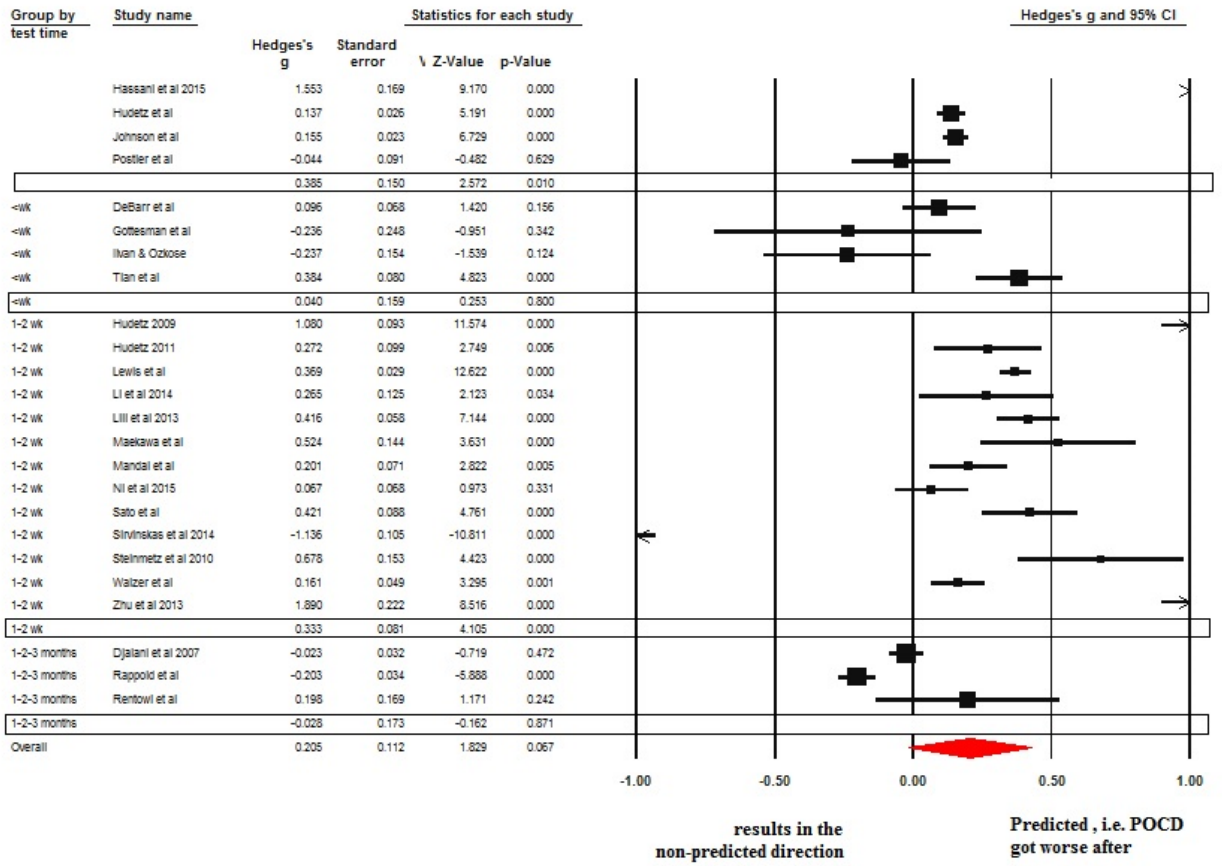

Figure 1. The Forrest plot displaying the average effects for studies as a function of the number of post-surgery days when testing took place.

In an effort to understand the heterogeneity in these 54 effects, the effects were examined as a function of the neuropsychological test. Tests were categorized into 1 of 9 types of neuropsychological tests and the weighted mean Hedges g effect size was calculated for each category. Table 2 displays the Hedges *g* effect size calculated for each test category, as well as an indication of the average effect sizes' difference from zero. The information from Table 2 is displayed graphically in a Forrest plot in Figure 2. All the test categories were significantly different from zero except Learning and Immediate Recall and Visual Spatial tests (i.e., no effect). The most sensitive test was the MMSE, which had a large effect size. Tests with moderate effect sizes included Delayed Recall, Language, and Processing Speed. The remaining tests had small effect sizes.

Table 2

Average Effect Sizes as a Function of Assessment Tool.

Category of Assessment	*ES*	*SE*	*N*	*z*	*p*	*Q*	*df*	*p*
Attention & Memory	.38	.15	4	2.48	.01	2.60	3	.46
Delayed Recall	.63	.16	10	3.95	<.01	31.29	9	<.01
Executive Functions	.32	.10	7	3.34	<.01	8.82	6	.18
Language	.55	.19	7	2.86	<.01	36.53	6	< .01
Learning & Immediate Recall	.28	.16	9	1.73	.08	43.10	8	< .01
MMSE	.89	.36	4	2.43	.01	32.49	3	< .01
Motor	.34	.09	3	3.71	<.01	4.89	2	.09
Processing Speed	.51	.12	6	4.11	<.01	16.16	5	<.01
Visual	.39	.20	4	1.91	.06	9.02	3	.03

Notes: ES – weighted mean Hedge's *g*, negative scores indicate change in the non-predicted direction.

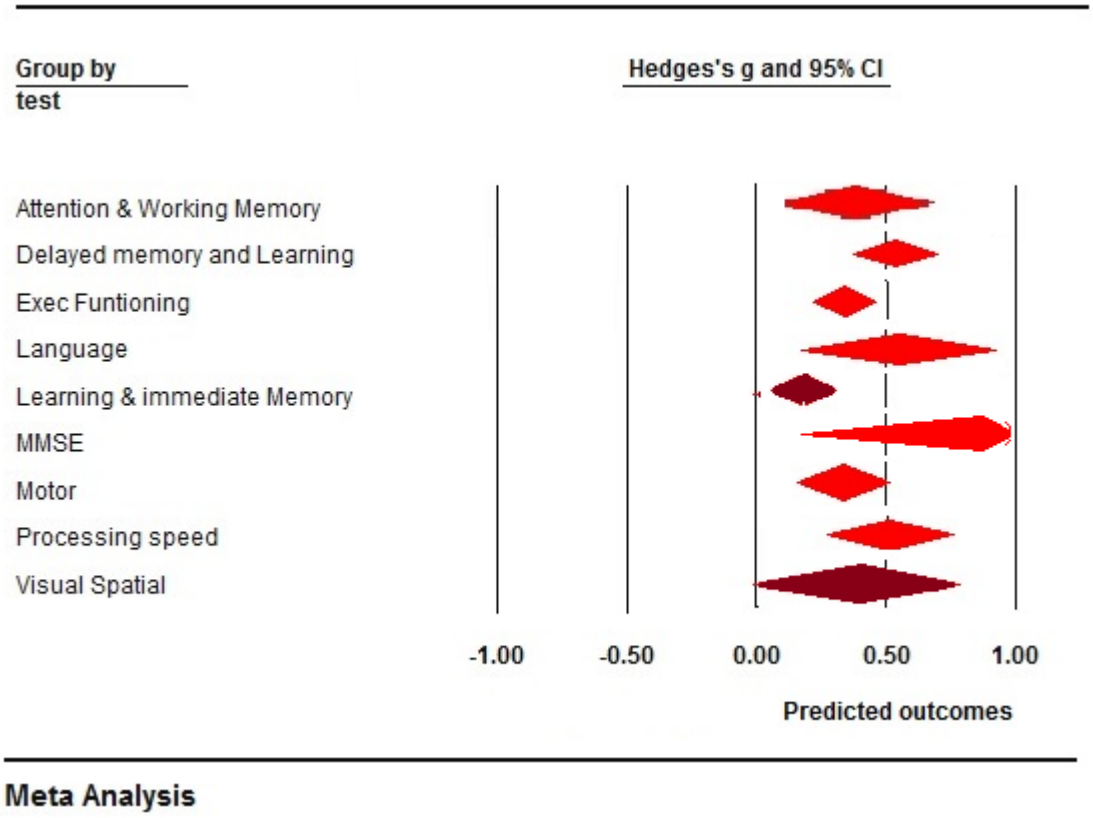

Figure 2. Forrest plot summarizing effect sizes for nine categories of neuropsychological tests.

Heterogeneity of Effect Sizes

While the analysis of effect sizes as a function of the neuropsychological test category is important, these results should be considered in light of the heterogeneity within each of the test categories. The right-three columns in Table 2 shed light on the heterogeneity. Significant heterogeneity exists for most of the categories. In fact only the categories of Attention, Executive Function, and Motor responses demonstrate homogeneity.

Estimate of the Potential for Bias

To investigate potential publication bias and illustrate the distribution of effect sizes, we performed a funnel plot analysis. Figure 3 plots the magnitude of effect size (Hedges' *g* on the

ordinate) against its standard error (on the abscissa). Effect sizes at a greater distance from the average are assumed to have larger standard errors, indicating less precision due to smaller samples. If many of the effect sizes fall outside of 95% confidence interval, it indicates especially large effect sizes were published even though they were based on small samples. The converse of this is also true, that small effect sizes based on small samples do not get published. Another important aspect is revealed by the symmetry of the funnel, since when a plot is asymmetrical it indicates studies reporting either positive or negative effect sizes are more readily published. For this study, Figure 3 shows a rather small number of effect sizes outside the confidence interval and a sufficient degree of symmetry. Further, an Orwin fail-safe analysis suggests that, given the overall effect in the 54 results in the final analysis, 3,583 studies with no effect would be needed to cause the overall effect to fall into the "no effect" category.

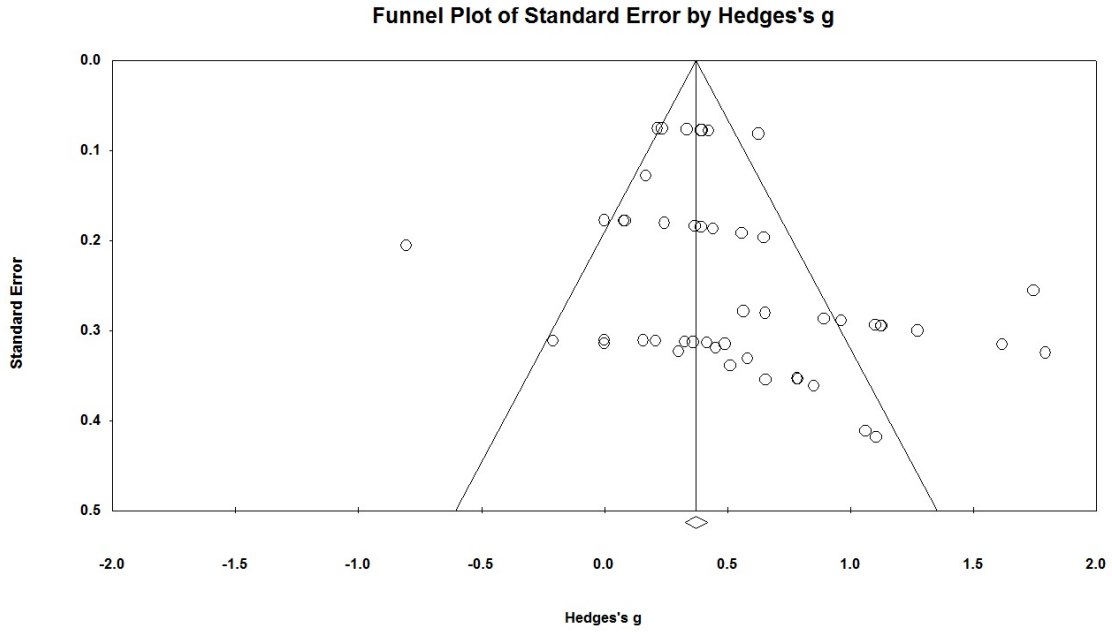

Figure 3. The magnitude of effect sizes (Hedges' g on the ordinate) against its standard error (on the abscissa).

Chapter 4

Discussion

The current analysis examined the moderating factors of POCD, including the type of surgery, whether the study was completed in China, the number of days post-surgery when the patient was evaluated, and the patients' age. Furthermore, the present study examined which cognitive domains are most impacted by POCD, and in turn what types of neuropsychological tests are most sensitive to POCD.

Moderating Variables and Sensitivity of Tests

The present analysis found type of surgery (cardiac versus non-cardiac) is not a significant moderating variable regarding whether patients develop POCD. This seems to be in contrast to previous findings, indicating POCD frequently occurs in patients undergoing cardiac surgery and seems to increase risk of cognitive dysfunction following surgery (Hudetz et al., 2009; Maekawa, Baba, Otomo, Morishita, & Tamura, 2014). However, it is important to remember that the present analysis did not investigate the difference in incidence of POCD for cardiac and non-cardiac surgery patients but instead examined differences in patterns of cognitive loss and test sensitivities to those cognitive losses. One speculation regarding the results of the current analysis could be that the goal of cardiac surgery is improvement of health and quality of life, which may in fact improve cognitive functioning after surgery. This has been seen in patients who undergo bariatric surgery and have considerable reduction in cardiovascular risk factors such as glucose levels and hypertension (Gunstad et al., 2012). Another theory is that

there are other variables involved in cardiac surgery that may be causing these difficulties rather than the surgery itself. For example, Gottesman et al. (2007) found a drop in arterial pressure during coronary artery bypass graft operation was a risk factor for POCD.

A second moderator variable which effected POCD study results was whether the study was conducted in China. The studies conducted in China utilized different methodology and study design than the other studies examined, which is why I decided to include this as a moderating factor. The Hedges *g* was significantly higher for Chinese studies, when compared with non-Chinese studies and studies from China were more often rejected from the final sample of papers for this meta-analysis because critical statistical results were not reported. In those cases in which I contacted Chinese authors for original data or missing statistics, I got no response to my inquiry or the authors told me their data were no longer available.

The third moderating variable I examined was the timing of post-surgery assessment. The results of the current analysis revealed that effects of POCD are most pronounced from 7-14 days post-surgery. This is an important result for patient care following surgery, as well as family and caregivers since the general assumption is most likely that the patient will progressively improve in the following weeks. However, these results suggest the patient may have more significant cognitive difficulty a week or two after the procedure is completed. This is helpful for the patient, family, and caregivers to be aware of so arrangements can be made to provide additional care and support for patients may need more assistance during that time.

Finally, the age of patients was examined as a moderating variable. Previous research shows evidence of POCD occurring frequently in older adults after surgery, as well as increases in prevalence with older age (Johnson, et. al., 2002; Postler, Neidel, Gunther, & Kirschner,

2011). In the present study, age was found to be a moderating factor in the severity of POCD symptoms. Older patients are more likely to develop cognitive difficulties after surgery and may be more susceptible to these changes. Furthermore, older adults are at higher risk for the occurrence of adverse events while in the hospital, which can impair outcomes post-surgery (Postler et al., 2011).

The focus of the current analysis was the sensitivity of neuropsychological tests included in pre- post-surgical assessment batteries to POCD symptoms. The MMSE was found to be the most sensitive to POCD, which makes sense, considering the fact that a screener for cognitive concerns is created to be very sensitive to even slight cognitive difficulties. It reinforces the efficacy of the use of the MMSE for picking up on cognitive issues from pre to post surgery. Furthermore, the MMSE is a useful tool to include in post-surgical evaluations, particularly for individuals who require a very brief or bedside evaluation of cognitive functioning. The tests with moderate effect sizes included Delayed Recall, Language, and Processing Speed. Memory, recall and processing speed tests are commonly included in neuropsychological batteries for pre-post-surgical evaluations for POCD, and this is likely an effective way of evaluating change in cognitive abilities. Including tests evaluating language ability is also important, and should be consistently included in neuropsychological batteries pre- and post-surgery. However, it can be stated with confidence that the cognitive domains of attention and working memory, executive functions, and motor abilities evidenced homogeneity among effect sizes. This pattern of POCD deficits is consistent with the previous literature. For example, Krenk et al. (2010) found deficits in memory and processing speed in patients with POCD.

The practical implications of these neuropsychological results for patients and their families are important in the recovery process. If patients experience POCD it would be most likely to occur in the 7-14 days post-surgery and affect cognitive abilities such as memory recall, language, and processing speed. Cognitive abilities such as attention, working memory, executive functions, and motor abilities are less likely to be affected. This might mean that behaviors such as recalling information or instructions, word finding, and being able to quickly understand and react to information being presented would be more difficult than expected after surgery. Abilities like making decisions, inhibition, problem solving, gross and fine motor movements, attention, and being able to hold information in their minds and manipulate it could be expected to be generally intact. Professional caregivers and family members might want to anticipate the need to provide additional support for remembering to take medications and follow doctor instructions during recovery, especially for geriatric surgery patients. They may also need to anticipate allowing extra time to complete these tasks due to the impact of POCD on processing speed.

Limitations

There are some limitations to the present study that should cause the reader to view the results with some skepticism. First, the heterogeneity of effects in the final analysis is problematic and should raise cautions in the interpretation of results. Second, grouping cognitive tests into specific domains, although common practice, can be challenging since overlap exists among the cognitive abilities being measured by these tests. Further, the current analysis confounds test sensitivity with the phenomenon of the pattern of cognitive loss in POCD. Thus, one is unable to tell whether a particular cognitive domain has smaller effect sizes because that

domain is less effected in the POCD syndrome or because the tests used to assess that cognitive domain are less valid or reliable than tests for other domains. Lastly, a significant challenge is the variability in study design, methodology, and reported data among journal articles being published on POCD. Further clarification of these components is necessary for progression in research since comparison among studies can be difficult due to these issues.

Directions for Future Research

Recommendations for research. The results from the present study indicate some very clear and practical standards for research design. First, all patients should be administered an MMSE pre- and post-surgery. The MMSE was found to have a very large effect size out of the measures analyzed indicating this measure is the most sensitive to detecting cognitive dysfunction following surgery. Second, the post-surgery administration of the MMSE should occur 7 to 14 days following surgery since results illustrated cognitive dysfunction is most prominent during this time. Third, the MMSE is a very cost-effective, timely, instrument that can be used bedside if needed as an efficient way of assessing for cognitive dysfunction. Another advantage to using this tool is that it can be administered by trained staff and does not require a neuropsychologist to administer.

Other areas worth continued improvement regarding research includes streamlining methodology and diagnostic criteria. For example, Rudolph et al. (2010) comment recent studies report both a dichotomous definition and a continuous summary measure of a patient's cognitive function, stating although calculation of a dichotomous definition has some clinical applicability it reduces statistical power. Combining multiple neuropsychological tests into a single measure

of a cognitive domain can also pose concerns and continues to be debated, since there is some overlap between cognitive domains and neuropsychological tests used to measure them.

Another difficulty encountered frequently while conducting the present study was that researchers in different professions reported different data in their articles. An example includes the difference in data physicians reported and data psychologists and neuropsychologists reported. Increased collaboration among fields of study would aid in the advancement of research, and therefore patient care and outcomes. An exemplar of best practice in how neuropsychological assessment data could be included in reporting of POCD results can be found in Sato et al. (2015). They include a summary table of the neuropsychological assessment data which included the cognitive domain assessed, the tests utilized, and pre-post scores for patient and control groups (values expressed as means and standard deviations) for each of the tests.

Newman, Stygall, Hirani, Shaefi, and Maze (2007) state an area for further study regarding POCD is how effects of surgery, such as pain or how post-surgery medications, may potentially influence patients' poorer performances on neuropsychological test batteries. The authors state this may account for some of the declines during the days after surgery when pain and medications may have the most significant impact on cognitive functioning and also at later assessment times (Newman et al., 2007). Heyer et al. (2000) state there is not much research on the effect of pain on an individual's performance on neuropsychological tests in general, including which tests are affected by pain, how significant the impact is, and other factors that could be confounding test performance in a sample of spine surgery patients. Heyer et al. comment pain is not always a prominent factor in some surgeries, coronary artery bypass

grafting (CABG) surgery being one example; however, surgeries like spine surgery can involve a considerable amount of pain pre- and post-surgery. Their findings are consistent with previous studies showing the effect of pain on attention (Heyer et al., 2000).

Recommendations for clinical practice. If depressed MMSE scores are found relative to pre-test scores, a more thorough comprehensive post-surgery neuropsychological evaluation may be warranted. This would include giving tests in the cognitive domains that had moderate effect sizes, which were delayed recall, language, and processing speed. These tests are likely the most sensitive to picking up on POCD deficits. Other tests that may potentially add value to a neuropsychological battery would be tests within the cognitive domains found to have small effect sizes with POCD, namely attention and memory, executive functions, and motor tests. The cognitive domains that did not have significant effect sizes with POCD would not be worth including in this battery (i.e., learning and immediate recall and visual spatial tests).

Conclusion

This analysis found older adults are at higher risk of developing POCD, that the most prominent time for symptoms is 7-14 days post-surgery, and that patients have the same pattern of POCD deficits after cardiac surgery as after non-cardiac surgery. The MMSE was found to be very sensitive to identifying POCD, and tests measuring delayed recall, language, and processing speed were found to be moderately effective in detecting POCD. These findings are important in order to improve the quality of evaluations of cognitive functioning pre- and post-surgery. Cognitive functioning has a significant impact on success following surgery, and is an important factor when predicting whether recovery following surgery will be successful. Warranting further discovery is determining what variables are correlated with better outcomes after surgery.

This is the aim of most pre-surgical evaluations, to determine with the most certainty possible the likelihood of success post-surgery and positive outcomes on quality of life. Further research in this regard would allow for a better understanding of the etiology of POCD and how to best manage its occurrence for better post-surgery outcomes.

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Appendix A

Summary of Database Searches

Database searches completed

Database	Search Terms	# of Hits	Abstracts Read	Articles Read	Met Criteria	Unique Articles
Medline	cognit* dysfunction post-operative	109	43	19	5	19
CINAHL	"post operative" cognitive dysfunction adults	0	--	--	--	--
PsychINFO	"cognitive dysfunction" Surgery	182	35	16	4	13
CINAHL with Full Text	postoperative cognitive dysfunction NOT delirium	92	46	32	7	26
PsychArticles	cognitive dysfunction surgery patients postoperative cognitive dysfunction operations	0	--	--	--	--
Psychology and Behavioral Sciences Collection	cognitive dysfunction postoperative	14	7	5	1	3
Health Source – Consumer Edition	postoperative cognitive dysfunction surgery or operation	0	--	--	--	--
Health Source – Consumer Ed., Cochrane Central Register of Controlled Trials	postoperative cognitive dysfunction NOT delirium	0	--	--	--	--
Academic Search Premier	postoperative cognitive dysfunction surgery patients NOT delirium	83	41	37	12	32

Appendix B

Raw Data for Each Study

Table B1

Summary of the Data from Studies Using Independent Groups Design

	Study name	surgery Mean	surgery SD	surgery n	control Mean	control SD	control n	Hedges's g	Std Err	time	Chinese ?	Mean Age	Cardiac Patients?	Test Category	test name
1	Hudetz 2011	18	3	30	19	3	15	0.33	0.31	7	n	65	n	Learning & immediate Memory	story recall
2	Hudetz 2011	25	5	30	26	4	15	0.21	0.31	7	n	65	n	Learning & immediate Memory	word list recall
3	Hudetz 2011	7	3	30	8	2	15	0.36	0.31	7	n	65	n	Delayed memory and Learning	delayed figure reconstruc-tion
4	Hudetz 2011	9	2	30	10	2	15	0.49	0.31	7	n	65	n	Delayed memory and Learning	delayed story recall
5	Hudetz 2011	5	2	30	5	3	15	0.00	0.31	7	n	65	n	Delayed memory and Learning	delayed word list recall
6	Hudetz 2011	9	2	30	10	2	15	0.49	0.31	7	n	65	n	Attention & Working Memory	digit span Backward
7	Hudetz 2011	13	5	30	12	4	15	-0.21	0.31	7	n	65	n	Language	phonemic fluency

8	Hudetz 2011	14	4	30	16	4	15	0.49	0.31	7	n	65	n	Language	semantic fluency
9	Hudetz 2011	21	7	30	22	4	15	0.16	0.31	7	n	65	n	Visual Spatial	figure reconstruc-tion
10	Hudetz 2011	42	9	30	47	16	15	0.42	0.31	7	n	65	n	Exec Funtioning	stroop
11	Johnson et al	14	5.08	508	14.5	5.07	183	0.10	0.09	7	n	50	n	Learning & immediate Memory	Word list
12	Johnson et al	17	4.49	508	17.5	4.47	183	0.11	0.09	90	n	50	n	Learning & immediate Memory	Word list
13	Johnson et al	4.25	2.51	508	4.75	2.49	183	0.20	0.09	7	n	50	n	Delayed memory and Learning	delayed verbal recall
14	Johnson et al	5.5	2.2	508	5.75	1.90	183	0.12	0.09	90	n	50	n	Delayed memory and Learning	delayed verbal recall
15	Johnson et al	15.5	3.85	508	17.5	3.83	183	0.52	0.09	7	n	50	n	Processing speed	coding
16	Johnson et al	18.8	3.55	508	19.3	2.94	183	0.15	0.09	90	n	50	n	Processing speed	coding
17	Johnson et al	18.4	10.9	508	16.7	10.9	183	-0.15	0.09	7	n	50	n	Exec Functioning	concept shifting
18	Johnson et al	13.9	9.48	508	19.6	7.16	183	0.63	0.09	90	n	50	n	Exec Functioning	concept shifting
19	Johnson et al	0.25	1.46	508	0.25	1.46	183	0.00	0.09	7	n	50	n	Exec Functioning	errors in concept shifting
20	Johnson et al	0.00	1.46	508	0.00	1.46	183	0.00	0.09	90	n	50	n	Exec Functioning	errors in concept shifting
21	Johnson et	0.25	1.46	508	0.25	1.46	183	0.00	0.09	7	n	50	n	Exec	stroop

	al													Functioning	errors
22	Johnson et al	0.00	1.46	508	0.00	1.46	183	0.00	0.09	90	n	50	n	Exec Functioning	stroop errors
23	Johnson et al	21.9	7.86	508	19.1	7.88	183	0.35	0.09	7	n	50	n	Exec Functioning	stroop time
24	Johnson et al	17.9	5.29	508	17.1	4.74	183	0.18	0.09	90	n	50	n	Exec Functioning	stroop time
25	Sato et al	29.8	7.2	30	29.5	5.1	19	-0.05	0.29	7	n	60	n	Learning & immediate Memory	story recall
26	Sato et al	26.3	8.5	30	27.4	6	19	0.14	0.29	7	n	60	n	Delayed memory and Learning	delayed story recall
27	Sato et al	74.5	18.2	30	87.3	14.1	19	0.75	0.29	7	n	60	n	Processing speed	coding
28	Sato et al	31.4	5.1	30	35.5	5.8	19	0.75	0.29	7	n	60	n	Attention & Working Memory	Digit cancella-tion 1
29	Sato et al	48	6.3	30	48.8	7.9	19	0.11	0.29	7	n	60	n	Attention & Working Memory	Digit cancella-tion 2
30	Sato et al	53.3	9.7	30	61.6	12.2	19	0.76	0.29	7	n	60	n	Attention & Working Memory	Digit cancella-tion 3
31	Sato et al	6.3	2.4	30	7.7	1.8	19	0.63	0.29	7	n	60	n	Attention & Working Memory	digit span B
32	Sato et al	57.9	9.9	30	63.2	9.1	19	0.54	0.29	7	n	60	n	Exec Functioning	stroop 1
33	Sato et al	50.8	9.6	30	53.8	8.2	19	0.32	0.29	7	n	60	n	Exec Functioning	stroop 2
34	Sato et al	42	7.2	30	42.8	6.3	19	0.11	0.29	7	n	60	n	Exec Functioning	stroop 3

35	Sato et al	34.8	9.8	30	41.2	10.3	19	0.63	0.29	7	n	60	n	Exec Functioning	stroop 4
36	Hudetz 2009	13.8	6.2	26	18.6	3.1	26	0.96	0.29	7	n	65	y	Learning & immediate Memory	story recall
37	Hudetz 2009	20.3	6.1	26	26.3	4.5	26	1.10	0.29	7	n	65	y	Learning & immediate Memory	word list recall
38	Hudetz 2009	4.7	2.9	26	7.8	2.5	26	1.13	0.29	7	n	65	y	Delayed memory and Learning	delayed figure reproduc-tion
39	Hudetz 2009	4.9	1.4	26	6.1	2.6	26	0.57	0.29	7	n	65	y	Delayed memory and Learning	delayed figure recognition
40	Hudetz 2009	5.9	3.3	26	9.2	2.4	26	1.13	0.29	7	n	65	y	Delayed memory and Learning	delayed story recall
41	Hudetz 2009	2.5	2.2	26	5.8	1.8	26	1.62	0.29	7	n	65	y	Delayed memory and Learning	delayed word list recall
42	Hudetz 2009	7.4	1.8	26	8.5	1.5	26	0.65	0.28	7	n	65	y	Attention & Working Memory	digit span B
43	Hudetz 2009	8	4.2	26	13.5	4.3	26	1.27	0.30	7	n	65	y	Language	phonemic fluency
44	Hudetz 2009	11.5	3.2	26	18.2	4.1	26	1.79	0.32	7	n	65	y	Language	semantic fluency
45	Hudetz 2009	15	6.2	26	21	7	26	0.89	0.29	7	n	65	y	Visual Spatial	figure reconstruc-tion

Table B2

Summary of the data from studies using within-groups design

	Study name	Mean Difference	SD of Difference	Sample size	Pre/Post Correlation	Effect direction	Hedges's g	Std Err	Time point	Chinese or not?	Age	Cardiac Patients?	Test Category	Test name
46	Lewis et al	0.78	3.6	178	0.5	3	0.21	0.08	7	n	70	y	Learning & immediate Memory	total recall
47	Lewis et al	4.6	7.3	178	0.5	3	0.62	0.08	7	n	70	y	Processing speed	coding
48	Lewis et al	6	25.4	178	0.5	3	0.23	0.08	7	n	70	y	Processing speed	Trails A
49	Lewis et al	2.9	8.6	178	0.5	3	0.33	0.08	7	n	70	y	Language	COWAT
50	Lewis et al	35.1	88	178	0.5	3	0.39	0.08	7	n	70	y	Exec Function	Trails B
51	Lewis et al	17.7	44.8	178	0.5	3	0.39	0.08	7	n	70	y	Motor	pegboard dom hand
52	Lewis et al	20.2	47.5	178	0.5	3	0.42	0.08	7	n	70	y	Motor	pegboard non dom hand
53	Rentowl et al	-0.29	1.43	34	0.5	3	0.19	0.17	90	n	60	n	Other	odor identification
54	Sirvinskas et al 2014	1.1	1.1	25	0.5	2	-0.96	0.24	10	n	63	y	Learning & immediate Memory	fig mem immediate
55	Sirvinskas et al 2014	0.3	1	25	0.5	2	-0.29	0.19	10	n	63	y	Delayed memory and Learning	fig mem delay
56	Sirvinskas	4.6	1.1	25	0.5	2	-4.04	0.60	10	n	63	y	Processing	coding

	et al 2014												speed	
57	Sirvinskas et al 2014	10.9	1.9	25	0.5	2	-5.55	0.80	10	n	63	y	Processing speed	Trails A
58	Sirvinskas et al 2014	0.9	0.6	25	0.5	2	-1.45	0.28	10	n	63	y	Attention & Working Memory	digit span - F
59	Sirvinskas et al 2014	1.7	0.8	25	0.5	2	-2.05	0.34	10	n	63	y	Attention & Working Memory	digit span -B
60	Sirvinskas et al 2014	31.2	5.5	25	0.5	2	-5.49	0.80	10	n	63	y	Exec Functioning	Trails B
61	Sirvinskas et al 2014	0.9	1.2	25	0.5	2	-0.72	0.21	10	n	63	y	MMSE	MMSE

Table B3

Summary of the Data from Studies Using Within-Groups Pre-Post Design

	Study name	Subgroup within study	Pre Mean	Pre SD	Post Mean	Post SD	Sample size	Hedges's g	Std Err	Time point	Chinese or not	Age	Cardiac or not	Test category	test name
62	Djaiani et al 2007	Both POCD + non	432.73	115.2	413.78	87.8	96	0.18	0.10	42	n	65	y	Attention & Working Memory	Crt minus Srt
63	Djaiani et al 2007	Both POCD + non	10.08	2.2	10.29	2.05	96	-0.09	0.10	42	n	65	y	Attention & Working Memory	digit span forward
64	Djaiani et al	Both POCD	7.29	1.45	7.23	1.44	94	0.04	0.10	42	n	65	y	Attention & Working	spatial span forward

	2007	+ non												Memory	
65	Djaiani et al 2007	Both POCD + non	6.83	1.76	6.9	1.61	95	-0.04	0.10	42	n	65	y	Attention & Working Memory	spatial span backward
66	Djaiani et al 2007	Both POCD + non	6.04	2.28	6.29	2.42	94	-0.11	0.10	42	n	65	y	Attention & Working Memory	digit span backward
67	Djaiani et al 2007	Both POCD + non	34.22	11.5	36.03	10.6	99	-0.16	0.10	42	n	65	y	Language	verb fluent
68	Djaiani et al 2007	Both POCD + non	5.05	2.14	5.27	2.01	99	-0.11	0.10	42	n	65	y	Visual Spatial	RVDLT
69	Djaiani et al 2007	Both POCD + non	53.86	33.9	56	44.78	97	-0.05	0.10	42	n	65	y	Exec Function	Trails A&B
70	Djaiani et al 2007	Both POCD + non	91.49	24.28	87.51	33.1	96	0.13	0.10	42	n	65	y	Motor	pegboard
71	Lili et al 2013	Both POCD + non	16.5	2.3	15.4	2.8	40	0.42	0.16	7	y	65	n	Learning & immediate Memory	paired associates
72	Lili et al 2013	Both POCD + non	9.4	3.5	8.3	2.5	40	0.35	0.16	7	y	65	n	Delayed memory and Learning	visual recall
73	Lili et al 2013	Both POCD + non	28.1	11.2	17	10.1	40	1.02	0.19	7	y	65	n	Processing speed	coding
74	Lili et al 2013	Both POCD + non	148.3	74.4	138.4	58.2	40	0.14	0.16	7	y	65	n	Processing speed	Trails A
75	Lili et al 2013	Both POCD	7.1	1.3	6.1	1.2	40	0.78	0.18	7	y	65	n	Attention & Working	digit span - Forward

		+ non												Memory	
76	Lili et al 2013	Both POCD + non	4.2	1.2	4.1	1.3	40	0.07	0.16	7	y	65	n	Attention & Working Memory	digit span - Backward
77	Lili et al 2013	Both POCD + non	93.8	28.4	82.1	17.8	40	0.46	0.16	7	y	65	n	Motor	pegboard dominant hand
78	Lili et al 2013	Both POCD + non	95.4	17.2	87.1	24.3	40	0.38	0.16	7	y	65	n	Motor	pegboard non dom hand
79	Maekawa et al	non-POCD	32.6	12.9	34	12	20	-0.11	0.22	14	n	73	y	Processing speed	coding
80	Maekawa et al	non-POCD	59.7	28.5	62.2	25	20	0.08	0.22	14	n	73	y	Processing speed	Trails A
81	Maekawa et al	non-POCD	7.1	1.7	6.9	1.9	20	0.11	0.22	14	n	73	y	Attention & Working Memory	digit span Forward
82	Maekawa et al	non-POCD	4.6	1.4	4.4	1.4	20	0.14	0.22	14	n	73	y	Attention & Working Memory	digit span - Backward
83	Maekawa et al	non-POCD	173	102	179	89	20	0.06	0.21	14	n	73	y	Exec Function	Trails B
84	Maekawa et al	non-POCD	26.9	1.9	26.8	3	20	0.04	0.21	14	n	73	y	MMSE	MMSE
85	Maekawa et al	POCD	32.8	8.3	22.6	8.1	8	1.11	0.42	14	n	73	y	Processing speed	coding
86	Maekawa et al	POCD	68.8	32.8	94.1	49.9	8	0.51	0.34	14	n	73	y	Processing speed	Trails A
87	Maekawa et al	POCD	8.1	1.1	8.1	1.7	8	0.00	0.31	14	n	73	y	Attention & Working Memory	digit span
88	Maekawa et al	POCD	5.5	1.3	5	1.6	8	0.30	0.32	14	n	73	y	Attention & Working	digit span - B

														Memory	
89	Maekawa et al	POCD	189	75	298	170	8	0.66	0.35	14	n	73	y	Exec Function	Trails B
90	Maekawa et al	POCD	26.8	1.9	24.4	2.1	8	1.06	0.41	14	n	73	y	MMSE	MMSE
91	Ni et al 2015	Both POCD + non	2.27	0.48	2.2	0.59	20	0.12	0.22	7	y	65	n	Delayed memory and Learning	word recog
92	Ni et al 2015	Both POCD + non	31.2	4.53	31.4	4.6	20	-0.04	0.22	7	y	65	n	Processing speed	digit symbol
93	Ni et al 2015	Both POCD + non	38.35	5.97	41.35	5.88	20	-0.49	0.22	7	y	65	n	Processing speed	stroop
94	Ni et al 2015	Both POCD + non	41.95	6.44	41.65	8.43	20	0.03	0.21	7	y	65	n	Processing speed	Trails A
95	Ni et al 2015	Both POCD + non	13.4	2.28	13.75	2.07	20	-0.15	0.22	7	y	65	n	Attention & Working Memory	digit span
96	Ni et al 2015	Both POCD + non	18.9	3.16	18.95	3.35	20	-0.14	0.21	7	y	65	n	Language	verb fluency
97	Ni et al 2015	Both POCD + non	28	1.69	28.7	1.26	20	-0.44	0.23	7	y	65	n	MMSE	MMSE
98	Ni et al 2015	non-POCD	2.22	0.48	2.4	0.48	63	-0.37	0.13	7	y	65	n	Delayed memory and Learning	word recog
99	Ni et al 2015	non-POCD	31.71	4.07	30.54	4.98	63	0.25	0.13	7	y	65	n	Processing speed	digit symb

100	Ni et al 2015	non-POCD	38.94	4.04	37.37	5.4	63	0.32	0.13	7	y	65	n	Processing speed	stroop
101	Ni et al 2015	non-POCD	41.02	4.57	42.1	5.29	63	-0.21	0.13	7	y	65	n	Processing speed	Trails A
102	Ni et al 2015	non-POCD	13.16	2.82	12.75	2.38	63	0.15	0.13	7	y	65	n	Attention & Working Memory	digit span
103	Ni et al 2015	non-POCD	18.62	2.96	17.56	3.17	63	0.34	0.13	7	y	65	n	Language	verb fluency
104	Ni et al 2015	non-POCD	28.1	1.54	27.51	1.86	63	0.34	0.13	7	y	65	n	MMSE	MMSE
105	Ni et al 2015	POCD	2.38	0.47	3.16	0.43	15	-1.63	0.39	7	y	65	n	Delayed memory and Learning	word recog
106	Ni et al 2015	POCD	31.47	4.58	27.6	6.03	15	0.67	0.27	7	y	65	n	Processing speed	digit symbol
107	Ni et al 2015	POCD	38.8	3.96	30.47	6.09	15	1.47	0.36	7	y	65	n	Processing speed	stroop
108	Ni et al 2015	POCD	40.93	3.9	45.2	6.46	15	-0.72	0.28	7	y	65	n	Processing speed	Trails A
109	Ni et al 2015	POCD	12.93	2.19	10.13	2.47	15	1.13	0.32	7	y	65	n	Attention & Working Memory	digit span
110	Ni et al 2015	POCD	18.2	3.1	12.8	3.8	15	1.46	0.36	7	y	65	n	Language	verb fluent
111	Ni et al 2015	POCD	27.73	1.79	25.33	1.54	15	1.35	0.35	7	y	65	n	MMSE	MMSE
112	Tian et al	Both POCD + non	6.8	0.8	6.3	1.1	35	0.50	0.18	3	y	75	n	Attention & Working Memory	digit span - Forward
113	Tian et al	Both POCD + non	3	0.4	2.8	0.5	35	0.43	0.17	3	y	75	n	Attention & Working Memory	digit span - Backward

114	Tian et al	Both POCD + non	15.3	1.5	13.8	1.7	35	0.91	0.20	3	y	75	n	Language	verbal fluency
115	Tian et al	Both POCD + non	3.5	0.5	3.7	0.7	35	-0.31	0.17	3	y	75	n	Exec Function	stroop
116	Tian et al	Both POCD + non	25.5	2.4	23.9	3	35	0.57	0.18	3	y	75	n	MMSE	MMSE
117	DeBarr et al	Both POCD + non	32	8	30	8	30	0.24	0.18	6	n	66	y	Learning & immediate Memory	Rey Auditory Verbal learning
118	DeBarr et al	Both POCD + non	64	15	64	230	30	0.00	0.18	6	n	66	y	Learning & immediate Memory	Sternberg
119	DeBarr et al	Both POCD + non	6	2	5	3	30	0.37	0.18	6	n	66	y	Delayed memory and Learning	Delayed Rey Auditory Verbal learning
120	DeBarr et al	Both POCD + non	24	5	24	4	30	0.00	0.18	6	n	66	y	Visual Spatial	line orientation
121	DeBarr et al	Both POCD + non	62	32	59	37	30	0.08	0.18	6	n	66	y	Exec Function	stroop
122	DeBarr et al	Both POCD + non	102	45	102	47	30	0.00	0.18	6	n	66	y	Exec Function	Trail A+B
123	DeBarr et al	Both POCD + non	121	27	121	30	30	0.00	0.18	6	n	66	y	Motor	pegboard
124	Li et al 2014	non-POCD	1.2	0.44	1.4	0.43	25	-0.45	0.20	7	y	65	n	Delayed memory and	word recognition

														Learning	
125	Li et al 2014	non-POCD	32.32	4.75	29.96	4.86	25	0.48	0.21	7	y	65	n	Processing speed	coding
126	Li et al 2014	non-POCD	17.6	5.68	17.84	6.06	25	-0.03	0.19	7	y	65	n	Processing speed	Trails A
127	Li et al 2014	non-POCD	16.7	1.77	16.35	1.85	25	0.19	0.20	7	y	65	n	Language	verbal fluency
128	Li et al 2014	non-POCD	29	0.67	28.83	0.68	25	0.24	0.20	7	y	65	n	MMSE	MMSE
129	Li et al 2014	POCD	1.3	0.48	1.9	0.42	21	-1.27	0.29	7	y	65	n	Delayed memory and Learning	word recognition
130	Li et al 2014	POCD	31	4.23	26.14	3.13	21	1.23	0.28	7	y	65	n	Processing speed	coding
131	Li et al 2014	POCD	19.4	5.62	20.5	5.86	21	-0.18	0.21	7	y	65	n	Processing speed	Trails A
132	Li et al 2014	POCD	16.01	1.58	14.51	1.71	21	0.88	0.25	7	y	65	n	Language	verbal fluency
133	Li et al 2014	POCD	29.3	0.34	27.1	0.41	21	5.57	0.88	7	y	65	n	MMSE	MMSE
134	Mandal et al	Both POCD + non	20.93	3.23	23.4	2.67	30	-0.80	0.21	7	n	65	n	Learning & immediate Memory	immediate recall
135	Mandal et al	Both POCD + non	19.53	0.73	19.46	0.97	30	0.08	0.18	7	n	65	n	Delayed memory and Learning	delayed recognition
136	Mandal et al	Both POCD + non	4.76	0.56	4.3	1.31	30	0.39	0.18	7	n	65	n	Processing speed	calculation
137	Mandal et al	Both POCD + non	14.9	0.3	14.9	0.3	30	0.00	0.18	7	n	65	n	Language	object naming

138	Mandal et al	Both POCD + non	30.8	6.63	27.86	6.27	30	0.44	0.19	7	n	65	n	Language	verbal fluency
139	Mandal et al	Both POCD + non	12.36	0.92	11.5	1.73	30	0.56	0.19	7	n	65	n	Visual Spatial	visual construction
140	Mandal et al	Both POCD + non	28.03	1.27	26.83	2.06	30	0.65	0.20	7	n	65	n	MMSE	MMSE
141	Rappold et al	Both POCD + non	8.47	2.19	10.17	2.61	149	-0.70	0.09	30	n	57	n	Learning & immediate Memory	RAVLT
142	Rappold et al	Both POCD + non	8.26	3.33	10.1	3.39	149	-0.54	0.08	30	n	57	n	Learning & immediate Memory	RAVLT - trial 8 correct
143	Rappold et al	Both POCD + non	14.57	6.2	16.52	7.79	149	-0.27	0.08	30	n	57	n	Delayed memory and Learning	complex figure delayed recall
144	Rappold et al	Both POCD + non	44.66	13.64	42.78	19.01	149	0.11	0.08	30	n	57	n	Processing speed	coding
145	Rappold et al	Both POCD + non	39.79	12.05	42.03	13.26	149	-0.18	0.08	30	n	57	n	Language	controlled word asso.
146	Rappold et al	Both POCD + non	32.79	5.58	30.77	10.05	149	0.23	0.08	30	n	57	n	Visual Spatial	complex figure copy
147	Steinmetz et al 2010	non-POCD	24	5.6	25.2	6.2	56	-0.20	0.13	7	n	67	n	Learning & immediate Memory	Vis Verb Learning
148	Steinmetz et al 2010	non-POCD	8.1	2.6	7.8	3.1	56	0.10	0.13	7	n	67	n	Delayed memory and	Vis Verb delay

														Learning	
149	Steinmetz et al 2010	non-POCD	23.3	6.2	22.9	6.7	56	0.06	0.13	7	n	67	n	Processing speed	coding
150	Steinmetz et al 2010	non-POCD	50.9	21.7	53.6	22.6	56	-0.12	0.13	7	n	67	n	Exec Function	concept shifting
151	Steinmetz et al 2010	non-POCD	60.6	25.2	59	21.8	56	0.06	0.13	7	n	67	n	Exec Function	Strrop
152	Steinmetz et al 2010	POCD	25.3	7.6	20.6	6.9	9	0.583503	0.331001	7	n	67	n	Learning & immediate Memory	Vis Verb Learning
153	Steinmetz et al 2010	POCD	9.3	2.9	6.3	3.4	9	0.85	0.36	7	n	67	n	Delayed memory and Learning	Vis Verb delay
154	Steinmetz et al 2010	POCD	25	6.9	18	8.8	9	0.79	0.35	7	n	67	n	Processing speed	coding
155	Steinmetz et al 2010	POCD	44.3	15	56	11.1	9	0.78	0.35	7	n	67	n	Exec Function	concept shifting
156	Steinmetz et al 2010	POCD	63	14.2	98.2	76.1	9	0.45	0.32	7	n	67	n	Exec Function	Strrop
157	Walzer et al	Both POCD + non	11	1.14	10.25	1.69	70	0.50	0.13	7	n	61	y	Other	arithmetic
158	Walzer et al	Both POCD + non	26	6.35	24.75	7.5	70	0.18	0.12	7	n	61	y	Learning & immediate Memory	verbal memory
159	Walzer et al	Both POCD	10	0.2	10	0.2	70	0.00	0.12	7	n	61	y	Language	naming

		+ non													
160	Walzer et al	Both POCD + non	16	7.51	14.75	6.06	70	0.18	0.12	7	n	61	y	Language	word fluency
161	Walzer et al	Both POCD + non	7	1.14	7	1.14	70	0.00	0.12	7	n	61	y	Visual Spatial	clock reading
162	Walzer et al	Both POCD + non	24.5	6.03	23.5	6.89	70	0.15	0.12	7	n	61	y	MMSE	MMSE
163	Gottesman et al	Both POCD + non	26.8	2.78	26	3.51	15	-0.24	0.25	4	n	70	y	MMSE	MMSE
164	Hassani et al 2015	Both POCD + non	27.37	1.87	24	1.91	38	1.75	0.26	10	n	66	y	MMSE	MMSE
165	Hassani et al 2015	Both POCD + non	27.37	1.87	24.83	1.66	38	1.40	0.23	60	n	66	y	MMSE	MMSE
166	Ilvan & Ozkose	Both POCD + non	27.5	2.4	28	2.6	20	-0.19	0.22	1	n	70	n	MMSE	MMSE
167	Ilvan & Ozkose	Both POCD + non	28.1	2.5	28.8	2.2	20	-0.28	0.22	1	n	55	n	MMSE	MMSE
168	Postler et al	Both POCD + non	27.37	2.29	26.77	4.03	60	0.17	0.13	7	n	70	n	MMSE	MMSE
169	Postler et al	Both POCD + non	27.37	2.29	28.02	2.59	60	-0.26	0.13	180	n	70	n	MMSE	MMSE
170	Zhu et al 2013	non-POCD	28.1	1.6	27.7	1.5	149	0.26	0.08	7	y	65	n	MMSE	MMSE

171	Zhu et al 2013	POCD	28	1.2	25.7	1.2	56	1.89	0.22	7	y	65	n	MMSE	MMSE

Table B4

Summary of the Data from Studies that Calculated Effect Size from the p-Values of Repeated-Measures t-Tests (Within-Groups Design)

	Study name	Paired sample size	p-value (paired t-test)	Tails	Hedges's g	Std Err	Time	Chinese ?	Age	Cardiac pt?	Test category	Test name
173	Hudetz et al	86	0.271	2	0.13	0.12	7	n	55	y	Learning & immediate Memory	story recall
174	Hudetz et al	86	0.162	2	0.17	0.12	90	n	55	y	Learning & immediate Memory	story recall
175	Hudetz et al	86	0.036	2	0.25	0.12	7	n	55	y	Learning & immediate Memory	word list recall
176	Hudetz et al	86	0.134	2	0.18	0.12	90	n	55	y	Learning & immediate Memory	word list recall
177	Hudetz et al	86	0.549	2	0.07	0.12	7	n	55	y	Delayed memory and Learning	delayed fig reproduction
178	Hudetz et al	86	0.841	2	0.02	0.12	90	n	55	y	Delayed memory and Learning	delayed fig reproduction
179	Hudetz et al	86	0.134	2	0.18	0.12	7	n	55	y	Delayed memory and Learning	delayed story recall

180	Hudetz et al	86	0.194	2	0.15	0.12	90	n	55	y	Delayed memory and Learning	delayed story recall
181	Hudetz et al	86	0.016	2	0.29	0.12	7	n	55	y	Delayed memory and Learning	delayed word list recall
182	Hudetz et al	86	0.089	2	0.20	0.12	90	n	55	y	Delayed memory and Learning	delayed word list recall
183	Hudetz et al	86	0.23	2	0.14	0.12	7	n	55	y	Attention & Working Memory	digit span
184	Hudetz et al	86	0.162	2	0.17	0.12	90	n	55	y	Attention & Working Memory	digit span
185	Hudetz et al	86	0.549	2	0.07	0.12	7	n	55	y	Language	phonemic fluency
186	Hudetz et al	86	0.841	2	0.02	0.12	90	n	55	y	Language	phonemic fluency
187	Hudetz et al	86	0.617	2	0.06	0.12	7	n	55	y	Language	semantic fluency
188	Hudetz et al	86	0.841	2	0.02	0.12	90	n	55	y	Language	semantic fluency
189	Hudetz et al	86	0.057	2	0.23	0.12	7	n	55	y	Visual Spatial	Figure reconstruction
190	Hudetz et al	86	0.194	2	0.15	0.12	90	n	55	y	Visual Spatial	figure reconstruction
191	Hudetz et al	86	0.194	2	0.15	0.12	7	n	55	y	Exec Function	stroop
192	Hudetz et al	86	0.424	2	0.09	0.12	90	n	55	y	Exec Function	stroop

Appendix C

Curriculum Vitae

Joanna H. Swartz
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971-312-8761 | jswartz12@georgefox.edu

Education

Doctor of Psychology, Clinical Psychology *Anticipated* Apr. 2017

Assessment Emphasis
George Fox University, *Newberg, OR*
Graduate Department of Clinical Psychology: APA Accredited
Cumulative GPA: 3.9

Master of Arts, Clinical Psychology May 2014
George Fox University, *Newberg, OR*
Graduate Department of Clinical Psychology: APA Accredited

Bachelor of Science, Professional Counseling/Bible Dec. 2011
Lancaster Bible College, *Lancaster, PA*
Dean's List, 2009-2011

Associate of Science, Office Procedures & Technology May 2009
Lancaster Bible College, *Lancaster, PA*
Dean's List, 2007-2009

Supervised Clinical Experience

Sioux Falls VA Health Care System (APA Accredited) – *Sioux Falls, SD* Jul. 2016-Present
Title: Psychology Intern
Rotations:

- Posttraumatic Stress – 4 months. Diagnostic interviewing, assessments, and treatment planning for PTSD, sub-threshold symptoms of PTSD, and military sexual trauma. Individual (Cognitive Processing Therapy) and group (Seeking Safety).
- General Outpatient Mental Health – 4 months. Diagnostic interviewing, treatment planning, Cognitive Behavioral Therapy for Depression (group and individual), Acceptance and Commitment Therapy for Depression.
- Primary Care Mental Health – 4 months. Evaluation/brief treatment for clinical and behavioral health issues within interdisciplinary medical treatment teams, mental health crisis management, consultation and collaboration with primary care providers/psychiatry, referrals to appropriate mental health programs.
- Neuropsychological Assessment – year-long/2 days per week. Develop knowledge/abilities required to complete diagnostic interview, test administration, scoring/interpretation, report

writing and feedback. Outpatient and inpatient evaluations.

- Community Living Center (CLC) – year-long/4 hours per week. Primary focus of working with geriatric patients in a medical setting. Understanding of psychologist's role in this setting. Conduct intake assessments for consults, treatment planning, and behavior planning as needed. Brief individual therapy. Focus on ACT conceptualization.

Training Director: Emily Blegen, PsyD
Supervisors: Jeffrey Ellison, PsyD, Kate Andal, PhD, Kyle Lythgoe, PsyD, Amanda Adcock, PhD, Darci Van Dyke, PhD

Samaritan Neuropsychology, Samaritan Health Services – *Albany, OR* Aug. 2015-Jun. 2016
Title: Practicum Student Technician
Description: Primary care neuropsychology clinic
Population: Lifespan. Common referrals included memory concerns, dementia, concussion, and LD/ADHD.
Duties: Completed clinical interviews, assessment administration, scoring/interpretation, wrote reports and provided feedback. Conducted warm hand-offs from PCPs for evaluation referrals, administered MoCA as a screening tool. Participated in weekly individual/group supervision and weekly journal club. Shadowed health psychologist and assisted with completing intakes. Attended monthly psychology staff meetings.
Supervisor: Robert Fallows, PsyD, ABPP-CN

Friendsview Retirement Community – *Newberg, OR* Sept. 2015-Jun. 2016
Title: Supplemental Practicum Student
Description: Retirement community
Population: Geriatrics
Duties: Oversaw program development of practicum site. Developed 6-week treatment protocol and conducted psycho-educational stress management groups. Developed psycho-educational presentations.
Supervisors: Glena Andrews, PhD, & Peggy Hanson, OTR(retired)

GFU Behavioral Health Clinic – *Newberg, OR* Sept. 2014-Jul. 2015
Title: Assessment Coordinator
Description: Community mental health clinic
Population: Children through adults, typically low SES. Presenting concerns included anxiety, depression, psychotic disorders, LD/ADHD, BPD and Bipolar Disorder
Duties: Conducted clinical interviews, administered assessment batteries, scored/interpreted, and wrote reports. Provided short-term individual therapy including for court-mandated clients. Completed intakes with clients referred from emergency department for suicidal ideation. Co-led group therapy sessions: Managing Chronic Pain, Changes That Heal. Participated in individual/group supervision and weekly didactics.
Supervisor: Joel Gregor, PsyD

Oregon State University Counseling & Psychological Services (CAPS) – *Corvallis, OR* Sept. 2013-Jun. 2014
Title: Practicum Clinician
Description: University counseling center
Population: University students with common concerns relating to anxiety, adjustment, depression, academic performance/career decisions, and interpersonal difficulties

Duties: Short-term individual therapy for students of varying age, ethnicity, backgrounds, and spiritual affiliation. Participated in student outreach. Observed interpersonal process group and wrote weekly notes on group dynamics/development. Engaged in individual/group supervision and didactics.
Supervisors: Staci Wade-Hernandez, PsyD; Lilia Miramontes, PhD; & Hannah Hoeflich, MS

GFU Graduate Department of Clinical Psychology – *Newberg, OR* Spring 2013
Title: Pre-practicum II Student Therapist
Description: Provided 10 therapy sessions per client as part of Clinical Foundations course to two undergraduate student volunteers
Population: Undergraduate students
Duties: Provided weekly individual therapy in a counseling setting utilizing a person-centered theoretical orientation and therapeutic techniques. Conducted intake interviews, developed treatment plans, wrote formal intake reports, completed progress notes, and completed termination summaries. Attended weekly group supervision with an advanced graduate student supervised by a licensed clinical psychologist. Reviewed videotaped sessions with student supervisor and during group supervision.
Supervisors: Carlos Taloyo, PsyD & Tyler Gerdin, MA

GFU Graduate Department of Clinical Psychology – *Newberg, OR* Fall 2012
Title: Pre-practicum I Student Therapist
Description: Completed five therapy role-play sessions with cohort mates as part of Clinical Foundations course to practice person-centered theoretical orientation and therapeutic skills

Duties: Recorded five sessions practicing person-centered therapeutic skills. Reviewed recording of sessions in a small group of classmates led by an upperclassman.
Supervisors: Carlos Taloyo, PsyD & Tyler Gerdin, MA

Supervised Assessment Experience

21-Item Test
Adaptive Behavior Assessment System, 3rd Ed (ABAS-III)
Advanced Clinical Solutions for WAIS-IV & WMS-IV (ACS) – Word Choice
Auditory Consonant Trigram (ACT)
Animal Naming
Beck Anxiety Inventory (BAI)
Beery-Butenica Developmental Test of Visual-Motor Integration, 6th Ed (BEERY VMI)
Behavior Assessment System for Children, 2nd Ed (BASC-2)
Benton's Judgment of Line Orientation (JLO)
Booklet Category Test (BCT)
Boston Naming Test
Brief Test of Attention (BTA)
Brief Visuospatial Memory Test – Revised (BVMT-R)
Calibrated Ideational Fluency Assessment (CIFA)
California Verbal Learning Test, 2nd Ed (CVLT-II)
Child and Adolescent Memory Profile (ChAMP)
Childhood Autism Rating Scale, 2nd Ed (CARS-2)

Conners 3rd Ed
Conners Adult ADHD Rating Scale (CAARS)
Conners Continuous Performance Test, 2nd Ed (CPT-II)
Controlled Oral Word Association Test (COWA)
Delis-Kaplan Executive Function System (D-KEFS)
Dot Counting Test
Hand Dynamometer
Epworth Sleepiness Scale
Everyday Memory Questionnaire
FAS
Finger Tapping
Generalized Anxiety Disorder – 7 Item (GAD-7)
Green's Word Memory Test (WMT)
Hopkins Verbal Learning Test – Revised (HVLT-R)
Independent Living Scales (ILS)
Millon Adolescent Clinical Inventory (MACI)
Millon Clinical Multiaxial Inventory, 3rd Ed (MCMI-III)
Millon Pre-Adolescent Clinical Inventory (M-PACI)
Minnesota Multiphasic Personality Inventory, 2nd Ed (MMPI-2)
Minnesota Multiphasic Personality Inventory, 2nd Ed Restructured (MMPI-2 RF)
Modified Wisconsin Card Sorting Test (M-WCST)
Montreal Cognitive Assessment (MoCA)
Neuropsychological Assessment Battery: Numbers & Letters
Personality Assessment Inventory (PAI)
Personality Assessment Inventory – Adolescent (PAI-A)
Patient Health Questionnaire (PHQ-9)
Pittsburgh Sleep Quality Index (PSQI)
PSU Symbol Cancellation Task
Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
Rey Complex Figure (RCF)
Rey Fifteen
Roberts Apperception Test, 2nd Ed
Ruff 2 & 7 Selective Attention Test
Salthouse Perceptual Comparison Test
Stroop Color and Word Test (Golden)
Symbol Digit Modalities Test (SDMT)
Test of Memory Malingering (TOMM)
Test of Premorbid Functioning (TOPF)
Texas Functional Living Scale (TFLS)
The b Test
The Pillbox Test
Token Test
Tower of London Test
Test of Variables of Attention (TOVA)
Trail Making A & B
Wechsler Abbreviated Scale of Intelligence, 2nd Ed (WASI-II)
Wechsler Adult Intelligence Scale, 4th Ed (WAIS-IV)
Wechsler Intelligence Scale for Children, 4th Ed (WISC-IV)

Wechsler Memory Scale, 4th Ed (WMS-IV)
Wechsler Test of Premorbid Functioning (TOPF)
Wide Range Achievement Test (WRAT)
Wide Range Assessment of Memory and Learning, 2nd Ed (WRAML 2)
Wisconsin Card Sorting Test (WCST)
Woodcock Johnson, 4th Ed Tests of Cognitive Abilities (WJ-IV COG)
Woodcock Johnson, 4th Ed Tests of Achievement (WJ-IV TA)

Research Experience & Presentations

Doctoral Dissertation Research Aug. 2012-Sept. 2016
George Fox University Graduate Department of Clinical Psychology
Topic: A Meta-Analysis of Neuropsychological Tests Utilized In Evaluations for Post-Operative Cognitive Dysfunction In Adult Surgery Patients
Proposal Defended: April 2015
Dissertation Defended: September 2016
Dissertation Chair: Kathleen Gathercoal, PhD

Research Vertical Team Spring 2013-2016
George Fox University Graduate Department of Clinical Psychology
Description: Research team consisting of graduate students from each year of the program with various research interests and led by a faculty member. Worked on personal dissertation, assisted peers with various aspects of their dissertations, worked with peers on supplemental research projects.
Faculty: Kathleen Gathercoal, PhD

Research Assistant Sept. 2015
George Fox University Graduate Department of Clinical Psychology
George Fox University Nutrition Matters Initiative, a four-year wellness education program that is funded by the Bob and Charlene Moore Foundation. Helped instruct undergraduate students on what they needed to complete during their initial class for the semester.

Sports Neuropsychology Jun. 2015
Samaritan Neuropsychology
Assisted with testing Oregon State University football athletes for neuropsychological baseline data. Administered a 35-minute neuropsychological battery to multiple athletes in a medical setting.

PEACE Village Project Jun. 2013-2014, 2015
George Fox University Graduate Department of Clinical Psychology
Pre-post evaluation of a summer camp teaching children conflict resolution skills. Collected qualitative data via brief interviews with children regarding understanding/use of stress and anxiety management skills. Transcribed interviews, coded responses, and analyzed data. Assisted in writing abstract.

Research Assistant Aug. 2013-Apr. 2014
George Fox University Graduate Department of Clinical Psychology
"Mild/Moderate Hearing Loss and Memory," research led by Heather Paige-Deming, MA. Administered pre-screening hearing test for volunteers. Administered the Wide Range Assessment of Memory and Learning (WRAML-2) to college student participants.

Research Presentations:

Swartz, J., & Fallows, R. (2017, February). *The relationship between interference and inhibition in a mixed clinical sample.* Poster presented at the 45th annual conference of the International Neuropsychological Society, New Orleans, LA.

Weiss, C., **Swartz, J.,** Gathercoal, K., & Headly, S. (August, 2014). *Training children in peace-making language and skills increases the variety of their responses.* Poster presented to the Society for Peace Psychology (Div. 48) at the Annual meeting of the American Psychological Association, Washington, D.C.

Kruszewski, M., McConnell., C., Webb., B., Sieg, C., Weiss, C., **Swartz, J.,** & Gathercoal, K. (July, 2013). *Fees paid and therapeutic satisfaction in community mental health*. Poster presented to the Annual meeting of the American Psychological Association, Honolulu, Hawaii.

Professional Presentations

"Understanding Stroke and Recovery" Apr. 2016
Community Presentation to Stroke Support Group – *Corvallis, OR*
Samaritan Neuropsychology
Supervisor: Robert Fallows, PsyD, ABPP-CN

"Disease Course and Mental Health Treatment of Multiple Sclerosis" May 2016
Presentation to Providers, Behavioral Health Meeting – *Albany, OR*
Samaritan Neuropsychology
Supervisor: Robert Fallows, PsyD, ABPP-CN

Academic Involvement and Leadership

Fourth Year Oversight Sept. 2015-Apr. 2016
George Fox University Graduate Department of Clinical Psychology
Oversight of second-year student. Developed goals for student's development for the practicum year. Assisted student in developing clinical/assessment skills. Assisted student with development of theoretical orientation. Provided both formative and summative feedback of student's clinical and professional skills.
Faculty: Kristie Knows His Gun, PsyD, & Rodger Bufford, PhD

Conducted interviews – GFU Behavioral Health Clinic Mar. 2015, Feb. 2016
George Fox University Graduate Department of Clinical Psychology
Assisted with group interview for practicum applicants. Collected data on interviewee performance and contributed to discussion with clinic director.

Peer Mentor Jun. 2013-2014
George Fox University Graduate Department of Clinical Psychology
Assisted incoming graduate student in transitioning into the program by providing personal/professional mentorship during their first year in the program.

Professional Affiliations

- **International Neuropsychological Society (INS)**
- **National Academy of Neuropsychology (NAN)**
- **American Psychological Association (APA)**
  - Division 19: Military Psychology
  - Division 20: Adult Development & Aging
  - Division 40: Clinical Neuropsychology
- **American Board of Professional Psychology (ABPP) Early Entry**

Teaching Experience

Training of students for Oregon State University athlete baseline testing Apr. 2016
Samaritan Neuropsychology
Supervisor: Robert Fallows, PsyD, ABBP-CN
Trained students on how to administer a fixed-flexible battery designed for baseline cognitive testing for OSU impact sport athletes. Discussed use and purpose of various tests included in the battery.

Teaching Assistant for PSYD 525 Neuropsychological Assessment Jan.-Apr. 2016
George Fox University Graduate Department of Clinical Psychology
Faculty: Glena Andrews, PhD
Proctored and graded biobasis background exam. Completed oversight of test administration competencies with students. Graded scoring assignments and provided students with feedback. Created grading rubrics for test administration assignments. Attended class and assisted with lab including test demonstration. Assisted professor with administrative tasks.

Guest Lecturer for General Psychology class Jan. 2016
George Fox University Graduate Department of Clinical Psychology
"The Biology of Mind and Consciousness: The Brain"
Presented on brain structures and basic neuroanatomy

Guest presentation for Comprehensive Assessment class Sept. 2015
George Fox University Graduate Department of Clinical Psychology
Faculty: Marie-Christine Goodworth, PhD
Presented a comprehensive assessment case. Discussed pertinent background and history, rationale for assessments administered, summary of results, rationale for diagnoses, and recommendations.

Graduate Assistant for SOCI 340 Statistical Procedures Aug.-Dec. 2014
George Fox University Graduate Department of Clinical Psychology
Faculty: Kathleen Gathercoal, PhD
Graded homework assignments and managed grading spreadsheet. Led review sessions for students in preparation for exams. Available to answer questions/meet with students on an individual basis as needed.

Guest presentation to undergraduate PCN 335 Research Design Aug. 2013

Lancaster Bible College
Professor: Freeman Chakara, PsyD, ABPP-CN
Discussed hypothetical research proposal assignment completed for class.

Relevant Employment History

Friendship Community Jul. 2010-2012
Title: Direct Care Professional Advisor I
Treatment setting: Group home for adults with intellectual and developmental disabilities
Duties: Assisted with personal care, activities of daily living, doctor appointments, activities/community outings. Assisted in implementing behavior plans for individuals. Certified to administer medications. Completed documentation and case notes for each shift.

Volunteer Experience

Serve Day at Juliette's House – *McMinnville, OR* Sept. 2012, 2014, 2015

Completed landscaping tasks, washed windows, stuffed envelopes for mailing

Martin Luther King, Jr. Serve Day – *Portland, OR* Jan. 2014

Professional Training and Education

Continuing Education Courses:

Neuroanatomical Dissection Course: Human Brain and Spinal Cord Jul. 2016
Marquette University
Three mornings of lectures on review of recent advances in functional neuroscience. Three afternoons of performing regional dissections.
Observed craniotomy and laminectomy.

Potentially Inappropriate Drugs in the Elderly: BEERS Criteria Updates Oct. 2016
University of South Dakota, Sanford School of Medicine
VA Medical CME

Neuropsychological Assessment Trainings:

Neuropsychology: What Do We Know 15 Years After the Decade of the Brain?, *Trevor Hall, PsyD, & Darren Janzen, PsyD* Feb. 2016

13th Annual Pacific Northwest Brain Injury Conference: "Living with Brain Injury and Neurological Changes – Thinking Outside the Box" Mar. 2015

Understanding, Assessing, and Treating ADHD in Children, *Erika Doty, PsyD* Oct. 2014

Learning Disabilities: A Neuropsychological Perspective, T*abitha Becker, PsyD*	Oct. 2014
2014 Annual Northwest Psychological Assessment Conference: "WISC-V: Overview and Demonstration," *Patrick Moran, PhD*	Jun. 2014
Neuropsychological Evaluation and Consultation: Clinical And Forensic Applications, *Paul Kauffman, JD, PhD, ABPP*	Feb. 2014

Primary Care Trainings:

The Role of Empathy in Primary Care Clinical Practice, *Michael Bachop, PhD, & Andree Volin, LCSW*	Aug. 2015
42nd Annual Winter Continuing Medical Education Conference, "*Cravings and Longings in Modern Psychiatry"*	Feb. 2015
Primary Care Behavioral Health*, Brian Sandoval, PsyD, & Juliette Cutts, PsyD*	Sept. 2013

Diversity Trainings:

Working with Multicultural Clients with Acute Mental Illness, *Sandy Jenkins, PhD*	Mar. 2016
Christian Association for Psychological Studies 2013 Conference, *"Cross-Cultural Care and Counseling"*	Apr. 2013
African American History, Culture, and Addictions & Mental Health Treatment, *Danette Haynes, LCSW, & Marcus Sharpe, PsyD*	Jan. 2013
Afrocentric Approaches To Clinical Practice, *Danette Haynes, LCSW, & Marcus Sharpe, PsyD*	Jan. 2013

Other Clinical Trainings:

Collaborative Institutional Training Initiative (CITI) Training *IRB research training completed at Samaritan Health Services Online course – Biomedical Research*	Aug. 2015
"Face Time" In An Age of Technological Attachment, *Doreen Dodgen-Magee, PsyD*	Nov. 2014
2014 Co-Occurring Disorders Conference, *Oregon Rehabilitation Association*	Jun. 2014
Evidence-based Treatments for PTSD in Veteran Populations: Clinical and Integrative Perspectives*, David Beil-Adaskin, PsyD*	Mar. 2014

DSM 5: Essential Changes in Form and Function, *Jeri Turgesen, PsyD, & Mary Peterson, PhD, ABPP*	Jan. 2014
Suicide Assessment Training, Oregon State University, *Jim Gouveia, LCSW-ACSW*	Jan. 2014
Trauma & Sexual Assault Training, Oregon State University, *Judy Neighbors, PhD*	Oct. 2013
When Strangers Meet: The First Session of Psychotherapy, *Peter Armstrong, PhD, & Winston Anderson, PhD*	May 2013

References

References available upon request.