University of Alberta

THE ATTENTIONAL DEFICITS ASSOCIATED WITH POST-OPERATIVE DELIRIUM IN THE ELDERLY

by

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In honor of my first teachers,
Mom and Dad

and

to my husband,
with my deepest gratitude

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CHAPTER I

Introduction

Background Information

Delirium is one of the oldest syndromes known to medicine, and it is still considered a significant health problem for elderly acutely ill hospitalized patients (Lindesay,1999; Lipowski,1990; Shua-Haim, Sabo & Ross,1999). Lipowski (1990), the progenitor of delirium investigation, has described this disorder as the "Cinderella of American Psychiatry: taken for granted, ignored, and seldom studied." Despite the high frequency of the syndrome, little research has been done on this subject until recently. This is due in part to the nature of delirium as it can be very difficult to study. There are many comprehensive reviews on the subject, but only a few empirical studies with respect to the area and severity of cognitive dysfunction.

The syndrome of delirium is one of the most common and serious cognitive disorders affecting older hospitalized patients. There has been a great variation in estimated rates of delirium among hospitalized elderly individuals. Estimates of the overall prevalence rates for delirium have been reported to be anywhere from 6 to over 50 percent. Prevalence rates for general medical inpatients range from 10 to 30 percent (Levkoff, Liptzin, Cleary, Reilly, & Evans, 1991); for geriatric inpatients from 10 to 50 percent (Johnson et al., 1990; Bergman & Eastham, 1974) and for post-operative patients between 6.5 to 51.5 percent (Gustafson et al., 1988; Levkoff et al., 1991; Lipowski,1990; Rogers et al., 1989; Tune et al., 1981).

This variation is due to a number of methodological issues. One of the main issues is the differences in groups chosen for each study. Populations have included surgical patients, medical inpatients, psychiatric inpatients, patients in geriatric units or a combination of the above (Berggren et al., 1987; Francis, Martin & Kapoor, 1990; Rabins & Folstein, 1982; Schor, 1992). Studies also differ with respect to their selection criteria, where some studies focus exclusively on the elderly, while others include patients of any age (Cameron, Thomas, Mulvihill, & Bronheim, 1987; Johnson et al., 1990). Others exclude individuals with dementia, or those in intensive care units (Francis et al., 1990; Levkoff et al., 1991).

Historical Perspective of Delirium

Lipowski (1990) has described the history of the syndrome as dating back as far as 2,500 years. References to delirium were numerous in the works of Hippocrates, particularly in the Books of Epidemics where the term "phrenitis" was used to describe a "transient mental disorder" characterized by insomnia, shifting moods, restlessness, nocturnal exacerbation of symptoms, unpredictable lucid intervals, and "wandering of the mind" (Chadwick & Mann, 1950). In 1870, delirium was referred to as "senile dementia." However it was deemed separate from dementia in that prompt treatment of the underlying cause of the confusion could lead to a reversal of the cognitive changes (Clary & Krishnan, 2001).

In the first and second editions of the Diagnostic and Statistical Manual of Mental Disorders vague and nonspecific terms such as "organic brain syndrome" and "acute brain disorders" were used to describe symptoms of cognitive disorder (American Psychiatric Association, 1952 & 1968). It wasn't until the third edition that more specific and explicit criteria to define organic mental disorders such as delirium were put into place (American Psychiatric Association, 1987). Hippocrates' observations are clearly represented in the modern definition of delirium. According to the Diagnostic Statistical Manual-IV-TR, there are three clinical features of delirium which include: (1) disturbed consciousness with a reduced ability to focus, sustain or shift attention, (2) a change in cognition including memory or language, (3) acute onset and fluctuation during the course of the day. Observations on the disturbances of consciousness relate to the sleep-wake cycle which is usually marked by drowsiness and naps during the day, insomnia at night, or both, and the continuum between alertness and coma which can be described as an impaired awareness of self and surroundings (Lindesay,1999; Lipowski,1990).

An acute change in cognition is one of the most common findings in delirium that usually takes the form of dysfunction in attention, memory or orientation. Attentional disturbances can be observed in the individual when attempting to engage them in a conversation. Questions may need to be repeated because the individual's attention wanders, or the individual may perseverate with an answer to a previous question rather than appropriately shifting attention (Rabbins, 1994). Other changes in cognition include memory impairment, primarily for recent memory, and language disturbance may be evident as dysnomia (impaired ability to name objects) or dysgraphia (impaired ability to write) (Chedru & Geschwind, 1972; Lipowski, 1983). Other clinical features can include abnormal psychomotor behavior, which can be of the hyperactive type described as restless, agitated behavior or of the hypoactive type where the patient appears sluggish, lethargic or stuporous (Lipowski, 1990). Both variants of the behavior can occur unpredictably in the course of a delirious episode. In some cases illusions and visual or auditory hallucinations are evident (Byrne, 1994; Lipowski, 1990). Overall, delirium can be described as a manifestation of numerous symptoms which include restlessness, sleep disturbances, distractibility, altered arousal, altered perceptions, disorganized thinking, cognitive changes, and disorientation occurring in a rapidly fluctuating course (Smith, Breitbart & Platt, 1995).

Recognition of Delirium

Despite its frequency, delirium has often failed to be recognized in hospitalized patients by physicians and medical staff. In one investigation, it was reported that only one case of 20 patients diagnosed with delirium was recorded by an attending physician (Cameron et al, 1987). A pilot study by Rockwood, Stolee, and Brahim (1991) found only 2.5% of elderly medical patients over a 3-month period were recognized by house staff to have delirium. In a follow up study, delirium or acute confusion was diagnosed in 3% of patients and after educational interventions aimed at increasing knowledge of delirium, there was a significant increase in the identification of delirium to 12%.

Delirium has also been reported to be misdiagnosed in hospitalized patients. For example, Farrell and Ganzini (1995) found that delirium was frequently diagnosed as depression. In comorbidity cases of delirium superimposed on dementia, Fick and Foreman (2000) reported that 87% of cases of delirium superimposed on dementia were not recognized by members of the nursing or medical staff. Interestingly, the low rate of recognition persisted despite family members indicating to the staff that they had observed an abrupt change in level of consciousness during the hospitalization of their loved one. Furthermore, 75% of the nurses interviewed stated that they were unable to distinguish the difference between delirium and dementia clearly illustrating the need for a more explicate and precise description of the symptomology of delirium.

Several factors appear to contribute to the under-recognition of delirium. One is the frequent changes in the diagnostic criteria for the syndrome. As Lindesay (1999) remarks, a "terminological chaos that has characterized its history from ancient times to the present day." Two, the fluctuating nature of delirium may confound the diagnosis and the early or prodromal symptoms may be overlooked by medical staff. Three, the clinical importance of delirium may not be sufficiently emphasized in medical school, and four, delirium's tendency to mimic other mental disorders such as mania, depression, or schizophrenia also make it difficult to diagnose. Lastly, due to its varied and multiple etiologies that often predominates in the clinical picture, the diagnosis of delirium appears to be less obvious than previously thought (Inouye, Rushing, Foreman, Palmer & Pompei, 1994; Johnson, 1999; Lipowski, 1990; Wahlund & Bjorlin, 1999).

Risk Factors for the Development of Delirium

There are certain predisposing, facilitating, and precipitating factors that increase the probability of developing delirium. Research illustrates that age is one of the most important predisposing factors in delirium. Susceptibility to delirium has been cited to be the result of the aging processes in the brain, vulnerability of the aging brain to hypoxia, reduced efficiency in the immune system and homeostatic responses that render the elderly less resistant to stress, and hence to disease. Patients over the age of 65 years are the most frequently affected, with the highest risk occurring in patients over 85 years old (Inouye, Schlesinger, & Lydon, 1999). Brain damage or chronic degenerative diseases of the brain are also strong risk factors for the development of delirium (Lipowski, 1990; Shuam-Haim et al., 1999). Erkinjuntti, Wikstrom, Palo, and Autio (1986) have shown that patients with dementia have a two to five-fold increased risk for delirium and found that 41.4% of individuals with dementia also suffered from delirium. Likewise, Koponen and Riekkinen (1993) estimated that over 81% of delirious patients have what is described as a co-existent brain disease such as dementia, stroke or other neurological disease.

Environmental and psychosocial variables such as bereavement or relocation to an unfamiliar environment can facilitate the onset of delirium, increase its severity, or prolong its course. For example, while many patients become delirious prior to admission to the hospital, the vast majority of delirium episodes occur after hospitalization (Inouye, 1994). Other facilitating factors of delirium cited include sleep deprivation, sensory deprivation or overload, immobilization, and malnutrition. Causative organic factors in delirium are multivariable. These include primary cerebral disease, cardiovascular disease, infections, endocrine and metabolic disorders, anoxia, and most commonly, adverse drug reactions, intoxication and withdrawal. The multiple medical problems that sometimes plague the elderly can require a multitude of drugs, which in turn increases the risk of drug interactions, consequently placing the patient at risk for developing a delirious episode (Byrne, 1994; Inouye, 1998; Lipowski, 1990).

Course of Delirium

Delirium has long been considered a transient, essentially reversible condition most often cited to last one week or less. However, there is some evidence that delirium may be more persistent than previously thought. In a retrospective study by Sirios (1988), it was observed that delirium lasted less than 24 hours in 20% of patients, 1-3 days in 30%, from 3-5 days in 17%, from 5-10 days in 20% and up to 30 days in 13%. In a study by Rockwood (1989), it was reported that 40% of the patients had complete recovery by discharge but 47% persisted beyond 7 days. Levkoff and colleagues (1992) found only 4% of their patients had complete resolution of symptoms by discharge and when re-evaluated at 3 and 6 months, only 20.8% and 17.7%, respectively, had complete recovery of all symptoms related to delirium. Furthermore, studies have found that episodes of delirium among hospitalized older adults are associated with a greater chance of institutionalization, greater dependence in activities of daily living, and increased risk for developing dementia and death (Dolan et al., 2000; Francis & Kapoor, 1992; Frances, Martin & Kapoor, 1990; Inouye et al., 1994; Levkoff et al., 1992; Marcantonio, Flacker, Michaels & Resnick, 2000; Pompei et al., 1994). Interestingly, poorer functional status was observed by several investigators up to 2 years post-discharge (Dolan et al., 2000; Inouye, 1998; Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963; O'Keefe & Lavan, 1997).

Purpose of the Study

In spite of the potentially long lasting serious functional, social, and psychological consequences, delirium remains a neglected focus of scientific inquiry. Liptzin and colleagues (1993), noted in their paper from the CDWG (Cognitive Disorder Work Group) of the American Psychiatric Association Task Force on the DSM-IV that the criteria for delirium has been mainly based on extensive clinical experience as very few empirical studies have been published investigating the specific symptoms of delirium. The literature of the last several decades regarding delirium is dominated by reviews synthesizing diagnosis, risk factors, and the evaluation of associated medical disorders and clinical management. The reviews address the limitations in the knowledge base regarding this disorder, but they do not provide any empirical data for better defining the syndrome. This is also evident with the few empirical studies investigating the risk factors and morbidity associated with delirium. Collectively, they do not describe specifically how each symptom or criteria meeting the diagnosis for delirium were rated, or whether the diagnosis was made on a global impression (Cameron, Thomas, & Mulvihill, 1987; Erkinjuntti, Wikstrom & Palo, 1986; Rockwood, 1989). In other words, how was it determined, for example, that the patient met the DSM criteria for "impairment of consciousness," and displayed a reduced ability to "focus or shift attention"? It can be implied that the judgments were based on "clinical expertise" of the examiners as opposed to being based on sound empirical research.

Furthermore, recent review papers although thorough in their etiological descriptions, risk factors, and assessment, fail to clearly and explicitly define specific attentional symptoms of delirium often using vague and broad terms. For example, Laurila and colleagues (2002) identify "impairment of attention" as a required criterion according to the previous DSM-III, and the DSM-III-R, as well as the DSM-IV, the ICD-10 classification and the Confusion Assessment Method. However, no further details are provided, such as how the construct "impairment of attention" is defined. Similarly, Segatore and Adams' (2001) review article define delirium as "marked by problems sustaining and shifting attention," while Roche (2003) describes the cardinal feature of delirium simply as "inattention." While Segatore and Adams' definition is more precise than Roche, neither mention the test on which the judgment is based on.

There is, however, a general agreement that the cognitive deficits characterizing delirium are the direct consequences of a specific deficit of the attentional system and as previously noted, a critical feature included as diagnostic criteria since the DSM-III (Caltagirone & Carlesimo, 1999; Mesulam, 2000). Nevertheless, with respect to attentional deficits, empirical work that documents the nature and areas of attentional dysfunction is scarce and outdated. In general, review papers outweigh primary research papers, and conclusions are rooted largely in clinical observations.

Limited studies have attempted to outline the qualitative characteristics of attentional impairment in a systematic way, therefore further empirically based research is needed (Chedru & Geschwind, 1972; Katz et al., 2001; Rogers et al., 1989). Neuropsychological testing serves the purpose of documenting the specific deficits within the attentional domain, which can lend information in the diagnosis and elaboration of brain-behavior relationships. Overall, the current literature documenting neuropsychological changes in delirium is limited, inconclusive and difficult to compare due to an inconsistent use of terminology and variability in methodology. Furthermore, the focus has been primarily for identification purposes between different clinical populations such as between delirious versus demented individuals (Foreman, 1990; O'Keefe & Gosney, 1997). There has been an absence of studies focusing on the changes in attentional capacity from the pre-morbid state to the resolved state of delirium. Unquestionably, the attentional impairments of delirium to date have not been clearly defined or operationalized. Operationalizing the diagnostic criteria of attention will aid in the further understanding of the phenomenology of delirium, which will help facilitate the design and selection of tools that more specifically measure the frequency and severity of the symptoms more likely associated with delirium. In turn, improved assessment tools will result in a quicker, more accurate diagnosis. Consequently, early diagnosis of delirium will lead to prompt medical treatment resulting in fewer negative outcomes for the patient.

The purpose of conducting this study is to examine the attentional disturbances that occur in the elderly during a delirious episode and to assess any residual symptoms observed several months after the initial delirious episode. The largely exploratory but empirical nature of this research is viewed as an appropriate starting point in an area that lacks data from experimental research. Therefore, this study is unique in that one, the examination of the attentional disturbances are based on theoretical models of attention. Two, the baseline attentional measures are obtained prior to the individual developing delirium in order to more clearly identify the true effects of the episode. Three, the performances are compared against a group of individuals who do not develop delirium. This is accomplished by targeting individuals who are scheduled for hip replacements and by assessing these individuals at three time points; 1) prior to surgery, 2) immediately after surgery, and 3) two months post-operatively. Several instruments designed to assess various constructs of attention, including sustained, switching, suppressing and sharing are administered at each time point. Results from these tests are compared between those individuals who ultimately developed delirium post-operatively versus those who do not.

It is important to note that the ability to be attentive is generally a prerequisite for carrying out any cognitive task, whether it requires the acquisition and manipulation of external stimuli, or whether it is based on the recall or processing of learned material (Mesulam, 2000). It can be surmised that attention is a critical component in the ability to cope. Individuals must be able to attend to relevant information and ignore irrelevant information in order to effectively meet most task requirements such as conversing, searching for a friend in a crowd or driving an automobile.

In conclusion, further understanding of the short and long term effects of a delirious episode on attention may lead to treatment or intervention programs being implemented in order to increase the quality of life for the elderly. It is vitally important in the elderly population to promote a vigorous quality of life. A crucial factor in fostering a high quality of life is through the assessment and treatment of cognitive deficits.

CHAPTER II

Literature Review

The following literature review will include a) a brief review of the concept of cognition, b) a discussion of the global cognitive effects of delirium, c) an overview of several models of attention, d) and finally, a review of the research discussing the attentional disorders associated with delirium.

Cognition

Cognitive disturbances are one of the definitive features of delirium (Ross, Shapiro & Folstein, 1991). Broadly defined, cognition includes all mental processes associated with thinking. Cognition is analogous to the computer operations of input, storage, and output of information (Galotti, 1999). Specifically, the cognitive process includes attention, perception, memory and learning, language, thinking and reasoning (Galotti, 1999; Podell & Lovell, 2000). Lezac (1995) reduces these processes into four major classes (1) receptive functions; (2) memory and learning; (3) thinking; and (4) expressive functions. Broadbent's (1958) well known filter model depicts these four classes within an information processing system.

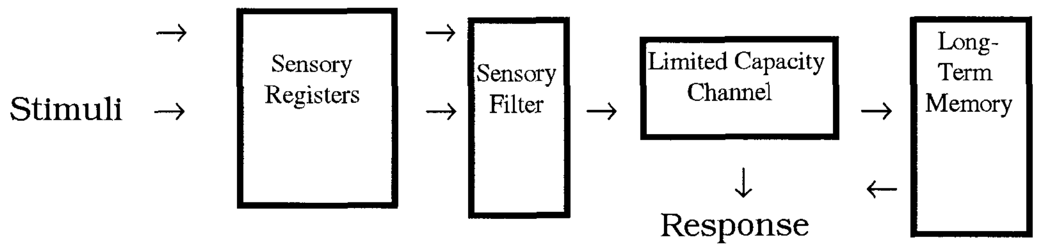

Figure 1. Broadbent's Filter Theory Model

Note. From *Perception and Communication* by D. Broadbent, 1958, London: Pergamon Press.

Entry of information into the central processing system proceeds from sensory stimulation. Sensory reception involves the abilities to select, acquire, classify and integrate information. Next, information reaches the *Sensory Filter*, which blocks out certain input channels while allowing other inputs to pass through. This has also been referred to as a sensory store that briefly holds information for 1 or 2 seconds at most (Loftus & Loftus, 1976). The attended message is then processed through a *Limited Capacity Channel* and is assumed to have accessed the individuals long-term memory and the response system that enables the person to produce the response. The Limited Capacity Channel is more commonly referred to as short- term memory storage, and can be further differentiated into two stages, the immediate memory and the working memory where the former typically lasts from 30 seconds to several minutes while the latter lasts from an hour to one or two days (Lezak, 1995). Short-term memory and attentive behavior are synonymous in that we are in fact 'attending' with our working memory. In fact, Baddeley (1993) has raised the question whether the term 'working memory' is a misnomer that could be better replaced by 'working attention'. The final steps in Broadbent's information processing system of response concern the "mental organization and reorganization" and expressive functions in which information is communicated.

Attentional functions differ from the functional groups listed above in that they underlie and energize the activity of the cognitive functions. Attention can be incorporated in Broadbent's model in two ways, through the concepts of selectivity and capacity. Broadbent (1958) postulated a filter that excluded irrelevant information, enabling the system to deal efficiently with task relevant signals or those signals that were 'attended' to. This would assume that long-term knowledge is contacted only for attended stimuli (those accepted by the filter). Later theorists contended that 'not attended to' information was attenuated, but still processed by the system in a superficial way (Treisman, 1964). Broadbent (1971) later adapted his model by introducing an attenuation filter.

Further development by Shiffrin and Schneider (1977) presented a two-process model of information processing which incorporated the concept of selectivity, and extended between automatic and conscious processing of information. In other words, new and unfamiliar tasks require 'full attention' while an over learned task seems to be executed automatically. While automatic processing occurs in parallel and the capacity of this mode of processing is unlimited, conscious processing is thought to proceed in a serial manner due to the interference with and from other tasks.

The models presented above provide a foundation in the development of the theories of attention. However, the weakness of these information processing theories is that they do not take into account the higher order aspects of attention, such as planning and regulation of goal-directed activity. The cognitive schema theory by Shallice (1982), to be described later in this chapter, addresses this relationship.

In general, attention has been described as the "front-end feature" of the cognitive process and "controls the amount and quality of the information available" for higher cognitive processes (Sparrow & Davis, 2000). Assessment of attention is necessary because attention is a prerequisite for successful performance in other cognitive domains (Podell & Lovell, 2000). There is a strong relationship between attentional functioning and the effectiveness and proficiency of perceptual, memory, motor, and problem solving systems (Douglas, 1983). American psychologist William James most aptly defined attention as :

> " ...taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneous possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrain state..." (James, 1890/1950).

Cognitive Disturbances in Delirium

Before examining specific attentional deficits, it is important first to discuss the global cognitive effects of delirium. With respect to the areas of cognitive impairment, very few studies have characterized the principal cognitive features of delirium. Numerous review articles note impairments in registration of new information, memory deficits, difficulties in integrating and responding to incoming sensory stimuli, and disorganized thinking (Hill, Risby, & Morgan, 1992; Inouye, 1998; Segatore & Adams, 2001). Despite clinical reports suggesting that patients who are delirious fail to store new information, Ptak, Gutbrod and Schnider (1998) were able to demonstrate that delirious patients were in fact able to learn and retain associative information, particularity when the information was presented in a visually rather than verbal form. Chedru and Geschwind (1972) presented the only large-scale study of neuropsychological functioning in delirium, with subjects under 60 years of age. They administered a neuropsychological battery of tests to 24 participants, both during and after the episode of delirium. Their results indicated that all participants performed very poorly on tests measuring attention, temporo-spatial orientation, language, and right-left orientation during the delirious episode. No abnormalities were detected on tests measuring visual recognition, praxis, oral spelling of single words, abstract thought, and comprehension. In contrast, both Christensen et al. (1996) and Bettin et al. (1998) found that those patients who were delirious performed poorly on tests measuring abstract thought and oral spelling. Christensen et al. (1996) results also agree with Chedru and Geschwind (1972) in finding deficits with temporal orientation.

In a follow-up study, Chedru and Geschwind (1972) examined the writing abilities of 34 acutely confused patients between the ages of 28 to 59. The motor and spatial aspects of writing were found to be impaired in 33 of the 34 cases, in addition to spelling and syntax.

Comparable findings were reported by Åakerlund and Rosenberg (1994) investigating postoperative patients, and by MacLeod and Whitehead (1997) in a palliative care setting. More recently, Baranowski and Patten (2000) evaluated the predictive value of dysgraphia for delirium among psychiatric inpatients and found that a global rating of writing quality and evidence of jagged or angled letter loops were the only informative clinical signs of delirium. It is important to note that in all reviewed studies the deficits observed during the episode of delirium were either not seen again or were seen in a very diluted form following recovery.

The literature also suggests that delirium is associated with cognitive decline. Research indicates that patients who have experienced episodes of delirium continue to function poorly in cognitive activity for up to 24 months post-discharge as assessed by the Mini-Mental State Exam (MMSE) (Dolan et al., 2000; Koponen et al., 1989). Koponen et al. (1989) conducted a one year follow up of cognitive functioning in 70 elderly patients with delirium and found a decline in the cognitive functions in one-third of the patients as assessed by the MMSE. Fifty-seven cases (81%) were found to have a predisposing structural brain disease, with these individuals having the most profound deterioration. Goldstein and Fogel (1993) tested the immediate postoperative changes in mental status of general surgical patients and found patients with a 3-point or greater decline in MMSE score 3 days after surgery were likely to maintain a 1-point deficit in MMSE score relative to baseline 10 months later. More recently, Dolan et al. (2000) reported that patients with delirium had lower cognitive scores post-surgery and continued to function poorly over 24 months. After 2 years, almost 50% of patients in the delirium group had a mean cognitive MMSE score in the impaired range, compared with only 24% of patients in the non-delirium group. In the above studies, baseline cognitive measurements (prior to the delirious episode) were not collected and hence it is difficult to determine the exact effects the delirium episode imposed on the patient's cognitive status. However, Chandarana et al. (1988) collected preoperative and postoperative data of patients undergoing coronary bypass surgery for changes in cognition as measured by the MMSE, and found that cognitive impairment was clinically obvious 24 hours post-operatively, was still significant after 8 days, but by eight weeks it had generally dissipated.

The MMSE is a general purpose clinical screening instrument developed to give an estimate of the severity of cognitive impairment and has been extensively used in studies examining delirium in the elderly (Folstein, Folstein, & McHugh, 1975; Nelson, Fogel & Faust, 1986; Smith, Breitbart & Platt, 1995). This instrument measures orientation, recall, attention, calculation, and language. However, MMSE items cannot be interpreted as reflecting specific cognitive domains. A thorough neuropsychological evaluation is required to provide a more valid assessment of an individuals cognitive ability (Tierney, Szalai, Snow, Fisher & Dunn, 1997).

Attention

It is hypothesized that the cognitive deficits observed in delirium are the direct consequence of a specific deficit of the attentional system (Chedru & Geschwind, 1972a; Mesulam, 1985). Most researchers agree that the fundamental neuropsychological deficit in delirium is attentional disturbances. Furthermore, attentional deficits are important distinguishing features between delirium and dementia (Chedru & Geschwind, 1972b; Johnson, 1999; Mesulam, 1985; O'Keefe & Gosney, 1997).

The definition of attention is broad. The word has been defined and used in numerous ways in scientific investigation. For example, Luria (1973) describes attention as having several different capacities that are related to reception and processing of information. Kahneman (1973) proposed that attention is the allocation of the available mental effort to particular aspects of information processing. Lipowski

(1990) describes the normal waking state as involving the capacity to mobilize, direct, focus, sustain, and shift attention not only in response to internal and external stimuli but also voluntarily and intentionally. Orientation, exploration, concentration, and vigilance are positive aspects of attention, whereas distractibility, impersistence, confusion, and neglect reflect attentional deficits (Mesulam, 2000). Though the nomenclature associated with attention is vast, it indicates the complexity and centrality of attention to behavioral experience.

The Manifestations of Attention

Attentional behaviors vary as a function of the task demands. The most commonly described behavioral situations that illustrate various attentional manifestations will be discussed next. These manifestations include focused, selective, divided, and sustained attention and can be influenced either directly or indirectly by a number of factors that put constraints on the processes of attention (Cohen & O'Donnell, 1993; Van Zomeren & Brouwer, 1994). The term focused attention refers to the amount of information selected at a given time relative to the temporal-spatial constrains of attention. In other words, attention is a process that is both temporally and spatially distributed and individuals direct focus to certain spatial positions in order to make our selections within time constrains (Cohen & O'Donnell, 1993; Van Zomeren & Brouwer, 1994). Selective attention refers to the process by which some informational elements are given priority over others and always occurs relative to a temporal-spatial frame of reference. Divided attention is the sharing between two or more sources or kinds of information, or two or more mental operations. As the amount of simultaneous information increases, attentional performance declines especially when the task requirements are demanding and are strongly dependent on automatic or controlled processes. Sustained attention refers to the requirement that attention be directed to one or more sources of information over long periods of time for the purpose of detecting and responding to small changes in the information to be presented (Cohen & O'Donnell, 1993; Van Zomeren & Brouwer, 1994).

Cohen and O'Donnell (1993) suggest that attention also depends on a minimum of four neurobehavioral factors: 1) sensory selection; 2) response selection and control; 3) factors that influence attentional capacity; and 4) factors that mediate sustained performance. As described by Cohen and O'Donnell (1993), the flow chart below incorporates the four primary attentional factors that are necessary for attention in humans.

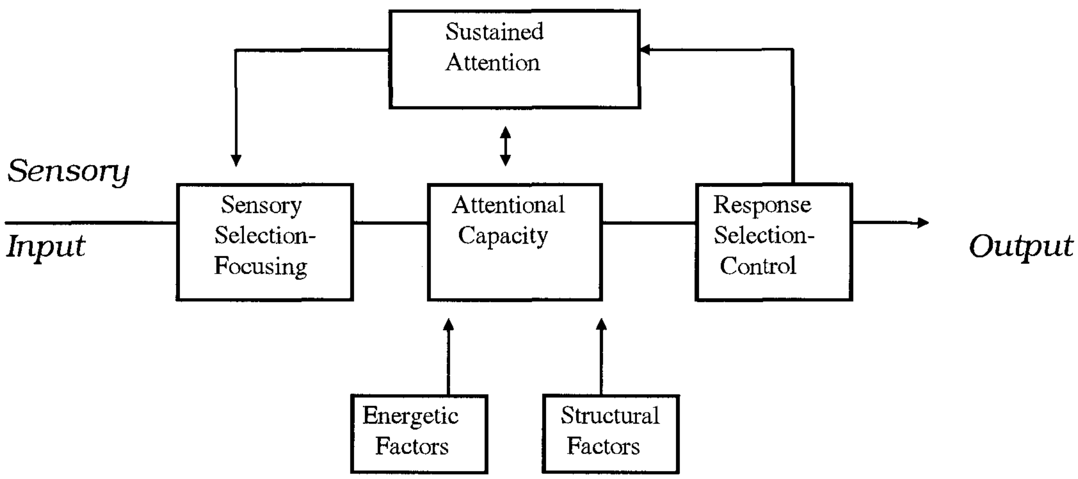

Figure 2. Attentional stages of information processing

Note. From "Neuropsychological models of attentional dysfunction" by R. Cohen, & B. O'Donnell, 1993, In R. Cohen (Ed.), *The Neuropsychology of Attention,* (pp.329-350) New York: Plenum Press.

Attentional control initially occurs relatively early in the stages of information processing and three related component processes are involved in early *sensory selection*: filtering, focusing and automatic shifting. The filtering mechanism allows for 'tuning in' to particular featural characteristics, subsequently focusing is accomplished through higher order sensory systems that interact with motivational and response influences. Automatic shifting of attention occurs as a result of focusing in conjunction with an orienting response which is controlled by habituation and sensitization. Habituation is a repeated sensory event which tends to lose its capacity to produce arousal rapidly (Hebb, 1958). The *response selection* is influenced by four processes: response intention, initiation and inhibition, active switching, and executive supervisory control. Intentionally, initiation and inhibition contribute to the capacity for active switching and executive control. The factors that influence attentional capacity are structural and energetic. Structural capacity is limited by the constrains of memory, processing speed, the nature of the temporal-spatial representation, and other neural system characteristics. The energetic factors refer to arousal and effort. Arousal characterizes the energetic state of the attentional system, while effort is governed by reinforcement and motivational influences. Lastly, sustained attention can be considered a function of fatigue and may be a by-product of a biological constrain. Additionally, sustained attention is determined by the sensory selection, response selection and capacity limitations previously explained.

Models of Attention

Although progress has been made towards an understanding of the processes of attention, in many ways the neuropsychology of attention is still in its infancy. Attention is not a unitary process but one that spans multiple psychological domains and includes many neural systems. As such, there have been many conceptual models put forth to explain attention (Mesulam, 1985; Posner, 1980; Shiffrin & Schneider, 1977). In all models there is a concensus that attention is biologically mediated through the interaction of neural networks within the reticular activating system (RAS), the thalamus, striatum, parietal cortex, the anterior cingulate gyrus and the limbic system (Cohen & Salloway, 1997; Mesulam, 1985; Posner, 1980; Shiffrin & Schneider, 1977; Stuss, Shallice, Alexander & Picton, 1995). Furthermore, all models describe a series of discrete components, each with their own specific competence and all functionally connected. For example, Mesulam (1985) subdivided attention into two categories: the *attentional matrix* and the *channel function*. The *attentional matrix* regulates the overall information processing capacity, focusing power, and vigilance. The *channel function* regulates the direction or target of attention and can be defined as selective attention.

Posner and colleagues (1988) introduced a cognitive system by which three subsystems mediate different but complementary attentional processes: 1) the Posterior Attentional System (PAS), 2) the Vigilance System, 3)the Anterior Attentional System (AAS). The PAS, centered in the parietal lobe, specifically the posterior parietal lobe, lateral pulvinar of the nucleus of the thalamus, and the superior colliculus is responsible for the allocation of visual attention. Studies with healthy individuals and brain damaged patients confirm that injuries to any one of the three areas (PAS, AAS and Vigilant System) will reduce the ability to shift attention covertly (Posner & Peterson, 1990). More specifically, the parietal lobe disengages attention from its present focus, then the midbrain area acts to shift attention to a new target and finally the thalamic pulvinar allocates the data from the new location.

The AAS, centered in the frontal lobe, is concerned with the executive control of attention and acts to detect sensory or semantic events that appear to be related to awareness and voluntary control of attention (Posner, Peterson, Fox & Raichle, 1988). Posner et al. (1988) suggested a possible hierarchy of attention systems in which the anterior system can pass control to the posterior system when it is not occupied with processing other material.

The Vigilance System composed of noradrenergic connections originating from the locus coeruleus and anterior cingulate cortex prepares and sustains alertness for processing high priority signals. There is evidence that the maintenance of the alert state is dependent upon right-hemisphere mechanisms and the norepinephrine system arising in the locus coeruleus. The alert state produces more rapid responding, but this increase is accompanied by a higher error rate (Posner, Peterson, Fox & Raichle, 1988).

Shallice (1982) presented a theoretical model of human behavior in which all activity, mental and overt, is viewed as the unfolding of mental schemas. These schemas specify the interpretations of external input and subsequent action. Specific trigger conditions in the external input are required for a schema to become active and to subsequently determine behavior. Often these triggers will be present at the same time, and hence many schemas could be activated simultaneously resulting in chaotic behavior. Shallice (1982) postulated two adaptive mechanisms to regulate the competing relationship between schemas: contention scheduling and supervisory attention control. *Contention scheduling* is an automatic conflict resolution inhibitory process that selects one of the conflicting schemas according to priorities and environmental cues and gives it precedence at any given moment. Schema selection is based on dependencies between schemas which have been developed through experience and are represented by associative connections between their representations in long-term memory. A compatible schema would be one experienced previously, which has led to successful performance in a similar context, this is optimally suited for routine behaviors. The *supervisory attentional control* is called upon in nonroutine situations. It is thought that the supervisory attentional control cannot select schemas in a direct manner but must proceed by influencing the excitability of schemas (Shallice, 1982).

Norman and Shallice (1986) further developed this model with the addition of a Supervisory Model that specifies the operations involved in executive abilities- the separation between routine and nonroutine activities. While the Shallice (1982) model is basically concerned with the selection of and switching between schemas, the Norman and Shallice model is concerned with the execution of activities specified by these schemas. First, a clarification of the Supervisory Model will be presented followed by a description of the types of tasks involved in the control of attention.

There are four components of the Supervisory Model: 1) cognitive units or modules, 2) schemata, 3) contention scheduling, and 4) supervisory (attentional) system. As previously discussed, the first three components are related to routine activities. *Modules or units* are used to carry out basic cognitive operations. Each of these units are controlled by *schemata*, which are programs for the control of over-learned skills. To repeat, *contention scheduling* refers to the inhibitory mechanisms that control competition between *schemata*. The fourth unit, the *supervisory system*, is the general executive component, and acts to handle non-routine behaviors. It functions primarily under four circumstances: 1) when there is no solution to a task at hand, 2) when specific selection among schemata is necessary, 3) when inappropriate schemata must be inhibited, and 4) when weakly activated schemata are evoked (Norman and Shallice, 1986).

The *supervisory system* can be further differentiated into five components or supervisory processes that are particularly important in attention: 1) energizing of schemata, 2) inhibiting of schemata, 3) adjustment of contention scheduling, 4) monitoring of schemata activity, and 5) control of "if-then" logical processes. The supervisory system is responsible for the activating and re-energizing of the task relevant schema, and for the inhibition of irrelevant schema. The framework is presented diagrammatically below in Figure 3.

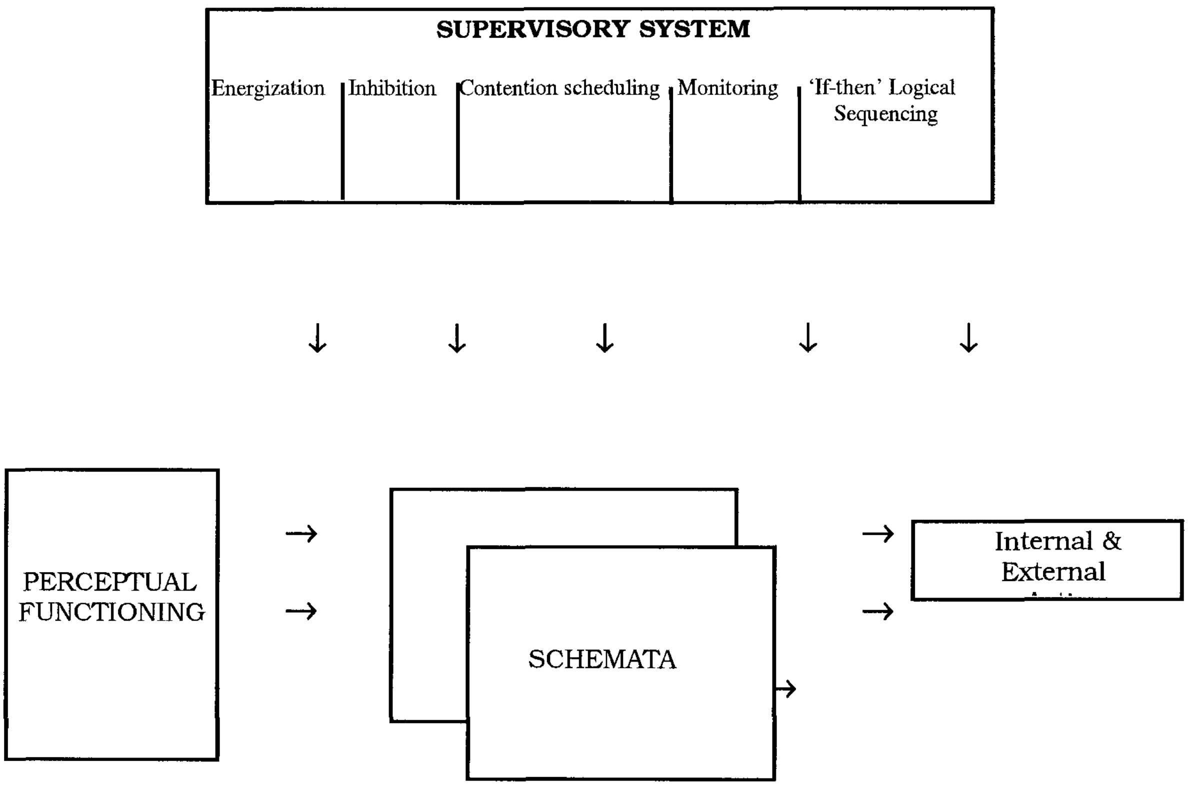

Figure 3. Component processes of supervisory system.

Note. "From Attention to action: Willled and automatic control of behavior" by D. Norman & T. Shalllice, 1986. In R. Davidson, G. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation* (Vol.4, pp.1-18). New York: Plenum.

Stuss, Shallice, Alexander and Picton (1995) assert that the control of attention can be shown in seven types of tasks which include sustaining, sharing, suppressing, switching, preparing, concentrating, and setting. The tasks of preparing, concentrating and setting have not been a major focus in the literature to date and therefore the theoretical understanding of these tasks is still not well understood. Moreover, the basic testing of these tasks require the use of a serial reaction time task which is normally administered in a controlled laboratory environment. Due to the practical constrains of this study, only four of these tasks will be the focus. These four tasks include *sustaining, sharing, suppressing* and *switching* of attention.

These tasks can be defined and characterized in terms of the Supervisory System Model. For example, *sustaining attention* or vigilance is required when events occur at a relatively slow rate over long periods of time. The Supervisory System must continuously reactivate or energize the target schemata in order to counteract the internal tendency for these schemata to become deactivated in the absence of input. Also, the system must ensure that other schemata do not become activated by monitoring and inhibiting these schemata. *Sharing or divided attention* is required when two or more unrelated tasks have to be carried out at the same time. Reduced activation of competing schema is required of the supervisory system. *Suppressing or selective attention* is required when schemata that are inappropriate to the task is selected. For example, where a subject must respond to a red 'X' or a blue 'O' but not to other red or blue letters and not to either a red '0' or blue 'X'. A sequential if-then test based on a conditional association is required.

This process would be elicited by the occurrence of a positive value of the relevant target. In addition, the supervisory process inhibiting schema would be needed to inhibit the output of the response schema while the if-then process was in operation. *Switching attention* is a component that requires the specific activation of the less active schema, and the deactivation of the currently selected schema (Stuss et al., 1995).

In summary, Posner, Norman and Shallice and above all, Stuss et al. (1995) provide a neuropsychological model for studying attention that specifically identifies a set of processes and elements involved in this cognitive function. It can be presumed from these models that attentional deficits in patients with delirium can be comprised at different levels of the cognitive system and with specific components. The question remains whether the cerebral damage that produced delirium impairs all aspects of attentional functioning or whether instead, it affects specific components or elements such as sustaining, sharing, switching, or suppressing.

Attentional Disorders in Delirium

As stated previously, there is a lack of research investigating the specific components of attention impairment with delirium. The descriptions of attentional impairment are primarily based on clinical observations and are therefore anecdotally based. These observations reflect impaired ability to mobilize attention, to select information output, to shift, focus and sustain attention, or to be distracted by extraneous stimuli, difficulty in maintaining a conversation and following demands, as well as having the tendency to perseverate with an answer from a previous question (Hill, Risby, & Morgan, 1992; Inouye, 1998; Lipowski, 1983). Understandably, the lack of empirical work is related in part to the fact that studying patients with delirium can be very difficult.

In one of the few empirically based studies, Foreman (1990) investigated the pattern of cognitive deficits representative of delirium in hospitalized medical patients over 60 years of age. In this study 238 patients chose to participate and 113 developed delirium. Patients were selected within 24 hours of admission and assessed once daily up to a maximum of eight days. No pre-morbid cognitive data was collected nor were any follow up assessments conducted once the delirium had resolved. Through stepwise discriminant function analysis Foreman found tests of attention such as spelling words backward and serial subtraction were extremely useful in differentiating acutely confused individuals from those that were not, in combination with other behavioral characteristics such as slurred and garbled speech, ability to draw a pentagon, ability to perform some activities of daily living (ADL) and forgetfulness. The spelling backwards and serial subtraction tasks are primarily tests of mental tracking and measure the attentional domains of capacity, focus and divided attention (Cohen & Salloway, 1997; Lezak, 1995).

O'Keeffe and Gosney (1997) sought to determine whether delirious patients were more impaired on tests of attention than were nondelirious patients and to identify cut-off points on the tests that might be helpful in the diagnosis of delirium. The subjects were patients admitted to an acute geriatric hospital. Of the 87 patients who were recruited for this study, 18 were delirious and 17 were demented. The four bedside tests of attention utilized included Digit Span Forward, Digit Span Backwards, Vigilance 'A' test and a timed Digit Cancellation Test. O'Keeffe and Gosney (1997) reported that all delirious individuals performed more poorly than nondelirious patients on all tests, including those measuring attentional capacity (Digit Span), sustained attention (Vigilance 'A' test), selective attention and focused visual attention (Digit Cancellation). Furthermore, when comparing delirious patients with demented patients with similar MMSE scores, the results of the Digit Span Backwards (attentional capacity) and Digit Cancellation Test (selective attention) indicated that the delirious patients scores were significantly more impaired. The Digit Span Backwards test requires patients to listen to a series of numbers and repeat them backwards. The Digit Cancellation Test requires participants to cross out specific target digits within a specified time frame. Similar to Foreman's (1990) study, the attention tests were administered only at the time of admission when patients had already developed delirium, and no pre-morbid measures were obtained.

Both Trzepac, Brenner and Thiel (1989) and Trzepac, Maue, Coffman and Thiel (1987) performed neuropsychiatric assessment following liver transplantation to candidates ranging from ages eighteen to fifty-eight years old. They found that patients suffering from delirium revealed significant deficits on the Trail Making Test, Part B, a measure of cognitive set-shifting, or attentional switching. This test was administered twice during the patients' admission to the hospital, usually within a three-day period. The researchers concluded that the Trail Making Test was sensitive at predicting the presence of delirium. Neither baseline measurement, nor post-operative measures were collected during this study.

A number of studies of delirium have initially screened older elective surgery populations in the expectation that some will develop delirium (Dyer, Ashton & Teasdale, 1995; Fisher & Flowerdew, 1995; Parikh & Chung, 1995; Marcantonio et al., 1994; Williams-Russo, Urquhart, Sharrock & Charlson, 1992). The nature of elective surgery allows for a more thorough preoperative assessment of the medical, functional, and cognitive status of the subject. The majority of these studies have focused on the incidence, diagnosis, risk factors, and treatment of postoperative delirium. Very few studies have examined the nature and specific areas of cognitive impairment, where the focus is specifically on changes in cognitive capacities. In one such study, Rogers et al. (1989), as part of a risk factor analysis study, attempted to investigate areas of cognitive impairment following elective joint replacement surgery. Neuropsychological screening tests were administered preoperatively to establish baseline cognitive performance in attention, language, visuospatial ability, memory, and conceptualization. The neuropsychological tests were repeated on all delirious patients and a subset of non-delirious patients on day eleven of the hospitalization or prior to discharge, if sooner. Results from the neuropsychological measures at baseline indicated that the subjects were very high functioning older persons and consequently the investigators chose not to conduct any postoperative analysis of the neuropsychological variables. Unfortunately, any results that were obtained from neuropsychological testing at baseline were also not reported (Rogers et al., 1989).

Katz et al. (2001) conducted a prospective study of delirium in a long term care facility in which subjects were followed for a period of one year in their place of residence, during any hospitalization that occurred during the year, and at least two months after discharge. 102 subjects were included in the study; 51 were from a nursing home and 51 from a congregate housing facility. Over the course of one year, 47 subjects were hospitalized and 12 patients developed delirium. The authors' observed the symptomatology of delirium including global cognitive performance and two specific tests of attention. These tests included the Stroop Test, a measure of cognitive inhibition and flexibility and the Verbal Vigilance test, a measure of auditory and sustained attention. The investigators found those who were diagnosed with delirium exhibited higher baseline impairments on the Stroop test relative to the rest of the patients who were hospitalized and experienced greater decline in global cognition during their hospitalization and over the course of the year. However, no significant differences were found between those who developed delirium and those who did not on the tests of attention.

Summary

In summary, preliminary evidence suggests that patients suffering with delirium perform worse on tasks of divided attention (Foreman, 1990), suppressing attention (O'Keeffe & Gosney, 1997), and switching attention (Trezpac et al., 1989;1987), while others have failed to observe any significant differences (Katz et al., 2001).

With the limited numbers of studies found, it is difficult to ascertain with any certainty the specific attentional deficits that were observed with individuals suffering from a delirious episode. Thus far the data suggest poorer performance from those individuals suffering from a delirious episode when attempting a variety of tasks of attention, including focus, sustained, and switching when compared to non-delirious individuals. While these findings are important, without baseline or post-morbid measures, it is unclear what effect a delirious episode has on specific attentional tasks. Moreover, no study to date has been done with the specific intent of investigating attentional abilities within a theoretical framework resulting in generalized conclusions with no clear distinctions or characterizations of attentional impairment. The question as to how a delirious episode affects different aspects of attention remains unanswered. For this investigation, a well designed experimental study, with sound psychometric practices grounded in theories of attention will be of importance.

Problem Statement

The relationship between delirium and attentional impairment needs to be further explored. In particular, further research is needed to document the nature of the deficits of attention during as well as after the delirious episode has resolved. Moreover, research is needed in order to explore whether delirium impairs global attentional functioning or if it affects specific aspects of attention. Additionally, further research is needed in order to determine whether the attentional disturbances of delirium persist over time.

The objective of this study is to examine specific areas of attentional impairment that occur in the presence of delirium and those that may persist after the resolution of the delirious episode. Four specific aspects of attention which include sustained, switching, sharing and suppressing (Stuss et al., 1995) were selected as the focus of investigation based on the model of attention developed by Norman and Shallice (1986). The model by Norman and Shallice (1986) provides a broad and comprehensive perspective of the attentional process. Three repeated measures of attentional functioning will be obtained: 1) baseline prior to the delirium, 2) during the delirious episode, 3) two months after discharge. The nature of any attentional disturbances and changes can then be compared and documented.

Research Questions:

1. As attentional disturbances are a significant feature of delirium, it is proposed that performances on tasks of attention will show significant deterioration during an episode of delirium. If so, which attentional aspect (sustaining, sharing, switching or suppressing) will show significant change during the delirious episode?
2. Will the attentional disturbances persist 2 months after discharge and if so, which specific aspect of attention show the greatest deterioration?
3. Are changes in attention in patients diagnosed with delirium accompanied by changes in overall cognitive status?

CHAPTER III

Methods

The design used in this study has been classified as comparative descriptive which examines the differences between groups on dependent variables of interest (Nieswiadomy, 1998). Frequently, the independent variable is an inherent characteristic of the subject, such as personality type, education level, or as in this case, a medical condition such as delirium. The study was conducted at the Royal Alexandra Hospital, a major acute care facility in the City of Edmonton, Alberta, Canada.

Participants

Participants in this research project were adults who attended the orthopedics pre-admission clinic for elective hip replacement surgery at the Royal Alexandra Hospital. Specific inclusion criteria were patients 65 years of age and older, as increasing age is a risk factor for the development of delirium (Lipowski, 1990). The exclusion criteria were those patients with preoperative communication problems (non-English speakers, blindness and/or deafness) and those individuals who had been diagnosed with dementia prior to admission. The exclusion of individuals diagnosed with dementia was to allow for a greater certainty that the observation of any cognitive changes was more likely due to delirium and not dementia (Lipowski, 1990).

A total of 201 patients agreed to participate in the study. At baseline (Time 1), data was collected from all 201 patients. Since the purpose of the study was to examine the effects of a delirious episode on attention, patients were followed and reexamined to monitor the development of delirium. Those individuals who developed delirium at Time 2 (post-operative) were assigned to the delirious group and those who did not develop delirium were assigned to the non-delirious group. Baseline (Time 1) data collection was terminated once 30 individuals had developed delirium. Thirty individuals from the group who did not develop delirium were selected and matched to the delirious group on the potentially confounding variables of age and comorbidity. Both groups were followed and reexamined 2 months post-operatively (Time 3).

212 patients met eligibility requirements, of these 201 expressed willingness to participate (94.81%); and 11 (5.19%) refused. Of the 201 patients willing to participate at Time 1, 15 (7.46%) patients dropped out during the data collection phase; thus 186 patients were followed through to the post-operative period at Time 2. Because subjects were recruited sequentially and not simultaneously, the dropouts were considered to form an independent sample and not to have

ever belonged to the same group as those who completed the study. Of the 186 patients who completed the study to Time 2, 65% were female, with a group mean age of 77.2 years. From the 186, 16.13% (30) of the individuals met the CAM criteria for POD (post-operative delirium).

At this point, 156 patients had not developed delirium and 30 of them were enrolled by means of a prospective matching strategy. The prospective, individual matching strategy was chosen as an alternative to randomization to ensure the patients in the study groups were comparable at baseline. A computerized algorithm was designed to match patients simultaneously on the basis of the chosen characteristics of age (within 5 years) and comorbidity (weighted index). These factors were selected as increasing age and severity of illness may have a negative impact on the performance on the attentional tests post-operatively. The Charlson Comorbidity Index was used to quantify medical comorbidity (Charlson, Pompei, Ales & MacKenzie, 1987). When more than one 'not delirious' patient was available, the algorithm selected the patient closest in age to the delirious patient, or in the case of ties, the patient with the closest weighted comorbidity index to the delirious patient.

The overall group of 60 (30 delirious and 30 not delirious patients) at Time 3 had a mean age of 74.92 and 56.7 % were female.

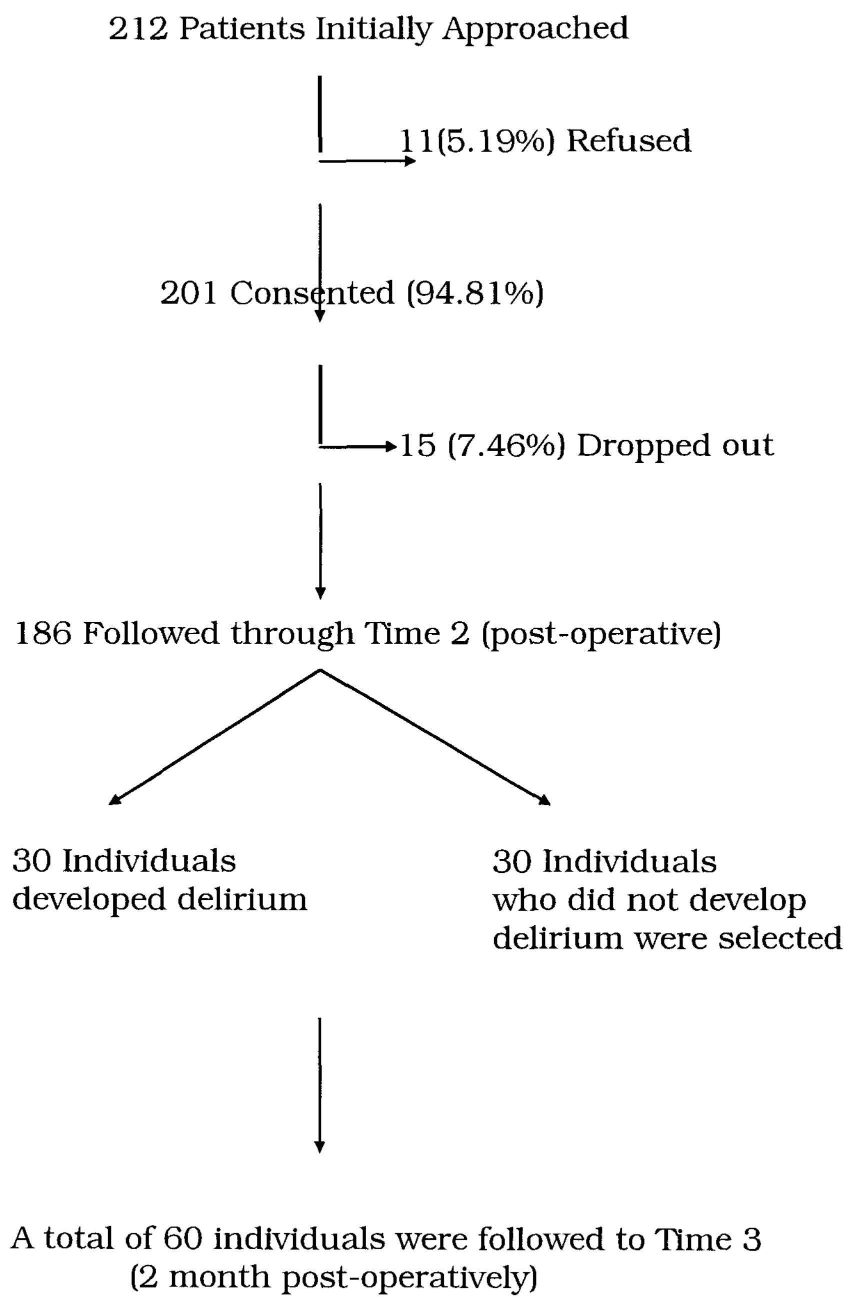

Figure 4. Flowchart depicting patient enrollment.

Instrumentation

Time 1: Baseline Measures

All patients were administered an extensive battery of neuropsychological measurements at baseline (Time 1:T1), when the patients attended the orthopedics pre-admission clinic for elective hip replacement surgery. Below is a list of the neuropsychological measures. More detailed descriptions of these measures is to follow.

Neuropsychological Measures

1. 3MS Mental Status Exam
2. Luria Alternating Sequence Test
3. Trail Making Test Part A & B
4. Stroop Color and Word test
5. Go-No-Go Test
6. Auditory Signal Detection Test
7. Sequence Test

In addition, the following information was collected: age, gender, marital status, education level, date of surgery, place of residence, contact number, underlying chronic medical conditions, minor corrected hearing or visual impairment, medical history and current medications. Medical history was obtained from the interview and this information was confirmed from the patient's chart.

Time 2: Post-Operative

A list was made of all the patients who had consented to the study along with their corresponding surgical date. Each patient was visited one day after the surgery and up to seven days post-operative or just prior to discharge. The post-operative assessments (Time 2) were collected on the day the patient was diagnosed with delirium or in the cases where delirium did not develop, on the day before discharge.

The Confusion Assessment Method was the first post-operative measure to be administered each day from the first to the seventh day postoperative. The majority of cases of delirium have been reported to occur on day two and three but some have occurred as late as day seven post-operatively (Marcantonio, Flacker, Micheals & Resnick, 1994). Additionally, a review of the progress notes from the patient's chart for behaviors consistent with delirium was conducted. The type of anesthesia and postoperative drugs prescribed were also recorded. If the patient developed delirium, the Memorial Delirium Assessment Scale (Breitbart et al., 1997) was administered in order to rate the severity of delirium.

Below is the list of all measures administered at Time 2:

1. Confusion Assessment Method
2. 3MS
3. Luria Alternating Sequence Test
4. Trail Making Test Part A & B
5. Stroop Color and Word test
6. Go-No-Go Test
7. Auditory Signal Detection Test
8. Sequence Test
9. The Memorial Delirium Scale (only for those patients who developed delirium)

Time 3: Follow-up 2 months post-operatively

At 2 months post-operatively, the researcher made a home visit. Family members were interviewed at these times and were asked to describe the patient's cognitive functioning and any recent cognitive changes. The following questions were asked:

1. Have you noticed if your family member has become more forgetful?
2. Are there any activities or tasks that your family

member now requires your assistance but was independent before?

All of the preoperative measures conducted at baseline were re-administered at Time 3 to both groups, which included:

1. 3MS
2. Luria Alternating Sequence Test
3. Trail Making Test Part A & B
4. Stroop Color and Word test
5. Go-No-Go Test
6. Auditory Signal Detection Test
7. Sequences Test
8. *Memorial Delirium Assessment Scale

*If the patient was delirious at Time 2, the Memorial Delirium Assessment Scale was also administered.

Neuropsychological Measures

Overall cognitive status was measured using the Modified Mini-Mental State Exam (3MS) (Teng & Chui, 1987). The 3MS consists of 22 simple questions, of which two require written answers, and has a maximum score of 100. The test takes only 10 to 15 minutes to administer. Reliability and validity have been reported to be excellent, although it is recognized that education level, age and ethnicity all affect the score (Smith, Breibart & Platt, 1995). Test-retest reliabilities are reported to be generally around .80, and internal consistency at .87 (McDowell, Kristjannsson, Hill & Herbert, 1997).

The 3MS is an expanded and modified version of the Mini-Mental Status Exam (MMSE). Modifications include the addition of four items, minor changes in item content and order of administration. As previously mentioned the MMSE is one of the most frequently used neuropsychological tests in the clinical evaluation of delirium and is important to administer for comparative purposes with other literature (Folstein, Folstein, & McHugh, 1975). The MMSE was developed as an estimate of the severity of cognitive impairment and has been found to be useful in documenting changes in cognition (Levkoff et al., 1991).

Measures of Attention

Attentional tests do not uniquely measure any single subprocess of attention and sometimes include a combination of complicated verbal, and motoric requirements. The following tests were carefully chosen on the basis of the ease of administration at bedside and categorized based on the predominate construct of attention which the test assesses.

(1). *Tests of Switching Attention*: The central features of *switching* attention requires the shifting of one concept to another within one set of stimuli, and theoretically requires the specific activation of the less active schema (Stuss et al., 1995). Characteristically, the Luria Alternating Sequence task is a good example of a simple bedside test that examines the ability to switch responses (Luria, 1966). The Alternating Sequence task is part of Luria's Neuropsychological Investigation battery for assessing brain damage (Christensen, 1979). The examinee is required to copy a segment of connected alternating open triangles and squares and extend the pattern to the end of the page, without lifting the pencil. Mesulam (2000) has found that individuals who developed a confusional state have a tendency to repeat a segment of the sequence drawn, before which results in a series of either perseverative triangles or squares instead of the alternating pattern. Although reliability and validity measures are not available, this test has been found to be sensitive to response perservation in patients with gross frontal lobe deficits (Hodges, 1994; Stowe, 1998). This test is scored on a pass or fail basis. Participants received a score of '1' if they passed (complete the task successfully) or a score of '2' if they failed.

The Trail Making Test (A&B) was also administered (Reitan, 1958).

The Trail Making Test is part of the Halstead-Reitan Battery for assessing brain damage (Jarvis & Barth, 1994). The Part B portion of this test predominately requires the alternation of response patterns, and the switching from one concept to another. Trail A requires the examinee to connect 25 numbers sequentially by placing a line between each number in order and is primarily a warm-up exercise for the Trail B portion of the test. On Trail B, the examinee must alternate in sequence between numbers and letters. For each test, the completion time in seconds is recorded as the participants score. Test-retest reliability coefficients have been reported to be from .64 to .98 for Part A and from .67 to .89 for Part B (Robbins, 1989; Spreen & Strauss, 1998). Factor analysis results show high loading on "cognitive set-shifting", or "switching attention", and on "focused mental processing speed" (Pontius & Yudowitz, 1980; O'Donnell, McGregory, Dabrowski, Oestreicher, & Romero, 1994). More recently, Crowe (1998) parsed the essential elements of the Trail Making Test and derived a series of 11 component measures in a healthy sample of college students using factor analysis for which Part A and B were predicted variables. While Part A was uniquely predicted by visual search and motor speed, Part B was predicted by the visual search and cognitive set shifting or *switching.*

(2) Test of Suppressing Attention: The central features of *suppressing or* selective attention require inhibiting attention to a salient dimension and attending to a nonsalient target dimension. The Stroop Color and Word Test is an excellent example where suppressing attention is required for the successful performance of the task (Golden, 1978). This test consists of reading color words printed in ink of different colors (red, blue and green). The subject is required to name a color of a word while ignoring the actual word. The Stroop Test yields three basic scores: the Word score, the Color score and the Color-Word score. On the first page, the time to read aloud a random sequence of color words in black print on white paper is measured (Word-Score). On the second page, the time to name the colors of an equal number of XXX's is recorded (Color score). On the third page, in an "interference condition," the words are printed in a nonmatching color and the task is to name the color of each word, inhibiting the automatic tendency to read the word (Color-Word Score). For the purpose of this study, although the examinees completed all conditions, the Color-Word score will be the only score used in the analysis of the results. The Stroop test places strong demands on inhibitory systems, which must suppress both the stimulus feature and a strong response tendency (Lezak, 1995; Cohen & Salloway, 1997). Test-retest reliability co- efficients are high, reported in the

range from .83 to .91, and are found to be highly correlated with the PASAT, a task thought to require speeded processing and selective attention (Macleod & Prior, 1996; Spreen & Strauss, 1998).

Another Stroop-like task that was administered is the very simple Go-No-Go test. The Go-No-Go test is part of the Luria's Neuropsychological Investigation battery for assessing brain damage (Christensen, 1979). The subject is asked to place a hand on the table and raise their index finger in response to a single tap while withholding the response to two taps. This test is scored on a pass or fail basis. The Go-No-Go is an interference task that requires the capacity to inhibit an incorrect automatic response in order to allow the correct response to occur (Cohen & Salloway, 1997; Stuss, Shalice, Alexander & Picton, 1995). Weintraub (2000) found that individuals with certain types of attentional problems cannot inhibit raising the finger in response to the "no-go" signal. As with the Luria's Alternating Task, this test is relatively insensitive, so any abnormality of responding is highly pathological (Hodges, 1994; Stowe, 1998). Participants received a score of '1' if they passed (complete the task successfully) or a score of '2' if they failed.

(3) *Test of Sustained Attention and Vigilance*: *Sustained attention* is required when relevant events occur at a relatively slow rate over a

prolonged period of time. Tasks such as the Auditory Signal Detection test from the Kaplan Baycrest Neurocognitive Assessment (KBNA) (Leach, Kaplan, Rewilak, Richards & Proulx, 2000) require the examinee to maintain vigilance throughout the testing trial for successful performance. In the Auditory Signal Detection test, the examinee listens to a tape recording of letters in random order and signals, by tapping the table, each time he or she hears the letter A. The letters are presented at a rate of 1 per second. Scoring is based on the number of target items endorsed minus the number of nontarget letters endorsed with a maximum score of 22 (Leach et al., 2000). The idea is to respond to the target letter A and not the distracters. These types of tests are widely used to measure performance over time and provide a mean of assessing *sustained attention* and vigilance (Cohen & Salloway, 1997). The Auditory Signal Detection shows a test-retest reliability of .67 (Leach et al., 2000).

(4) Test of Sharing Attention: *Sharing* or divided attention is required when two or more unrelated tasks have to be carried out at the same time. The following tests chosen from the Kaplan Baycrest Neurocognitive Assessment exhibit the classic dual-task condition as the examinee is asked to manipulate or sequence information mentally as quickly as possible. For example, in the Sequence test the examinee is

required to hold facts in memory while concurrently reciting other words backwards. This Sequence test consists of 5 tasks. In the first task, the examinee is required to recite the months of the year in the normal sequence, and then secondly the examinee is to recite the months in reverse sequence. In the third task the examinee must selectively attend to the phonetic characteristics of the letters of the alphabet and name the letters that rhyme with the word *key.* The fourth task involves attending to the orthographic features of the letters and requires naming the printed capital letters that contain curved lines. The last task involves asking the examinee to perform the mental computation task of counting backwards by fours. The total score includes the correct number of items from each task with a maximum score of 57 (Leach et al., 2000). Leach et al. (2000) report an average reliability coefficient of .80 for the ages 60 thru 89 years, and a correlation coefficient of .71 with the Wechsler Memory Scale-III attentional measures.

Diagnostic Measures.

(1) The Confusion Assessment Method (CAM). The CAM is a simple method of identifying features of delirium based on the DSM III-R diagnostic criteria, although these criteria fit well also with the current DSM-IV (Inouye et al., 1990). The CAM is a simplified diagnostic

algorithm that focuses on four key features: (1) acute change in mental status with a fluctuating course, (2) inattention, (3) disorganized thinking, and (4) altered level of consciousness. The first feature is usually obtained from the attending nurse and/or chart notes. It is shown by positive responses to the following questions: Is there evidence of an acute change in mental status from the patient's baseline? Did the abnormal behavior fluctuate, tend to come and go or increase and decrease in severity? The inattention feature is shown by a positive response to the following question: Did the patient have difficulty focusing, being easily distractible or having problems in keeping track of what is said? The third feature is shown by a positive response to the following question: Was the patient's thinking disorganized or incoherent, such as rambling or irrelevant conversation, unclear or illogical flow of ideas, or unpredictable switching from subject to subject? The fourth feature requires any answer other than 'alert' to the following question: How would you rate this patient's level of consciousness? The diagnosis of delirium requires both features 1 and 2 as well as either 3 or 4. The CAM ratings for feature 2, 3 and 4 were based on the observations made during an interview at the time of the administrations of the tests. Inter-rater reliability for the four features is very good, with a Kappa of .81. Additionally, it has a reported 94%-100% sensitivity and 90%-95%

specificity (Smith, Breibart, & Platt, 1995).

(2) The Memorial Delirium Assessment Scale. An appropriate instrument used for rating the severity of delirium is the Memorial Delirium Assessment Scale (Breitbart et al., 1997). It is a ten item, four point observer-rated scale, which integrates both objective cognitive testing and evaluation of behavioral symptomology. Scale items assess disturbances in arousal, level of consciousness, memory, orientation, disturbances in thinking, and psychomotor activity. This instrument reflects the new definition of delirium as in the DSM-IV and has been specifically validated to be repeatable at short intervals (Smith et al., 1995). High levels of inter-rater reliability (.92) and internal consistency (.91) have been reported (Breibart et al., 1997).

Procedure

The researcher obtained a list of patients attending the orthopedic pre-admission clinic at the Royal Alexandra Hospital from the unit clerk on a daily basis and arranged times when patients were free from other obligations in order to interview them and to administer tests. The researcher first screened the list of patients attending the pre-admission clinic to select those patients meeting the inclusion criteria.

Patients who met the inclusion criteria were asked in-person if they would like to participate in a study examining the effects of post-operative delirium. After a brief introduction by the researcher detailing the purpose of the study, a 'Letter of Information' (Appendix 1) and a 'Letter of Consent' (Appendix 2) was given to the patient and any attending family member or caregiver. As many older adults have difficulty with vision, a larger font (14) was used to print the consent form and information letter. The consent form followed the Health Research Ethics Board format. The content of the information letter was written at a 7.3 Grade level on the Flesch-Kincaid reading scale. In regards to privacy and confidentiality all participants were assigned a participant number. Data collection sheets contained only the participant number.

Statistical Methods

The SPSS 8.0 package was used to analyze the data with the exclusion of the categorical data analysis where the SAS program was then utilized. An alpha level of .05 was used for all statistical tests. The design of this study required a series of statistical analyses that compared the two groups on changes in attention and cognition over time. In all statistical tests of the research questions, the dependent variables were test scores from all of the psychological testing and the independent variable was the development of delirium as indicated by the results from the CAM. A 3 x 7 x 2 (time by test by group) repeated measures multivariate analysis of covariance (MANCOVA) with the covariable 'education' was used for the seven psychological tests. The repeated measures design is known to be one of the most powerful and efficient research designs because error variance is reduced substantially and fewer subjects are needed (Shaughnessy & Zechmeister, 1990). This procedure was to provide a test of the null hypothesis that the case and control groups have parallel profiles on the repeated measures. The next step involved repeated measures univariate analysis investigating each psychological test across groups on the mean test scores for each time (3 x 2). The analyses were conducted for each four constructs of attention which included switching, suppressing, sustained and sharing attention. The 3MS was analyzed separately through repeated measures univariate analysis investigating each group on the mean test scores for each time (3 x 2). The repeated measures univariate analysis was to provide a test of the null hypothesis that the delirious and not delirious groups performed differently across the three administration times. Please refer to Appendix 3 for all ANCOVA tables.

It has been found that a realistic error rate is maintained if the multivariate test statistic is used for a single decision about the null hypothesis. As such, a significant multivariate result may be followed by a small number of univariate tests to determine which variable have important group mean differences (Finn, 1974; Hummel & Sligo, 1971). In addition, for the two psychological tests with categorical responses, a Logit Loglinear Analysis procedure was utilized. This technique models the log of the frequency in a cell as a function of main effect and interaction terms. This procedure is analogous to the analysis of variance model but with categorical rather than continuous response (Agresti, 2002).

As a follow-up analysis to any significant effects a confidence interval procedure was performed. The 95% confidence interval at each time was examined between each group for no overlap among the intervals.

Ethical Approval

An extensive multiple-stage independent ethical review process was completed before the study commenced. A protocol outlining the characteristics of the population to be studied, any inherent risks, and ethical safeguards to the patients confidentiality was submitted on a standard form to the Chair of the Ethics Committee of the Department of Educational Psychology, under the auspices of the Dean's Office, Faculty of Education at the University of Alberta. In addition, a written ethical submission detailing the title, investigators, description of the project, description of the sample, inclusion/exclusion criteria, informed consent, risks, benefits, privacy, and confidentiality issues was submitted to Health Research Ethics Board (Panel B) of the Capital Health Region in Edmonton, Alberta, Canada .

CHAPTER IV

Results

Participant Characteristics

Table 1 summarizes the means and percentages on patient characteristic variables of age, gender, comorbidity, medication, marital status, vision, hearing and education of the initial 201 patients at Time 1. Table 2 presents the 15 patients who dropped out during the course of the study and summarizes the means of the same patient characteristics. There is a higher level of comorbidity for the individuals who chose to opt out of the study (M = .73, SD = 8.34) versus those individuals who remained in the study (M= .36, SD = 1.3) t = 169.70, $p < .05$. Table 3 summarizes the means and percentages of the patient characteristic variables of age, gender, comorbidity, medication, marital status, and education of the subset of patients who did not develop delirium and were not followed up compared to the 30 patients selected for follow up. The patients who were selected for follow up were significantly older (M = 76, SD = 5.67) than the group who were not selected (M = 71.92, SD =5.01), t= 4.03, $p < .05$. Table 4 presents a summary of the patient characteristics on the matched 30 controls from the group of 156 not delirious patients and the 30 patients who developed delirium. There were no statistically significant differences for education, χ^2 (3, N = 60) = 5.61, p = .13, or marital status, χ^2 (3, N = 60) = 8.36, p = .84, between the two groups. Likewise, no significant differences were found for medication (M= -.27, SD =.69), t= -.39, p = .70, Charleston's Comorbidity Index, (M = .13, SD =.13), t= -.99, p = .33, or visual impairment, χ^2 (1, N = 60) = 3.16, p = .08. However, hearing impairment, χ^2 (1, N = 60) = 3.75, p = .05, almost reached significance. All patients who reported hearing impairments used hearing aids, therefore this deficit is expected to have a minimal effect on test performance.

Table 1.

Description of the Baseline Patient Population (n= 201).

Variable	Mean	Standard Deviation
Age	73.51	5.31
Number of Medications	4.62	2.23
Charlson's Comorbidity Index	0.47	0.54
	Percentage	
Female	57.20	
Impaired Vision	11.44	
Impaired Hearing	18.91	
Education		
Elementary	4.98	
Junior High	10.45	
High School	55.22	
University	29.40	
Marital Status		
Married	56.70	
Widowed	32.30	
Single	4.90	
Divorced	5.90	

Table 2.

Description of Patients Who Withdrew from Study During or After Time 1 (n= 15).

Variable	Mean	Standard Deviation
Age	79.13	6.42
Number of Medications	5.21	3.11
Charlson's Comorbidity Index	.73	8.34

	Percentage
Female	73.30
Impaired Vision	40.00
Impaired Hearing	6.70
Education	
Elementary	20.00
Junior High	33.30
High School	33.30
University	13.30
Marital Status	
Married	60.00
Widowed	26.70
Single	0.00
Divorced	13.30

Table 3.

Description of the 30 Selected Patients Compared to the Remaining 126 Patients That Were Not Selected.

	Mean (Standard Deviation)	
	Selected	Not Selected
Age	76.00 (5.57)	71.92 (5.01)
Medications	4.93 (2.61)	4.53 (3.43)
CCI	.57 (.58)	.36 (1.29)

	Percentage	
	Selected	Not Selected
Female	63.30	56.70
Impaired Vision	10.00	11.10
Impaired Hearing	10.00	19.80
Education		
Elementary	3.30	3.20
Junior High	23.30	5.60
High School	56.70	58.70
University	16.70	32.50
Marital Status		
Married	53.30	57.10
Widowed	46.70	31.80
Single	0.00	4.80
Divorced	0.00	6.40

Table 4.

Description of the Studied Sample.

	Mean (Standard Deviation)	
	Delirious (n=30)	Not Delirious (n=30)
Age	73.83 (4.67)	76.00 (5.57)
Medications	4.67 (2.72)	4.93 (2.61)
CCI	.70 (.47)	.57 (.58)

	Percentage	
	Delirious (n=30)	Not Delirious (n=30)
Female	50.00	63.30
Impaired Vision	0.00	10.00
Impaired Hearing	30.00	10.00
Education		
Elementary	0.00	3.30
Junior High	10.00	23.30
High School	50.00	56.70
University	40.00	16.70
Marital Status		
Married	60.00	53.30
Widowed	20.00	46.70
Single	10.00	0.00
Divorced	10.00	0.00

Incidence of Delirium

Of the 186 participants, 16.13% developed delirium during the course of this study. All episodes of delirium were relatively mild in severity with an average of 10.7 out of a possible 40 points on the Memorial Delirium Scale, with the most severe symptoms occurring during the night. A typical episode involved nighttime occurrences usually on the second or third day post-operatively with associated attempts to get out of bed and escape. Many patients reported perceptual disturbances, either visual, auditory, or olfactory, accompanied by difficulties in arousing the following day. Due to the fact that with delirium a fluctuation of symptoms can be observed throughout a 24 hour period, the assessments were conducted at a time when the delirium was in a less severe stage (agitation, severe drowsiness or hallucinations were absent) and when the participant was willing, usually on the third or fourth day post-operative. The CAM was re-administered on the third and fourth day to ensure that patient was still delirious, albeit a less severe state than during the initial onset.

At the 2-month follow up assessment, no individual from the delirium group presented with symptoms of delirium. As a result, the Memorial Delirium Scale was not administered. All individuals presented as alert, and coherent without any evidence of attentional difficulties or disorganized thinking. For all cases, family members reported a significant improvement since the operation.

Descriptive Results of the Psychological Tests

Performance Levels

Table 5 summarizes the mean scores and standard deviations for the Trail Making, Stroop, Sequences and Auditory Signal Detection Tests for both groups. Table 6 summarizes the percentage of patients that passed on the Luria Alternating Sequence Task and Go-No-Go for all three times. The scores were compared to norms for older adults to determine whether the overall mean scores fell within the normal range of performance. The scores for all attentional tests for both groups at baseline (Time 1) fell within the normal range of functioning, with the exception of the Trail Making Test Part A and B. According to Ivnik et al.'s (1996) norms for older adults, the mean for both groups for Part A and B fell within the 11th -18th percentile range. Examination of the test results from Time 2, show a marked decrease in performance for the delirious group on the Trail Making Test Part B, with the mean score falling below the 1st percentile (Invik et al., 1996). All other test scores for both groups at Time 2 fell within the normal ranges of performance. Similarly, at Time 3, all test scores for both groups including Trail Making Test fell within the normal range.

Table 5.

Means and Standard Deviations of Psychological Test Scores For the Delirious and Not Delirious Group at Time 1, Time 2 and Time 3.

	Delirious (n=30)			Not Delirious (n=30)		
	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
Tests	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Trail Making Test Part A (seconds)	61.30 (38.30)	63.17 (32.85)	54.10 (26.58)	51.27 (24.10)	49.90 (21.08)	48.03 (20.45)
Trail Making Test Part B (seconds)	212.30 (169.81)	303.23 (184.03)	189.43 (162.13)	168.53 (109.79)	165.97 (113.22)	153.10 (109.14)
Stroop Test (T-score)	46.77 (8.32)	45.93 (9.12)	45.23 (8.16)	44.33 (8.24)	44.57 (8.18)	43.80 (7.75)
Sequences (0-57)	45.30 (9.04)	44.13 (9.44)	44.60 (9.41)	47.87 (7.93)	47.40 (8.38)	46.30 (9.10)
Auditory Signal Detection Test (0-22)	18.60 (2.31)	17.93 (2.75)	18.10 (2.58)	18.73 (2.07)	18.87 (2.11)	18.77 (1.96)

Table 6.

Percentage of Patients Passed at Time 1, Time 2 and Time 3.

		Delirious (n=30)	Not Delirious (n=30)
Time 1	Luria's Alternating Task	90.0	87.0
	Go-No-Go Test	93.3	93.3
Time 2	Luria's Alternating Task	76.4	86.7
	Go-No-Go Test	96.7	93.3
Time 3	Luria's Alternating Task	76.7	90.0
	Go-No-Go Test	90.0	90.0

Analysis of the Modified Mini-Mental State Exam

Table 7 summarizes the means and standard deviations of the 3MS scores for all three administrations of the test. Inspection of these test scores reveals a minor decrement in performance for the delirious group at Time 2. However, the mean for both groups at all three time points fell within the normal range, hence no significant impairment was identified either prior to surgery or post-operatively.

Table 7.

Means and Standard Deviations of the 3MS Test Scores.

	Delirious (n=30)		Not Delirious (n=30)	
Time	Mean	SD	Mean	SD
Baseline	90.83	6.18	87.30	8.18
Post-operative	86.33	13.45	88.27	8.15
2-Month Follow-Up	90.63	6.39	88.47	8.67

A repeated measures ANCOVA was conducted looking at the effects of time by group (3 x 2) with the variable education as a covariate. A significant interaction between time and group for the 3MS, $F(2, 57) = 5.23$, $p < .02$, was found demonstrating differences in performance between patients who developed delirium versus those patients who did not develop delirium over the three times of administration. Examination of Figure 5 below shows that while the not delirious group performed relatively consistent over the three times, the 'delirious' groups performance declined significantly at Time 2.

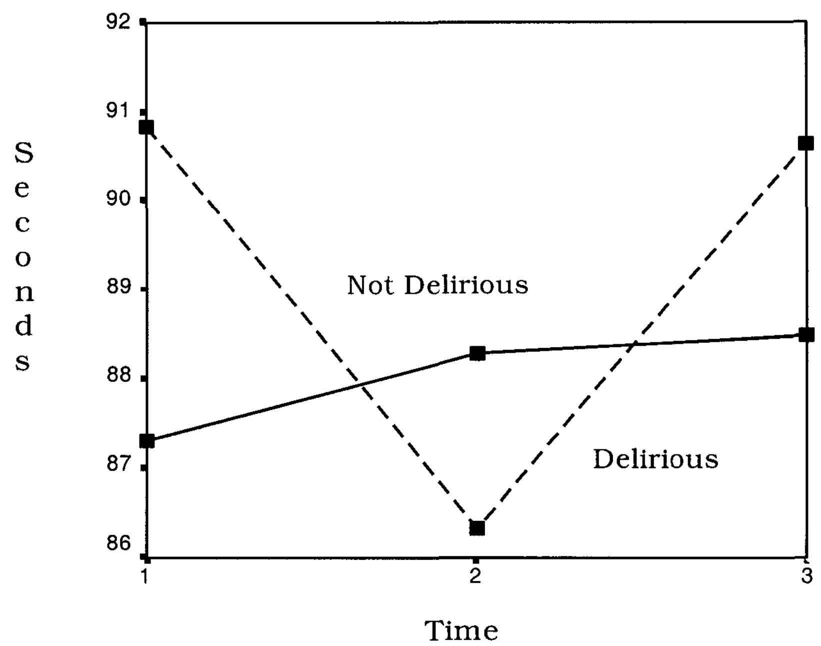

Figure 5. Mean scores for the 3MS over the three times of administration by group.

As a follow-up analysis to the significant interactions effects for time by group, a confidence interval procedure was performed. Table 8 displays the confidence intervals for each time by group for each corresponding test. The 95% confidence interval at each time was examined for each group for no overlap among the intervals. All intervals overlapped at each time demonstrating no significant difference in scores at each time between the two groups. This result can be attributed to the large standard deviation. Further examination of the data set revealed that only 2 of 30 patients from the delirious group showed a significant decrease in their performance. Their scores fell at least three standard deviations away from the mean.

Table 8.

95% Confidence Interval for 3MS Scores at Time 1, Time 2 and Time 3.

Time	Delirious	Not Delirious
1	87.55 - 92.79	85.34 - 90.58
2	81.11 - 88.88	85.72 - 93.48
3	87.09 - 92.45	86.65 - 92.01

Analysis of the Seven Tests of Attention

A repeated measure MANCOVA was used to analyze mean differences in all test scores over the three time periods. The study constituted a 3 (time) x 7 (test) x 2 (group), with repeated measures on the first variable (time). Preliminary analysis identified significant differences in level of education between the delirious and not delirious group. As level of education has been known to greatly influence test performance, the dependent variable ‘education’ was included as the covariate (Lezak, 1995). Table 9 displays the results of the repeated measures MANCOVA. Of primary interest, a significant interaction between Time x Group was found, $F\ (14, 44) = 2.61$, $p = .01$.

The assumptions required for repeated measure analysis include 1) independence of observations; 2) multivariate normality; and 3) sphericity. Regarding assumption number one, the tests were individually administered; as such the observations are independent. Regarding number two, MANCOVA is fairly robust against violation of multivariate normality and any deviation has only a small effect on Type I error (Stevens, 1986). In respect to number three, according to Mauchly’s Test of Sphericity, this assumption was violated, $\chi^2\ (35, N = 60) = 3673$, $p < .05$.

Table 9.

Repeated Measure MANCOVA.

Source	df	F	η^2	*p*
Between Subjects				
Group (G)	7	1.65	.14	.19
Within Subjects				
Time (T)	14	1.77	.36	.08
T X E	14	1.48	.25	.43
T X G	14	2.61*	.45	.01

Note. E= education.
* p< .05

Switching Attention

The MANCOVA results prompted further analysis investigating Trail Making Test Part A & B through repeated measures MANCOVA looking at the effects of time by group (3 x 2) with the variable education as a covariate. A significant interaction between time and group was found, $F\ (2,\ 56) = 10.77$, $p < .01$, demonstrating differences in performance between patients who developed delirium versus those patients who did not develop delirium on both Trail Making Test A

& B. Separate repeated measures ANCOVA was conducted for Trail Making Test Part A and Part B looking at the effects of time by group (3 x 2). No significant interactions were found for the Trail Making Part A, F (2, 56) = 2.21, *p* = 12. However, as shown on Figure 6, significant interaction effects were found for the Trail Making Test Part B, F (2, 56)= 10.40, *p* < .01.

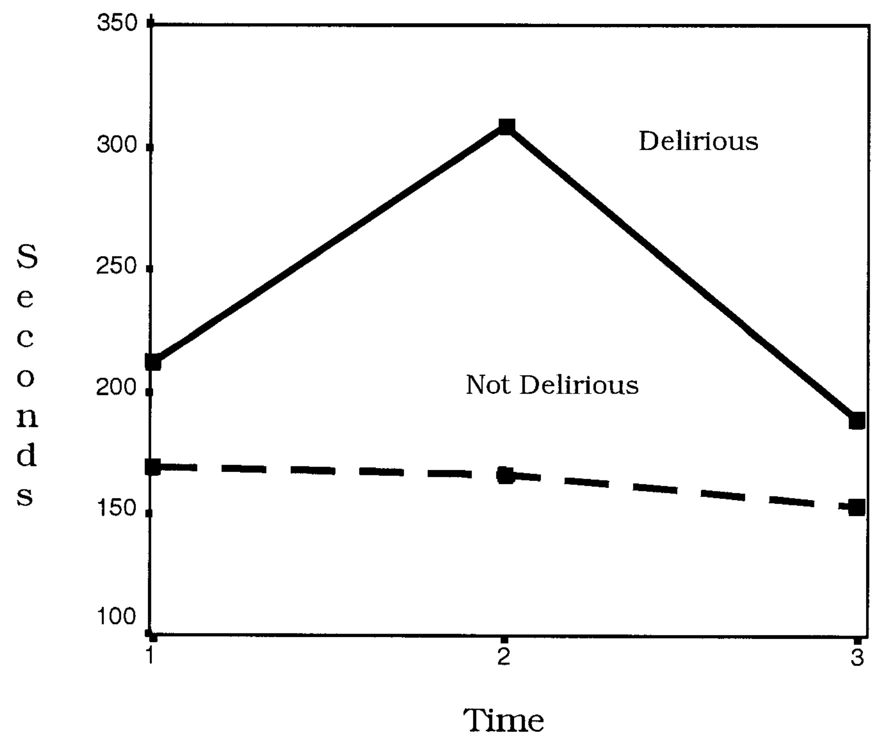

Figure 6. Mean scores for the Trail Making Test Part B over the three times of administration by group.

Examination of Table 5 shows a large initial performance difference between the two groups at Time 1 on the Trail Making Test Part B. Although this difference is not statistically significant at an alpha of .05, (M = 43.77, SE = 36.92), t = 1.19, $p = .24$, it is important to account for this difference in the analysis. As such a repeated measure ANCOVA looking at the effects of time by group (3 x 2) with Time 1 as a covariant was administered. The three dependent time variables for this analysis were created by subtracting the scores from two time pairs. More specifically, variable one was defined as Time 2 Trail Making Test Part B scores subtracted from Time 1 scores. Variable two was defined as the Time 2 scores subtracted from the Time 3 scores and variable three included Time 3 scores subtracted from Time 1 scores. A significant interaction effect was found between group and time for the Trail Making Test Part B, $F(2, 56) = 10.64$, $p < .01$.

As a follow-up analysis to the significant interactions effects for the Trail Making Part B, a confidence interval procedure was performed. Table 10 displays the confidence intervals for each time by group. The 95% confidence interval at each time was examined between each group for no overlap among the intervals. No interval overlap was found at Time 2. The delirious and not delirious group differed in their test performance on the Trail Making Part B only at Time 2.

Table 10.

95% Confidence Interval for Trail Making Test Part B Scores at Time 1, Time 2, and Time 3.

Time	Delirious	Not Delirious
1	159.91- 267.94	112.89- 220.92
2	250.85- 366.37	107.83- 223.34
3	136.31- 240.78	101.75- 206.22

A Logit Loglinear repeated measures analysis was also conducted separately for the psychological test with categorical response, the Luria alternating Task. The interaction effect of group by time was not statistically significant χ^2 (2, N = 60) = 4.32, p = .12.

Suppressing Attention

A repeated measures ANCOVA was conducted for the Stroop test looking at the effects of time by group (3 x 2) with the variable education as a covariate. No significant interaction was found for group by time , F (2, 56)= .39, p = .68.

A Logit Loglinear repeated measures analysis was also conducted separately for the Go- No-Go task, another psychological test with a categorical response. The interaction effect of group by time was not statistically significant, χ^2 (2, N = 60) = .23, p = .89, for the Go-No-Go test.

Sustained Attention

A repeated measures ANCOVA was conducted for the Auditory Signal Detection test looking at the effects of time by group (3 x 2) with the variable education as a covariate. No significant interaction was found for group by time , F (2, 56)= 1.50, p = .23.

Sharing Attention

A repeated measures ANCOVA was conducted for the Sequences test looking at the effects of time by group (3 x 2) with the variable education as a covariate. No significant interaction was found for group by time , F (2, 56)= .89 p = .42.

Summary of Results

In Chapter II the purpose of this study was specified. The questions addressed in this study are reiterated here, followed by a summary of the results.

Research Questions

1. As attentional disturbances are a significant feature of delirium, it is proposed that performances on tasks of attention will show significant deterioration during an episode of delirium. If so, which attentional aspect (sustaining, sharing, switching or suppressing) will show

significant change during the delirious episode?

A repeated measure multivariate analysis of covariance was used to compare the mean scores of the delirious and not delirious group on the seven neuropsychological measures of attention. These measures were Trail Making Test Part A & B, Stroop test, Sequences, Auditory Signal Detection Test, Luria's Alternating Task, and the Go-No-Go test. In addition, a logit loglinear analysis, a method designed for categorical responses was conducted for the Luria's Alternating Task and the Go-No-Go test. Results showed that patients who developed delirium performed significantly worse than those who did not develop delirium on the Trail Making Test Part B, primarily a task of attentional *switching*. No significant differences in performances were found between the delirious and not delirious on the remaining six tests of attention.

2. Will the attentional disturbances persist 2 months after discharge and if so, which specific aspect of attention show the greatest deterioration?

The Trail Making Test Part B was the only test of attention to show a decrease in performance at Time 2. Closer examination of the data (no overlap between the confidence intervals) revealed a significant improvement in performance on the Trail Making Test Part B, 2 months after discharge.

3. Are changes in attention in patients diagnosed with delirium

accompanied by changes in overall cognitive status?

A repeated measures ANCOVA was conducted looking at the effects of time by group (3 x 2) and a significant interaction effect was found. However, closer examination of the data revealed that the interaction effect was caused by only two participants. Further analysis revealed no significant difference in scores at each time between the two groups.

CHAPTER V

Discussion and Conclusion

The purpose of this chapter is to discuss the results reported in the previous chapter, to summarize the conclusions drawn from the research, and to propose further areas of research.

The following discussion will first address how the development of delirium affected the performance on the seven different tests of attention. This will be followed by a discussion on the effects of a delirious episode on global cognitive functioning. Finally, a conclusion will be presented along with suggestions for future research.

Tasks of Attention

The only test of attention which clearly showed significant diminished performance during the delirious episode in comparison to the individuals who did not develop delirium, was the Trail Making Test Part B, which is primarily a task of *switching* attention. One other study confirms this finding. Trzepac et al. (1986) found delirious liver transplant candidates performed worse on the Trail Making Part B test and was as specific and sensitive to the presence of delirium as medical laboratory tests which included serum albumin level and EEG.

The individuals who developed delirium demonstrated significantly longer completion times for Trail Making Part B during the delirious episode, demonstrating a mean average time of 308 seconds compared to 166 seconds for the non-delirious group. The mean score for the delirious group performed within the significantly impaired range ($<1^{st}$ percentile) when compared to healthy adults of the same age (Ivnik et al., 1996). The time needed for task completion is an indicator of the difficulty encountered when trying to make consistent alternations without breaks in responding.

The sensitivity of the Trail Making Test Part B to brain damage is very strong (Lezac, 1995). The Trail Making Test has been shown to be one of the most sensitive tests to the presence of brain dysfunction of any type (Golden, 1979; Van Zomeren & Brouwer, 1994). For example, the Trail Making Test Part B has been found to be discriminating between patients with Alzheimer's, cerebrovascular dementia and healthy controls (Lafleche & Albert, 1995; Barr, Benedict, Tune & Brandt, 1992; Rasmusson, Zonderman, Kawas & Resnick, 1998). Although poor performance points to the likelihood of significant brain dysfunction, it does not indicate whether the problem is one of motor slowing, poor coordination, visual scanning difficulties, or conceptual confusion. As such, the qualitative dimensions of the performance provide crucial information. In this study, the majority of individuals demonstrated predominantly perseverative errors, such that the individual had difficulty in switching from number to letter, at times "freezing" during the exam, consequently sacrificing speed of performance. This "freezing" has been referred to as pathological inertia and has been identified with many disorders that affect frontal lobe or executive functioning disorders (Cohen & O'Donnell, 1993; Luria, 1973). In some instances, individuals were completely unable to complete the task due to frustration. Other cognitive factors may account for the errors observed which may include tracking problems or difficulties in sequencing or not understanding the task.

This study did not replicate findings from previous research demonstrating significant differences in performance between delirious and nondelirious individuals on measures of sustaining, sharing or suppressing attention. O'Keeffe and Gosney (1997) reported that delirious individuals performed more poorly than nondelirious patients on tests measuring sustained (Vigilance 'A' test), and selective attention (Digit Cancellation) as well as attentional capacity (Digit Span). Given that these patients presented with delirium at admission suggests that these patients may have suffered from a more severe level of delirium compared to patients from this study. The differences in performances may be attributed to the severity of the impairment.

However, this conclusion cannot be substantiated as the diagnosis of delirium in the O'Keeffe and Gosney (1997) was reported as a dichotomous variable and was not analyzed by the level of severity.

Foreman (1990) reported the tasks of spelling words backwards and serial subtraction tests of divided and focused attention useful in differentiating individuals who were delirious from individuals who were not. In the present study, a very similar test (Sequences) was administered, however, both groups (delirious and nondelirious) performed similarly. However, in Foreman's study, the tests of divided and focused attention were only statistically significant when combined with other behavioral and cognitive variables. Analyzed alone, these tests did not yield significant results and as such in this respect were in agreement to the findings from this study.

Lastly, Katz et al. (2001) observed significant differences in performances between delirious and nondelirious patients on the Stroop test at baseline relative to the rest of the patients who were hospitalized. This task of suppressing attention did not generate the same results in the current study and this may have followed from our exclusion of patients with cognitive impairment. In contrast, 40% of Katz et al. (2001) sample were cognitively impaired. Interestingly, Katz et al. (2001) did not report differences in Verbal Vigilance test, similar to the Auditory Signal Detection test administered in this study. These results may reflect the tests lower sensitivity to cognitive impairment in comparison to the Stroop. Indeed, the Stroop task is reportedly sensitive to the effects of closed head injuries (Lezak, 1995).

Relation to Models of Attention

According to Stuss et al. (1995), active switching theoretically depends on the deactivation of the currently selected schema and activation of the less active schema. To recall, schemas are one of the three subcomponents of Norman and Shallice's (1986) Supervisory Model which are specialized routines for performing individual tasks that involve well learned perceptual motor and cognitive skills. Each schema has a current degree of activation that may be increased by either specific stimuli or output from other related active schemas.

At times, multiple schemas may be activated simultaneously by different trigger stimuli, creating conflicts if they entail mutually exclusive responses. In order to resolve these conflicts, contention scheduling allows task priorities and environmental cues to be assessed on an individual basis, however, this may not always suffice to handle conflicts when new tasks, unusual task combinations, or complex behaviors are involved. Consequently, the Supervisory

Attentional System (SAS) organizes complex actions and performs novel tasks by selectively activating or inhibiting particular action schemas. More specifically, the preservative errors observed with the delirious individuals on the task of switching on the Trail Making Part B task may stem from temporary failure of the SAS to regulate contention scheduling adequately. In other words, the contention-scheduling was not properly adjusted and consequently inhibited the unused schemata, causing the observed perseverative response.

The Posner and Peterson (1990) model of attention is based upon the consideration of three major functions: 1) orienting to sensory events; 2) detecting signals for processing, and 3) maintaining an alert state. Within this framework, they demonstrated three stages in shifting attention: disengage-move-engage. As suggested by Parasuraman and Nestor (1991), the essential element in switching ability is the *disengagement* component of attention. By extension, the Posner-Peterson model would predict that the perseverative errors observed were due to the inability of the patient to disengage attention from their present focus. While this model facilitates a simple conceptual basis behind the failure to 'switch attention', it cannot account for more complex paradigms, such as how perseverative errors were not observed from the active switching tasks of the Luria Alternating Sequence Task and Trail Making Part A task during the delirious episode. With the Norman and Shallice (1986) model, there is at least some correspondence between the complexity of the task and ability to switch attention. For example, comparatively both the Luria Alternating Sequence Task and Trail Making Part A are simple, less cognitively demanding tasks in comparison to the Trail Making Part B. As such, these tests would theoretically require less interference from the SAS. Furthermore, for the Luria Alternating Sequence Task , switching consistently occurs between only two items; a triangle and a square. At first the SAS must suppress the responses to triangle and energize the square response until the subject becomes more practiced in the new task, therefore requiring the SAS to a lesser degree. In contrast, for the Trail Making Part B, the individual in required to switch attention to many more items; twelve letters and thirteen numbers, extending the practice time required and consequently depending heavily on the SAS for correct responses.

Performance on the tasks of attention representing suppressing, sustained and sharing attention was not influenced by the delirious episode. To clarify each task in terms of the Supervisory Model, suppressing attention also requires the control of the SAS, however, the process involves a sequential 'if-then' test based on a conditional association. For example, for the Stroop test the individual comes to the task with a general schema for making fast motor responses to targets. The individual must monitor responses and perform a controlled 'if-then' logical analysis (e.g, if the color is red, does the word spell 'red' ?). To prevent an incorrect target response the SAS must suppress the responses to the words until the 'if-then' logic can be performed. For sharing or divided attention, while the energizing process within the SAS system is important as seen with switching attention, it is more important that the balance of activation between the two tasks schemata is regulated by monitoring the activity of one and to activate the second in proportion to the activity level of the first.

Lastly, sustaining attention in contrast to switching requires the constant monitoring of the activation of the task relevant schema, and then re-energizing of this schema when the activation is low. For example, for the Auditory Signal Detection Test requires maintaining vigilance throughout the testing for a successful performance of the task (i.e., without constant attention the verbal presentation of the letters, the participant would miss responding to the target letter).

This decrement in performance observed during the delirious episode with the attention switching task of the Trail Making Part B, did not persist at the 2 month follow up. In fact, for both Trail Making Part A and Part B both groups revealed better performance post-operatively.

To conclude, the results from the Trail Making Test Part B, a task of switching attention, tentatively suggests a deficiency or temporary failure of the SAS to regulate contention scheduling adequately during a delirious episode. However, because researchers have not included pre-morbid psychological testing or applied their findings within any theoretical framework, supporting evidence related to this hypothesis is unavailable. Notably, however, Trzepac et al., (1989 &1987) identified impairment on the Trail Making Test, Part B a specific and sensitive test to the presence of delirium in liver transplantation candidates. In contrast, others have found impairments during the delirious episode on the attentional tasks of capacity, selective attention, and sustained attention (Foreman, 1990; Katz et al., 2001; O'Keeffe & Gosney, 1997; Rogers et al., 1989). These studies reflect test criterion impairment, not a comparative analysis from pre-morbid to the individuals morbid performance. Thus, without any base line measurement, it leaves some uncertainty if the performance on the attention tests were in fact affected by the delirious episode.

Global Cognitive Performance

The overall cognitive measure obtained from the 3MS for both groups revealed significant difference from pre-operative to the post-operative administration. However, contrary to previous studies, those individuals who developed delirium did not display any changes in tests scores at the 2 month follow up. This result did not replicate findings from previous research demonstrating that delirium is associated with cognitive decline (Dolan et al., 2000; Katz et al., 2001; Koponen, 1989). The results from this study may have followed from the exclusion of participants with dementia or those with cognitive impairment. Previous studies have found that 15% to 57% of individuals with delirium exhibited predisposing diseases, including Parkinson's, vascular diseases, and Alzheimer dementia's. Consequently, pre-morbid mean MMSE scores were significantly lower than found in this study, and more importantly declines in scores were primarily evident among those individuals with a predisposing brain disease. Not surprisingly, the delirium in those cases was found to be more severe than the delirium observed in the present study (Dolan et al., 2000; Francis & Kapoor, 1992; Koponen, 1989). In addition, contributing to these results is the high proportion of participants who obtained post-secondary education. In this sample, 36.7% of the participants who developed delirium had attained a university level education, and previous research suggested that higher education is related to higher scores on global cognitive tests, and furthermore, is considered a protective factor against cognitive decline (Aevarsson & Skoog, 2000; Alvarado et al., 2002; Meguro et al., 2001).

Conclusion

In summary, Posner (1988), Norman and Shallice (1986), and Stuss et al. (1995) provide a framework for studying attention that specifically identifies a set of processes and elements involved in this cognitive function. It is surmised that attentional deficits in patients with delirium can be comprised of different levels of the cognitive system and with specific components. More specifically five components that are particularly important in attention are: 1) energizing schemata, 2) inhibiting of schemata, 3) adjustment of contention scheduling, 4) monitoring of schemata activity, and 5) control of "if-then" logical processes. It follows that the control of attention can be shown in several tasks of *sustaining, sharing, suppressing* and *switching* of attention.

The CAM instrument selected for the diagnosis of the delirium includes as one of the key features the presence of general inattention, and it does not clearly specify which attentional tasks need to be impaired to meet the criteria. As such, this study sought to determine whether delirium impairs all aspects of attentional functioning or if instead, it affects specific components or elements of attention such as sustaining, sharing, switching or suppressing. The study attempted to elucidate which attentional tasks will show significant change during the delirium and hence clarify which specific attentional components are most affected by the episode. The data indicated that the attentional component most affected by the delirious episode was *switching*, but this was only observed when the psychological test was relatively complex, with the simple less cognitively demanding tasks. It is also important to reiterate that the psychological tests were administered to the patients when the delirious episode was in a less severe stage. As such it is worthy to make the distinction that only the attentional task of *switching* was observed to be impaired during a "mild" episode of delirium.

Performance on each of the tasks examined requires yet more specific assumptions as the analysis of the component-attentional task relationship are far from self-evident. Thus, any single study for testing specific predictions from the theoretical framework seems unlikely to be sufficiently powerful. Although these findings could be of conceptual importance, until sufficient empirical data has been accumulated, the relevant analysis must be considered exploratory, and the findings viewed with caution.

Limitations and Delimitations

Several delimitations of the present research must be acknowledged. First, the results presented may only be generalized to non-cognitively impaired, community-dwelling older adults who experienced hip replacement. This sample was limited to one hospital in the Central Edmonton region, and it is possible that these individuals may be different from patients in other geographic regions. In addition, individuals who are admitted to the general medical units directly from emergency or individuals attending other pre-admission clinics (e.g. other surgical procedures) were not included.

There are several limitations to this study. The tests of attention were administered by the same individual who determined whether patients were delirious introducing possible experimenter bias. The diagnosis of delirium was made between one day post-operative to up to seven days post-operative or just prior to discharge. It must be recognized, however, that cases with short-lived symptoms occurring between clinical evaluations may have been missed and that this may have limited the sensitivity of case identification. As such the group of hospitalized patients diagnosed without delirium may have been 'contaminated' with delirium patients, and the analyses reported here may have underestimated the prevalence of delirium. Other limitations include the limited overall sample size and the small number of patients diagnosed with delirium. Several issues were not addressed in the current research. While memory and language may be affected by episodes of delirium, this was beyond the scope of this research.

The results from the current study are only relevant to the clinical interpretation of the chosen tests of attention. Standard assessment methods used to study attention are not currently based on any theoretical constructs. As such problems in the interpretation of the results can arise due to the differences in the system requirements of different tasks and their different levels of processing. Some required limited perceptual discriminations, whereas others required more complex conceptual discriminations and decisions at a higher level of analysis. The amount of processing required may also relate to the automaticity of the task and the different modes required (e.g manual or vocal). How each of these components and constructs influence task performance and interact with attentional constructs cannot be discerned from current research, therefore these results must be interpreted with this in mind.

An important feature of this study was the use of premorbid psychological test data, which makes this study distinctive when compared to all other published studies examining delirium. This offers the advantage of eliminating assumptions in regards to the impaired performance observed during the delirious episode by comparing the results to baseline measures.

Implications of the Study

The tentative findings indicate that individuals suffering from mild delirium, with the absence of comorbid dementia, may have difficulties with tasks requiring the ability to switch attention. This elucidates an important point. Individuals who are suffering from mild delirium may present with only one attentional deficit, rather than a host of attentional impairments as has been clinically observed and proposed in past literature. As a result, this finding may have important implications in further clarifying and understanding the phenomenology of delirium and in turn offer important clinical utility. For example, the Trail Making Part B can become *part of* the diagnostic procedure to detect those patients suffering from mild delirium. It is suggested that the best cutoff point for minimizing false positives and false negatives for both delirious and non-delirious patients is represented by a cutoff score of 160 seconds. The reader should note, however, that when using this cutoff point 30% of the non delirious individuals fell in the impaired range and 17% of the delirious individuals fell in the normal range.

Given the emphasis on attention deficits in delirium, increased efforts should be directed at training clinicians to recognize attention deficits in a clinical setting. In addition, as previously discussed delirium is often under-recognized and misdiagnosed among primary health care workers. Early detection of delirium is best achieved through routine, systematic and comprehensive assessment of a patient's cognitive status. It cannot be disputed that without assessment there can be no detection or treatment of delirium (Foreman, 1990). Providing an explicit attentional definition of delirium can only aid in the recognition and diagnosis of this syndrome, therefore generating a faster and more efficient diagnosis consequently lowering the risks of developing the long-term effects associated with this syndrome.

In this study, patients with any form of dementia were excluded and the patients presented with a fairly high global cognitive functioning as measured by the 3MS. Results showed no cognitive changes during the delirious episode or at the two month follow-up. This underscores an important finding. A mild episode of delirium does not necessarily predispose an individual to future cognitive decline. In fact, the current results suggest that an individual can suffer from an episode of delirium and suffer no long term effects. Surprisingly, in contrast to other findings, decline in cognitive performance was not observed post-surgery. Conversely, this finding also highlights the association between premorbid cognitive impairment and future cognitive decline, demonstrating the importance of increasing the intensity of medical care of older patients with brain impairment, and how it may serve a role in preventing future deterioration.

These findings raise a number of important issues. Below is a compilation of suggestions for future research.

Suggestions for Further Research

1. Individuals suffering from mild delirium, with the absence of comorbid dementia, may have difficulties with tasks requiring the ability to switch attention. The findings from this study raise the question whether the level of severity of delirium varies with the nature of attentional disturbances. In other words, are there distinguishing attentional characteristics between differing levels of severity of delirium. As such, more work is required to determine whether the specificity of the attentional impairment observed in this study holds true with individuals with more severe delirium or suffering from dementia.
2. Given the relative health of this study population, this work

should be extended to include more impaired populations such as individuals institutionalized or receiving home care.

3. This study included individuals who were scheduled for elective hip placement surgery. It will be important to replicate this study with those patients arriving at the emergency room with a hip-fracture to compare the severity and consequently the effects on the attentional functioning to those scheduled for elective surgery.
4. "He or she was never the same after surgery" is an observation often reported by families and patients at various times. This would imply that observed changes differed from those excepted over the course of the aging process. Due to practical restrains, long-term change was defined here as that occurring only 2 months after surgery. As such more extended studies are warranted with this population.
5. The theoretical constructs of attention are numerous, varied and increasingly complex. Unfortunately, the assessment of the theoretical constructs of attention have not been approached in a systematic manner. The results from this current study are only relevant to the clinical interpretation of the chosen tests of attention. Further research is required to determine both the sensitivity and specificity of various attentional measures, while utilizing common terminology of the attentional constructs within a

theoretical framework. Knowledge of the sensitivity of different measures should improve our ability to evaluate the contribution of various neurologic and nonneurologic factors to the disturbances of attention. Efforts along these lines would substantially advance our understanding of the complex nature of attention.

6. Delirium is a powerful subjective cognitive state which is measured from a strictly objective position. An episode of delirium is conceptualized and operationalized from an outsider's perspective, a perspective of those who do not directly experience the phenomenon. This outside perspective may actually distort reality, and therefore knowledge of this phenomenon (Foreman, 1990). A change in perspective from which this phenomenon is studied is required to obtain a greater understanding of delirium. Both objective and subjective perspectives combined could be used to develop more efficacious methods of prevention and care.

7. The task of switching attention can be considered an aspect of the domain of executive control. A mechanism for 'switching' between response alternatives is thought to be necessary for executive control, such as proposed by Posner's *disengagement* mechanism. Executive control, however, connotes an even broader cognitive

capacity, one that is responsible for top-down metacognitive control over attention. As such, future research can take on a more parsimonious approach, where switching attention may be further explored in terms of the executive control process such as planning.

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APPENDIX 1
REFERRAL HOSPITAL SYSTEM
Royal Alexandra Hospital Site

INFORMATION SHEET

Title of Research Project: The Attentional Deficits of Postoperative Delirium

Investigator: Sylvie Pappas, MSc., C. Psych. (Provisional)
Institutional Affiliation: University of Alberta
Phone Number: 492-3746

Investigator: Dr. Katherine Lechelt, Associate Professor, Residency Program Director
Institutional Affiliation: Glenrose Rehabilitation Hospital
Phone Number: 474-8828

Sometimes after surgeries such as hip replacements, a patient may become temporarily confused. This confusion may come and go during the day. The patient may also have trouble following a conversation, or have difficulty in focusing their attention. At times they may become drowsy or even feel very excited. Most times, these symptoms disappear after a few days. However, there may still be some problems with their attention after they return home. The purpose of this study is to look at the kinds of attention problems the patient may be having during and after becoming temporarily confused.

If you choose to participate in this study, you will be asked to complete different tasks, which would involve looking at how you think and feel. Some responses will be verbal and others will be written. The whole procedure will take no longer than 1 hour. If you were to experience temporary confusion after your surgery, these questions will be repeated at this time in your hospital room. Every precaution will be taken to maintain confidentiality during these proceedings. Even though at this time you may not remember consenting to the study, the investigator will proceed with the assessment.

A 3-month follow-up assessment will be conducted at the Glenrose Rehabilitation Hospital or if the patient is unable to travel to the hospital, the investigator will make a home visit. Family members will be interviewed at

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REFERRAL HOSPITAL SYSTEM
Royal Alexandra Hospital Site

this time and asked to describe the patient's cognitive functioning and any recent cognitive changes. If at any time during the study, the investigators find that the patient requires further assessment and follow-up, thepatient will be seen by the research team geriatrician.

Your health record will also be reviewed to obtain details regarding your age, gender, marital status and current health status.

Benefits:
You will not be paid for taking part in this study. Participating in this study will help contribute to the understanding and course of delirium.

Risks:
There are no known harms in taking part in this study.

Confidentiality:
No one will be allowed to see the results of this test or any other personal information except the investigator above. No patients will be named in written reports or presentation of the study. All information will be kept for a period of five years after the study is done. The information will be kept in a secure area. All information will be held confidential except when professional codes of ethics and or legislation requires reporting of same. If any further analysis is conducted with the study, further ethics approval will be sought first.

Freedom to Withdraw:
You may remove yourself from the study at any time. This action will not affect the care provided to the patient at the hospital. Furthermore, you have the right to decline answering any individual questions within this project.

Additional Contracts:
If you would like further information, please contact Sylvie Pappas at 492-3746. If you would like to know the results of this study, you can request this by calling the number above. If you have any concerns about any aspect of this study, you may contact the Patient Concerns Office at the Capital Health Authority at 407-1040. This office has no affiliation with the study investigator.

Thank you for helping complete this project.

After reading this document, please initial to indicate that you understand its content.

Participant Investigator ____
Royal Alexandra HOSPITAL

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Royal Alexandra Hospital Site
10240 Kingsway Avenue
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Canada T5H 3V9
Tel: (403) 477-4111

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INFORMATION SHEET

Title of Research Project: The Attentional Deficits of Postoperative Delirium

Investigator: Sylvie Pappas, MSc., C. Psych. (Provisional)
Institutional Affiliation: University of Alberta
Phone Number: 492-3746

Investigator: Dr. Katherine Lechelt, Associate Professor, Residency Program Director
Institutional Affiliation: Glenrose Rehabilitation Hospital
Phone Number: 474-8828

Sometimes after surgeries such as hip replacements, a patient may become temporarily confused. This confusion may come and go during the day. The patient may also have trouble following a conversation, or have difficulty in focusing their attention. At times they may become drowsy or even feel very excited. Most times, these symptoms disappear after a few days. However, there may still be some problems with their attention after they return home. The purpose of this study is to look at the kinds of attention problems the patient may be having during and after becoming temporarily confused.

If you choose to participate in this study, at three months following the patient's surgery, you will be asked to describe the patient's cognitive functioning and any recent cognitive changes. This will take approximately 15 minutes of your time. The questions asked will be:

1. Have you noticed if your family member has become more forgetful?
2. Are there any activities or tasks that your family member now requires your assistance with but was independent with before?

Benefits:
You will not be paid for taking part in this study. Participating in this study will help contribute to the understanding and course of delirium.

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Confidentiality:
No one will be allowed to see the results of this test or any other personal information except the investigator above. No patients will be named in written reports or presentation of the study. All information will be kept for a period of five years after the study is done. The information will be kept in a secure area. All information will be held confidential except when professional codes of ethics and or legislation requires reporting of same. If any further analysis is conducted with the study, further ethics approval will be sought first.

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APPENDIX 2:Consent Form

REFERRAL HOSPITAL SYSTEM
Royal Alexandra Hospital Site

Consent Form

Part 1: Researcher Information		
Name of Principal Investigator: Sylvie Pappas, MSc., C. Psych. (Provisional) Affiliation: University of Alberta Contact Information: 492-3746		
Name of Supervisor: Dr.Katherine Lechelt, Associate Professor, Residency Program Director Affiliation: Glenrose Rehabilitation Hospital Contact Information: 474-8828		
Part 2: Consent of Subject		
	Yes	**No**
Do you understand that you have been asked to be in a research study?		
Have you read and received a copy of the attached information sheet?		
Do you understand the benefits and risks involved in taking part in this research study?		
Have you had an opportunity to ask questions and discuss the study?		
Do you understand that you are free to refuse to participate or withdraw from the study at any time? You do not have to give a reason and it will not affect your care.		
Has the issue of confidentiality been explained to you? Do you understand who will have access to your records/information?		
Part 3: Signatures		
This study was explained to me by: __________ Date: __________		
I agree to take part in this study. Signature of Research Participant: __________ Printed Name: __________		
Witness (if available): __________ Printed Name: __________		
I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate. Researcher: __________ Printed Name: __________		

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Appendix 3: Ancova Tables

Repeated measure ANCOVA for the 3MS

Source	df	F	η^2	*p*
	Within Subjects			
Time (T)	2	1.94	.07	.15
TXE	2	1.76	.06	.18
TXG	2	3.71*	.12	.03

Note. E= education.
* p< .05

Repeated measure ANCOVA for the Trail Making Test Part A & B

Source	df	F	η^2	*p*
	Within Subjects			
Time (T)	2	5.99	.18	.04
T X E	2	2.46	.08	.09
T X G	2	10.77*	.28	.00
Test (TE)	1	2.97	.05	.09
TE X E	1	.05	.00	.82
TE X G	1	3.38	.06	.07
TE X T	2	7.45*	.21	.00
TE X T x E	2	2.95	.10	.06
TE X T x G	2	9.34*	.25	.00

Note. E= education.
* p< .05

Repeated measure ANCOVA for the Trail Making Test Part A

Source	df	F	η^2	*p*
	Within Subjects			
Time (T)	2	1.79	.06	.18
T X E	2	1.15	.04	.32
T X G	2	2.21	.07	.12

Note. E= education.

Repeated measure ANCOVA for the Trail Making Test Part B

Source	df	F	η^2	*p*
	Within Subjects			
Time (T)	2	7.41*	.21	.00
T X E	2	3.00	.10	.06
T X G	2	10.39*	.27	.00

Note. E= education.
* $p < .05$

Repeated measure ANCOVA for the Trail Making Test Part B-time 1 as Covariate

Source	df	F	η^2	*p*
	Within Subjects			
Time (T)	2	33.03*	.54	.00
T X TR	2	1365.61*	.98	.00
T X G	2	10.64*	.28	.00

Note. TR = Trail Making Test Part B- Time 1. G = Group.
* $p < .05$