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Communicative Competence In Persons With Aphasia: The Impact Of Executive Function

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Introduction

Aphasia is an acquired language disorder that can affect an individual's ability to comprehend and produce speech as well as to read and write (National Aphasia Association; NAA, 1999). Research examining the relationship between aphasia treatment and non-linguistic cognitive impairments is relatively sparse. Few studies have examined specifically the effects of impaired memory (Hillis & Caramazza, 1987) or impaired attention (Helm-Estabrooks, Connor & Albert, 2000; Murray, Keeton & Karcher, 2006) on aphasia recovery. The few researchers who have investigated the relationship between aphasia and executive function have found that deficits with initiation, planning, and generalizing often result in poor response to language treatment (Beeson, Bayles, Rubens & Kaszniak, 1993; Costello & Warrington, 1989; Lawson & Rice, 1989; Purdy, 1992).

In the current study, executive function and language function were examined in adult stroke survivors with frontal lobe injury and aphasia. The specific purposes of the current study were twofold: 1) To examine the relationship between executive function impairment and the successful use of an augmentative and alternative communication (AAC) device in structured and unstructured settings; and, 2) To examine the relationship between executive function impairment and performance in a non-linguistic functional activity of daily living.

A person with aphasia (hereafter referred to as PWA) may have deficits in one or all of the following language input modalities or output modes: verbal expression, auditory comprehension, reading comprehension, written expression and gestural communication. As a result of the language impairment the individual may participate in speech-language therapy for several months following a stroke. Despite the demonstrated effectiveness of aphasia rehabilitation for many stroke survivors (Basso, 1992; Hinckley & Craig, 1998; Holland, Fromm, DeRwyter & Stein, 1996; Robey, 1994, 1998; Robey, Schultz, Crawford & Sinner, 1999), unfortunately others do not make significant progress in therapy. For example, individuals who are trained to implement various compensatory strategies often do well in the structured treatment room but demonstrate poor carry-over of technique outside the therapy setting. For some stroke survivors, impairment in non-linguistic cognitive skills such as attention, memory, processing speed and executive function may influence their ultimate success in aphasia rehabilitation. Few research studies have been focused on how these non-linguistic cognitive functions may directly influence aphasia recovery. The current research project will focus specifically on the effects of executive function impairment on aphasia recovery.

Executive Function

The executive function system refers to those cognitive abilities involving initiation, planning, sequencing, organization and regulation of behavior (Stuss & Benson, 1986). Other cognitive skills thought to be under the executive function domain are working memory, self-monitoring, inhibiting irrelevant behavior, shifting between concepts and actions, generation and application of strategies, temporal integration and integrating multimodal inputs from various areas throughout the brain (Keil & Kaszniak, 2002). Deficits in executive function typically occur following injury to the frontal lobes and prefrontal cortex, particularly the dorsolateral prefrontal cortex, although damage to other areas may result in similar deficits (Baddeley, DellaSalla, Gray, Papagno & Spinnler, 1997; Fuster, 1997; Lezak, 1995; Stuss, 2006; Stuss & Benson, 1987). In fact, impairments on tests of executive function are often found after diffuse brain damage without evidence of focal frontal injury.

Stuss (2006) notes that the term "executive" function is merely a psychological nomenclature that does not necessarily relate to anatomical structures (e.g., frontal lobes), although he concedes that the frontal lobes may play the biggest role in executive functions. Stuss and Levine (2002) discussed four categories of functions within the frontal lobes: behavioral, emotional, self-regulation and metacognition, and indicated that not all frontal lobe functions are executive (e.g., planning, monitoring, shifting task setting). Recently, Stuss (2006) classified his investigation of the relationship between the frontal lobes and attention as processes of "executive function". This classification was used because lesion studies on attention have shown impairments in different processes secondary to pathology in various frontal regions, thereby indicating fractionation of the "supervisory attentional system", or attentional system that affects conscious control of a task (Norman & Shallice, 1986). In Stuss' (2006) lesion studies he sought to determine if the frontal lobes act as a unitary (global) or independent (fractionated) processor. Task complexity and structure were manipulated to look at frontal lobe processes of fractionation and adaptability. The results of this seminal study will be discussed further below.

Brain Pathology and Executive Function

The executive functions appear to involve multiple processing centers from several regions within the brain. Although the executive functions have been primarily localized to the prefrontal and frontal brain regions, this interactive system also involves connections to subcortical structures such as the limbic cortex, basal ganglia, thalamus, hypothalamus and midbrain, as well as the posterior areas of the parietal and temporal lobes (Cummings, 1993). The prefrontal association cortex is thought to be especially crucial for mediating the various executive functions (Cummings, 1993; Miller & Cummings, 1999). The prefrontal lobes are widely connected to cortical and subcortical regions, thereby affecting behavior by activating, inhibiting and integrating ideomotor and sensorimotor activity (Mesulam, 1990). Due to the prefrontal lobes' dense interconnections with other brain regions and their independence from sensorimotor activities, executive dysfunction often has a global impact affecting many aspects of behavior and personality. Unlike other neural areas and brain networks that process specific types of information (e.g., visual, auditory) or connect this information to other pieces of information, the prefrontal cortex processes "if"-"then" contingencies in a flexible manner that is appropriate to the situation (Powell & Voeller, 2004).

Prefrontal cortex and related subcortical areas. The frontal lobe consists of three primary areas: the premotor cortex, the primary motor cortex, and the prefrontal cortex. These brain regions are tightly connected to each other as well as other cortical and subcortical structures. Subsequently, the prefrontal cortex or the "command and control center" of the brain can be divided into three regions: the dorsolateral circuit, the orbitofrontal circuit and the anterior cingulate circuit. Each of these circuits is part of the larger fronto-subcortical system. The subcortical areas of this system include the basal ganglia, cerebellum and thalamus (Chow & Cummings, 1999).

Subcortical regions. The basal ganglia consists of the striatum (which is composed of the caudate nucleus and putamen), the globus pallidus, and the substantia nigra. The basal ganglia regulates many behaviors and is rich in excitatory and inhibitory neurotransmitters (Mendez, Adams & Lewandowski, 1989). Lesions in the basal ganglia have been associated with impairments in conceptual reasoning, processing speed, planning, sequencing and attention, and have been linked to disinhibition, impulsivity, visual neglect, and aphasia (Mendez, Adams, & Lewandowski, 1989; O'Brien, Wiseman, Burton, Barber, Wesnes, Saxby & Ford, 2002; Rao, Bobholz, Hammeke, Rosen, Woodley, Cunningham, Cox, Stein & Binder, 1997; Weiller, Willmes, Reiche, Thron, Buell, & Rigelstein, 1993).

The thalamus maintains a state of arousal, integrates sensory input, motor behaviors and emotional-cognitive information, and relays this information to the cortex (Stuss & Benson, 1986). Left-sided lesions of the dorsomedial thalamus are often associated with deficits in verbal processing, impaired memory, decreased response initiation and inhibition, perseverative behaviors, poor judgment and poor insight (Baumgartner & Regard, 1993; Sandson, Daffner, Carvalho, & Mesulam, 1991), whereas right-sided lesions have been associated with hemineglect, impaired visuospatial processing and memory deficits. In a study by Graff-Radford, Damasio, Yamada, Eslinger & Damasio (1985), lesions to the left anterolateral thalamus were found to result in impairments in language, visuoperception, construction, temporal orientation and memory. Right-sided lesions in this area produced deficits in nonverbal abilities such as visual memory and construction.

The basal ganglia and thalamus are connected to various cortical areas, such as the frontal lobes, by several corticostriatothalamocortical circuits (Chow & Cummings, 1999; Stuss & Benson, 1986). The role of the striatum and portions of the basal ganglia is to integrate the selection and execution of motor and cognitive functions. There is some evidence that the striatum may play a role in processing emotion (Adolph, 2001). In addition, the functions of these subcortical structures are subserved by a large network of neurotransmitters. These neurotransmitters play a crucial role to the function of the frontal-subcortical circuits. They act as excitatory transmitters as well as inhibitory transmitters (Bronstein & Cummings, 2001).

The cerebellum has recently been recognized as having an important role in regulating the processes involved in language, visuospatial organization and memory, planning, and sequencing, emotional response and personality (Leiner, H., Leiner, A., & Dow, 1991; Middleton & Strick, 1996; Strick, 2004). A strong relationship between cerebellar activity and executive function tasks has recently been supported by research studies. For example, several neuroimaging studies (Berman, Ostrem, Randolph et al., 1995; Karatekin, Lazareff & Asarnow, 2000; Nagahama, Fuykuyama, Yamauchi et al., 1996) have shown that the cerebellum and the dorsolateral prefrontal cortex were activated during the performance of a variety of cognitive tasks that required planning, shifting of set, verbal fluency, abstract reasoning and working memory.

Fronto-subcortical circuits. The fronto-subcortical circuits include the dorsolateral and orbitofrontal circuit. They are recognized as having a crucial role in executive function. The dorsolateral prefrontal cortex is located in the upper and lateral portions of the prefrontal cortex and it receives connections from the parietal and temporal lobes. The parietal and temporal lobes convey information about location, object meaning and emotional status of others (Baddeley, 1986; Cavada & Goldman-Rakic, 1989; Rodman, 1994). The dorsolateral prefrontal area is thought to play a central role in the control, regulation and integration of cognitive activities. In addition, it mediates attention, controls distractibility, allows for mental flexibility, and is involved in memory and generating verbal or nonverbal activity (Chow & Cummings, 1999; Duncan & Owen, 2000; Miller & Cohen, 2001; Stuss & Benson, 1986). Individuals with injury to this system may have trouble staying focused on a task and may be rigid and perseverative in thought (Rowe, Johnsrude, & Passingham, 2001; Smith & Jonides, 1999).

The dorsolateral area has been found to play an important role in working memory, which is the ability to mentally manipulate information or hold it “on-line” (Goldman-Rakic, 1995; Kimberg & Farah, 1993). Several researchers (Zarahn, Aguirre & D’Esposito, 1999; D’Esposito

& Postle, 2002) have utilized the classic delayed response task to assess working memory (Jacobsen, 1935). In the spatial version of this delayed response task, a desirable object is presented and then removed from sight. After a delay the subject is expected to locate the object or to perform a task that requires remembering the spot where it was hidden. To succeed in this task the individual must keep the relevant information in mind (using working memory) while the object is not present. The dorsolateral prefrontal cortex has been found to be activated when encoding information related to the original stimulus, maintaining the information despite time delays and manipulating the information until selecting the appropriate response (D'Esposito & Postle, 2002).

The orbitofrontal cortex is located at the most anterior portion of the frontal lobe and is considered to be the primary area for integrating various sources of information (Zald & Kim, 2001). It is part of the limbic system and involves two subcurcuits: the lateral orbitofrontal subcircuit and the medial orbital subcircuit. The lateral orbitofrontal subcircuit interacts with portions of the caudate nucleus, globus pallidus, substantia nigra, the anterior ventral area of the thalamus and back to the medial orbitofrontal cortex. The medial orbital subcircuit follows a similar path but first projects to the ventral striatum (Chow & Cummings, 1999; Middleton & Strick, 2001). This circuit integrates emotions, memories and impulses to produce appropriate behaviors. Subjects with medial orbitofrontal lesions have been found to be impaired in their ability to empathize with other people (Shamay-Tsoory, Tomer, Berger & Aharon-Peretz, 2003). In addition, injury to this circuit often results in disinhibited, impulsive behaviors. Patients with orbitofrontal lesions often perform well on all neuropsychological tests but may have difficulty with tasks requiring inhibition, switching, discriminating, and maintenance of a set (Moll, deOliveira-Souza & Eslinger, 2003). Thus, the orbitofrontal cortex may be involved in the assimilation of two or more cognitive functions to achieve a high level goal.

The Anterior cingulate circuit. The anterior cingulate circuit is considered a part of the limbic system. Subcallosal areas of the cingulate are involved in the regulation of autonomic nervous system functions (Vogt & Gabriel, 1993). Supracallosal regions of the cingulate have been found to be activated during effortful activities that involve early stages of learning or when increased attention is required (Bradshaw, 2001). Bradshaw (2001) concluded that the supracallosal regions are involved in executive control, divided attention, response monitoring, error detection and the initiation and maintenance of appropriate behaviors. Consequently, injury to the anterior cingulate circuit often results in decreased motivation, apathy, poor attention, flattened affect and hypokinesia (reduced movement). In a study by Miller & Cohen (2001) the anterior cingulate area was found to be involved in the detection of conflicting information (e.g., information that does not conform to expectations) and in the generation of increased activation or arousal that is necessary to address the conflict. Thus, Miller and Cohen hypothesized that the anterior cingulate is helpful for monitoring behavior and guiding compensatory responses.

In summary, the corticostriatothalamocortical circuit (prefrontal cortex and subcortical connections) is a complex unit which controls various executive function processes. Injury to any of the cortical or subcortical components or connecting pathways can result in the various cognitive impairments outlined above.

Prefrontal cortex lateralization. Most cognitive processes appear to be equally represented throughout the prefrontal cortex, however, there is some lateralization of function to the left or right hemisphere. For example, the left prefrontal area is more often associated with language function, whereas the right prefrontal area is associated with visuospatial function or the nonverbal aspects of communication (e.g., pragmatics). For example, reduced verbal fluency and limited spontaneous speech frequently are a result of left prefrontal injury (Grady, 1999), whereas impaired design fluency and compromised spatial working memory are often a result of lesions in the right anterior prefrontal area (Jones-Gotman 1991; Jonides, Smith, Koeppe, Awh, Minoshima & Mintun, 1993; Podell , Lovell & Goldberg, 2001).

Current theories of lateralization of cognitive function have focused on hemispheric localization as opposed to function. For example, Podell et al. (2001) discovered that the right hemisphere was crucial when dealing with novel cognitive situations and the left hemisphere for repetitive, rehearsed activities and strategies including language. In addition the left frontal lobe system was found to be driven by context and working memory. However, the right frontal system has been found to be important in adjusting responses to environmental stimulus changes (Goldberg, Podell, & Lovell, 1994). Interestingly, Podell and colleagues (2001) found that as children become more linguistically proficient many language functions shift from greater right to left hemisphere activation. They also found that, in adults, both verbal and nonverbal tasks shifted from right to left hemisphere activation as task demands became more automatic.

Clinical Models of Executive Function

As pointed out above and as explained by Stuss (2006), the frontal lobes are known to handle executive function tasks of increased levels of complexity. However, the terms “executive function” and “frontal lobe” are not always synonymous since impairments of executive function may occur due to damage in other cortical and subcortical areas with inter-connecting pathways to the frontal lobes. Furthermore, complex tasks of attention and memory may require the involvement of the frontal lobes to act as the main “executor” or “controller” to ensure task initiation and successful completion, especially under novel conditions (Norman & Shallice, 1986; Stuss, 2006). For the purposes of this study the term “executive function impairment” will be used to indicate deficits that may pertain to language, memory or attention due to the inefficiency or absence of neuronal processes that control initiation, maintenance, organization, fluency and flexibility, as well as self-awareness and monitoring of behavior.

Previous researchers investigating the role of the frontal lobes in attention have disputed the concept of a “global attentional process” versus a “fractionated attentional process” (Duncan & Owen, 2000; Godefroy, Cabaret, Petit-Chenal, Pruvo, & Rousseaux, 1999; Stuss, Shallice, Alexander & Picton, 1995). The “global” view proposes that the frontal lobes act in a unified manner to complete an attention task. The “fractionation” theory describes the specific roles of distinct frontal regions and networks to complete various attentional functions depending on the type and complexity of the task. Recently, Stuss (2006) conducted a meta-analysis of the frontal lobe and attention research that provides support for the “fractionation of attentional process” position. In addition, he proposes that the attentional processes are “domain general” thereby implying that they are not specifically linked to just one cognitive domain such as language or perception. Instead, they are thought to be displayed across any and all cognitive domains as dictated by task demands. Stuss argues for a high degree of adaptability within this frontal lobe region, e.g., smooth transition of recruitment of different attentional processes under varied conditions. For example, a more complex attention task consisting of imposed distraction may require activation of the frontal lobes along with posterior lobe activation. Within the frontal lobe there appear to be networks of frontal processes that work together depending on task demand. In addition, these frontal processes may also interact with posterior brain regions in feedforward or feedback manner.

The fractionation and integration theory as it applies to the frontal lobes (Duncan & Owen, 2000; Stuss, 2006) can be applied to language-based tasks that require the central executive for successful completion. Treatment of language deficits can occur in a structured therapy setting, with or without the use of cues, or a non-structured conversational setting. In addition, the individual task complexity can be varied. For example, the therapy task may focus on the complexity of the syntactic structure of an utterance such as, complex, object-cleft sentence versus simple, wh-questions (Thompson, Shapiro, Kiran & Sobecks, 2003) or the semantic complexity of the targeted response such as,typical category exemplars vs. atypical category exemplars (Kiran & Thompson, 2003).

In addition to the recent Stuss models (2006) there are a number of other clinical models that have been used to describe how the brain processes complex tasks (Fuster, 1997; Mateer, 1999; Norman & Shallice, 1986). Most of these models have been constructed by analyzing the various symptoms associated with frontal lobe impairment in the traumatic brain injured population. One such model represents Fuster's (1997) temporal integration theory. On this theory, the prefrontal cortex (PFC) is essential for the formulation and execution of novel plans. In this model, groups of actions along with their goals are represented in neuronal networks within the PFC in the form of abstract schemas. The frontal cortex with its links to the posterior cortical regions is thought to perform three functions: 1) working memory (supported by dorsolateral prefrontal cortical areas); 2) selection and preparation of established motor acts (supported by dorsolateral prefrontal cortical area and the anterior medial cortex); and, 3) inhibitory control (supported by the orbitomedial PFC).

An earlier model of executive function is Norman and Shallice's (1986) model of the supervisory attentional system. In this model, routine and non-routine activities are thought to operate differently and involve specific cognitive processes. For example, in this model tasks that are over-learned or automatic (e.g., dressing, brushing teeth) do not require frontal lobe activation. On the other hand, non-routine tasks, such as employing a new route to get to a desired location, do involve frontal lobe activation. Norman and Shallice described four levels of increasing organization. The first level includes “cognitive or action units” which are basic abilities (e.g., reaching, reading). Schemata or actions that occur through repetition comprise the second level. The third level consists of “contention scheduling”. Contention scheduling enables a person to prioritize the order in which competing activities will be performed (e.g., watching the news on television while talking on the telephone). Finally, the fourth level involves the cognitive system that effects the conscious execution of an activity; that is, the supervisory attentional system. The supervisory attentional system is described as operating when there is no known solution to a specific task (e.g., not knowing how to operate a computer program). Norman and Shallice proposed that executive functions include those abilities that are required to complete goal-directed activities that are not automatic or overlearned.

Mateer (1999) developed a model of executive function that incorporates neuroanatomically- and cognitively- based theories of frontal lobe functioning. Six domains of executive function are conceptualized along with their neuroanatomical correlates:

1) Initiation and drive or starting behavior. Damage to the medial frontal lobe can lead to apathy and inability to initiate volitional behavior. The anterior cingulate is considered important for initiation (Duffy & Campbell, 1994).
2) Response inhibition (stopping behavior). The ability to inhibit automatic responses is crucial for flexible goal-directed behavior. Common problems that are caused by impaired response inhibition include stimulus-bound behavior and perseveration. The

orbitofrontal cortex is associated with the ability to control prepotent (e.g., automatic and over-learned) response tendencies (Dempster, 1993).

3) Task persistence, which is the ability to maintain behavior until the task is complete. It relies on working memory and response inhibition.
4) Organization. The frontal cortex is involved in controlling how information is planned, sequenced and organized, as well as establishing a time sense. These abilities have been found to be related to dorsolateral prefrontal cortex activation (Stuss & Benson, 1986).
5) Generative thinking, fluency and flexibility. The ability to generate solutions to a problem and to think in a flexible manner is paramount to successful problem solving. Frontal lobe damage can result in rigid thinking with subsequent difficulties viewing things from another person's perspective.
6) Awareness and the ability to monitor and modify one's own behavior. Self-awareness is thought to be highly reliant on the prefrontal brain systems and on interactions between the frontal lobe and the right parietal lobe (Damasio, 1994). An individual's self-awareness of deficits in memory, speech and language, or motor function is required if the person is to acknowledge and to respond to errors, or to implement compensatory strategies.

In Mateer's model, these six cognitive domains can operate independently as well as jointly. For example, an individual may present with one distinct deficit area or may exhibit executive function problems from multiple areas.

The evaluation of frontal lobe function has proven to be a difficult yet essential task because the symptoms caused by damage to this area are often tenuously identified (Burgess, Alderman, Evans, Emslie & Wilson, 1998; Lezak, 1995; Keil & Kazniak, 2002; Sohlberg & Mateer, 2001).

However, impairment to the frontal brain system often result in negative consequences to an individual's daily activities of living, social competency, and the skills necessary for sustaining employment.

There are several reasons why frontal lobe functions remain evasive to researchers and clinicians (Burgess, 1998; Keil & Kazniak, 2002; Sohlberg & Mateer, 2001; Stuss, 1993). One reason is that opposite symptoms or behaviors may be present in one individual. For example, the person may exhibit impulsivity during one task while displaying problems with initiation during morning activities of daily living. Another obstacle in pinpointing executive function deficits lies in the method in which they are assessed. Most neuropsychological tests that assess planning, organizing and mental flexibility do so in a laboratory-type setting instead of a real-life setting. In many cases the executive function tests that are used with brain-injured patients may not be sensitive in depicting the commonly associated deficits of initiation, planning, flexibility and self-regulation that are necessary to planning a functional act such as a vacation. Therefore, it is often helpful for clinicians to not only administer standardized tests of executive function but to also implement behavioral questionnaires to help detect symptoms of impaired executive function.

Aphasia and Executive Function

As previously discussed, frontal lobe activation may become more intense and widespread during complex tasks. Linguistic tasks that require spontaneity in an unstructured environment such as, spontaneous generation naming (e.g., generating as many items as possible in a target category) tend to rely more on the executive skills of initiation, organization and planning. However, highly structured tasks such as verbal sentence completion or auditory picture identification rely less on the executive controller. The greater the task demand for executive function skills the more difficult the task regardless of whether it is verbal, non-verbal or non-linguistically based. The severity of one's acquired language deficit may depend on the extent of frontal and fronto-subcortical circuit damage.

Aphasia typically occurs as a result of focal injury to the left fronto-temporal areas of the brain as a result of a stroke, traumatic brain injury or tumor (ASHA, 1997). Injury to the insular cortex or frontal lobes of the brain, involving Broca's area, the supplementary motor area, posterior temporal lobe or connecting neural pathways can result in an expressive or receptive aphasia (Albert, Goodglass, Helm, Rubens, & Alexander, 1981; Nolte, 1993). These language and motor areas of the brain receive their blood supply from the middle cerebral artery and this artery is often found to be occluded in strokes resulting in aphasia. Injury from middle cerebral artery stroke may not only result in aphasia but also may affect executive functioning, given the neuroanatomical reliance of executive function on the prefrontal cortex and connections between the frontal lobes and other brain areas (Keil & Kaszniak, 2002).

The frontal lobes have been found to have a control-monitoring role with language. There often is a failure to apply a strategy despite verbalizing an awareness of it (Levine, Stuss, Milberg, Alexander, Schwartz, & MacDonald, 1998). In some cases individuals may perseverate on an incorrect verbal response despite their recognition of the inaccurate answer (Stuss & Benson, 1986). Deficits of executive functioning may also result in impaired social communication. Turn-taking skills, verbal organization, topic maintenance and social judgment are often impaired as a result of frontal lobe injury (McDonald, 1993).

The assessment of executive function in persons with aphasia is a challenge to the speech-language pathologist and other related rehabilitative specialists for a number of reasons. First, the majority of the executive function tests that are used are linguistically- based making the results invalid for true interpretation within the aphasic population. Several studies have implicated impairments of executive function in persons with aphasia but testing was confounded by language limitations (Beeson, Bayles, Rubens & Kaszniak, 1993; Glosser & Goodglass, 1990; Purdy, 1992). Secondly, a valid test of executive function should require the examinee to perform a novel or non-routine activity. The comprehension deficits that are often concomitant with aphasia might make the understanding of the directions for the novel task difficult. Finally, many of the neuropsychological tests that are used to assess planning, generative thinking and problem solving may be difficult for some persons with aphasia due to a limb apraxia or visuo-spatial deficit. Careful selection of executive function tests and the employment of communication aides (e.g., gesture) may lessen the complexity of the testing situation for the person with aphasia.

In an attempt to alleviate linguistic confounds in testing, Helm-Estabrooks (2002) conducted a study in which she administered her non-linguistically based assessment tool to 13 persons with aphasia secondary to left-hemisphere stroke. She reported that executive function was the most likely cognitive skill to be impaired secondary to brain damage associated with aphasia. In addition, this study showed that the greater the task demand for executive skills, the more difficult the task, regardless of whether the task was linguistically or non-linguistically based.

In another diagnostic study, the executive control skills of 22 left-brain-damaged persons with aphasia (PWA), 19 right-brain-damaged persons without aphasia and 49 healthy controls were compared when performing four modified tests of executive function (Glosser & Goodglass, 1990). The PWA with lesions in the left frontal and prefrontal regions of the brain were more impaired on the executive function tests than the PWA with nonfrontal lesions. The frontal and prefrontal lobe PWA group was impaired on a test of sustained attention and on two tasks that required the generation of a novel response to a single problem or visual pattern. The executive function impairments were not found to be a result of the PWA's language disorder nor of their visuospatial deficits as the PWA with frontal lobe infarcts did not differ from patients with postrolandic lesions or mixed lesions on tests of naming, auditory comprehension, and visual perceptual and constructional abilities. Further analyses provided evidence that the observed attention and problem solving deficits were related to impairments in nonverbal executive control.

Beeson and colleagues (1993) studied the impact of executive function during verbal long-term memory tasks administered to 14 stroke-induced PWA. They tested the hypothesis that the selective impairment of verbal long-term memory in individuals with aphasia due to frontal lobe lesions is due to executive dysfunction rather than a specific impairment of long-term memory. The results of the study indicated that PWA with anterior and posterior brain lesions exhibited low verbal short-term memory and long-term memory scores compared to the matched controls. In fact, there was a more pronounced deficit of verbal long-term memory associated with anterior lesions, and more impairment of verbal short-term memory with posterior lesions. Since both of the groups containing PWA had relatively high object naming scores, the verbal memory deficits were not thought to be reflective of general language impairment. Instead, the posterior lesion group was better at employing retrieval strategies during the time-delayed, verbal free recall tasks. In contrast, the anterior lesion group produced fewer items in the time-delayed, free recall task and was unable to successfully implement retrieval strategies. The authors concluded that the impaired verbal long-term memory scores in the anterior lesion group were associated with deficits of initiation, organization and planning secondary to frontal lobe injury.

In an unpublished doctoral dissertation study by Purdy (1992) the concept of communicative success via alternate means was investigated, and communication performance scores were compared to executive function test scores in 15 nonfluent stroke survivors with aphasia and 12 control subjects. The author hypothesized that many PWA lack the ability to initiate, plan and regulate their communicative performance resulting in poor usage of alternate communication devices. The subjects completed five executive function tests and a structured communication task. The executive function tests included the Porteus Maze (PM) (Porteus, 1959), Tower of London (TOL) (Shallice, 1982), Tower of Hanoi (TOH) (Prescott, Gruber, Olson & Fuller, 1987), Wisconsin Card Sorting Test (WCST) (Berg, 1948) and, the Block Design test from the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981). For each test she obtained accuracy, speed and efficiency scores. The subjects with or without aphasia did equally well on the TOL but the PWA had significantly lower efficiency scores on the PM, BD and WCST, lower accuracy on the BD and TOH, and overall worse performance on 8 of the 10 executive function variables. During a communication board training task, Purdy found that the PWA were able to successfully utilize the board during structured tasks but failed to "switch" or implement it during functional conversation tasks when their initial verbal communication attempt was unsuccessful. The subjects frequently persisted with their ineffective verbal method without apparent recognition that the nonverbal mode offered a more effective communicative means. Final results of the study did not show a correlation between performances on the executive function tests and poor communication modality switching. The author attributed the poor performance on the structured communication board and the high percentage of perseverative errors on the Wisconsin Card Sorting Test to attention allocation deficits. For example, during the communication board tasks the author found that subject performance was influenced by the different types of cueing made available. Therefore, when certain pieces of information were made more obtrusive, more attention was allocated, and performance improved. The high percentage of perseverative errors on the WCST was thought to represent a deficiency of attentional resources necessary for the subject to pull out of their perseverative state and redirect to new or different stimuli.

The relationship between aphasia and executive function has been examined in the relatively few studies mentioned above, but primarily from a diagnostic perspective. Certainly the performance of subjects with diverse aphasic profiles on executive function tests can help us to begin to characterize the interaction between language and executive function. However, many questions regarding the effects of impaired initiation, planning, inhibition, attention, problem solving and self-awareness on the daily, non-routine activities of the PWA remain unanswered.

Treatment of Aphasia in Individuals with Deficits of Executive Function

The ability of the PWA to initiate, select and self-monitor the use of trained compensatory techniques surely has an impact on the success of treatment. Since individuals with frontal lobe injury have been found to have difficulty with self-generation of compensatory strategies (Burgess & Shallice, 1996) it is not surprising that individual's with left frontal lobe strokes often are not successful in transferring learned strategies to real-life situations. While there may be many reasons that account for the lack of ability to generalize in these patients, several researchers have recently emphasized that the contribution of impairments in non-linguistic cognitive skills should be evaluated (Helm-Estabrooks, 2002; Keil & Kazniak, 2002; Purdy, 1992; Reitan, 1988; Van Mourik, Vershaeve, Boon, Paquiers, & Van Harskamp, 1992). Describing each PWA's non-linguistic cognitive deficits may help in predicting treatment prognosis as well as in planning appropriate treatment.

While a few researchers (Helm-Estabrooks, 2002; Keil & Kazniak, 2002; Purdy, 1992) have outlined the detrimental effects of dysexecutive functions on aphasia treatment outcomes, there have not been any studies that look at the effects of simultaneously treating executive function and aphasia. However, Hinckley, Patterson and Carr (2001) investigated the relationship between cognitive abilities (executive function, learning and memory) and specific treatment type (e.g., context-based and skill-based) with 17 chronically aphasic subjects. The goal of the experiment was to improve the subject's ability to order clothing items from a catalogue. The context-based treatment consisted of role-playing during functional activities. The skill-based training focused on training targeted vocabulary words without use of functional context. The subjects in the context-based treatment were trained compensatory strategies such as using notebooks for visual cues. The individuals in the skill-based therapy benefited from cueing hierarchies to improve their word retrieval for words related to the catalogue-ordering task. The results of the study showed that the context-based group showed greater improvement in the trained version of the task but their transfer was not as good as the skill-based group. The skill-based group demonstrated greater transfer across modalities (e.g., speaking to writing) during the catalogue ordering tasks and across general communicative abilities as measured by standardized language tests of functional communicative competence. The authors discussed the role of executive function and working memory during the context-based treatment where compensatory strategies are trained.

In a similar study, Hinckley & Carr (2001) investigated the effects of executive function and problem solving skills in relation to treatment outcomes using the skill-based and context-based therapy approach with 18 adults with aphasia. The context-based treatment group focused on role-playing during a functional catalogue ordering task. The skill-based treatment consisted of a picture naming task involving words often used when ordering from a catalogue. The relationship between cognitive abilities and the amount of treatment time required for the patient to achieve a performance criterion of 90% or greater during three consecutive training probes was also investigated. The training probes for each group consisted of 50% of the items being trained. The authors found that the lower the scores on the executive function tests the longer it took the patients in the context-based group to achieve performance criterion. In addition, the test scores for the context-based treatment group were significantly related to the ability to perform the functional catalogue ordering task six months after therapy. This relationship was not observed with the skill-based treatment group. In other words the subjects with higher executive function skills generally maintained or improved their performance speed (e.g., time to complete each task) on trained and untrained tasks at post-test and at follow-up, while subjects with lower executive function scores required more time to achieve success with the targeted functional task.

There have been several studies over the years that have investigated the generalization of communicative behaviors in PWA (Coelho & Duffy, 1985; Doyle, Goldstein, & Bourgeois, 1987; Hopper & Holland, 1998). These studies have shown that many individuals with aphasia are able to acquire target words, concepts or symbols in a structured therapy setting but are unable to use the trained targets purposefully in natural communicative settings. For example, in a multiple-baseline across behavior study by Doyle, Goldstein and Bourgeois (1987), the effects of syntax training on four subjects with Broca's aphasia were examined. The subjects were trained to produce five models of five sentence types (e.g., imperative transitives/intransitives, wh-interrogatives, declarative transitives/intransitives). Response generalization was measured by training a select number of exemplars of each sentence type and probing with untrained exemplars of those forms. The 5 probe items of each sentence type were developed to mirror the 5 trained sentence types. Photographs, real objects and role playing situations were used, accompanied by verbal prompts similar to those used during the initial training period. Results of the study showed that generalization to novel prototypes occurred for three of the four subjects. Maintenance varied across subjects and sentence types. Generalization across stimulus conditions (e.g., subject describes function of object, imperative transitive; or, subject is told to generate a question to interrogate the examiner, wh-interrogative) was limited for all subjects. The authors concluded that the effects of syntax training procedures may be limited to those specific grammatical forms taught and that generalization of learned forms to novel stimulus conditions is not an automatic result of acquisition. That is, there may be few stimulus characteristics common to both situations and the opportunities to respond with a specifically trained form may be significantly reduced.

Coelho and Duffy (1985) conducted a single-subject treatment study of nonfluent aphasia in a single subject. The subject was trained to use several signs from the American Sign Language system within his home during three types of communicative tasks: a) communicating a message about a picture; b) communicating a printed message; and, c) conversation. As the communicative setting became less structured and spontaneous the subject's number of message attempts decreased. In other words, he had more success using the trained signs to describe a target picture than initiating use of the trained sign in conversation. In addition, he utilized more of the trained signs during the picture description and printed message task than during unstructured conversations. During the conversational tasks the subject tended to rely on inherent signals such as pointing, pantomiming or tracing a shape in the air. Message success or how well the listener was able to decode the intended message was higher with the picture description and printed message tasks compared to the conversational tasks.

Hopper and Holland (1998) trained two individuals with aphasia in how to effectively communicate in simulated emergency situations using a situation-specific training model. The situation-specific technique consisted of training the subjects to correctly name the targeted emergency situation depicted in 10 picture-items to an unknown telephone listener. The ten pictures were divided into two sets. One set consisted of six pictures to be used in training and the other set of four untrained pictures was used to assess response generalization. Both individuals improved within the ten designated treatment sessions; however, subject 1 had limited generalization of the four untrained items, whereas subject 2 demonstrated successful response generalization of the four untrained items. Both subjects had high levels of response accuracy at four weeks following treatment. The subjects' success in therapy and ability to generalize responses to the untrained emergency naming task may have been due to the type of treatment utilized, more specifically one that places less burden on the individual's executive function system. That is, the situation-specific treatment technique utilized in this study focused on training a specific targeted verbal response within context, unlike process-based treatment approaches which focus on training strategies and responses that can be applied to a variety of situations. In the situation-specific training the subject does not have to independently employ the executive skills of organization, planning, generation and application of strategies.

Treatment of Aphasia in Individuals with Concomitant Attention Deficits

In Stuss's frontal lobe-attentional model (2006), he classifies attention skills within the executive function domain because of its reliance on frontal activation. Complex attentional tasks were found to activate larger areas within the frontal lobes as well as to recruit additional help from supporting cortical and subcortical networks. The frontal lobes were found to easily adapt as task complexity increased by smoothly recruiting different cortical processes under varying conditions.

Attention is a multidimensional cognitive skill that consists of a number of basic (e.g., arousal and sustained attention) and complex (e.g., selective and divided attention) functions (O'Donnell, 2002). Previous studies utilizing both linguistic and nonlinguistic stimuli have shown that any or all of these basic and complex attention processes can be compromised in PWA (Erickson, Goldfinger & LaPointe, 1996; Murray, 2000; Murray, Holland & Beeson, 1997; Sander, 1998; Tseng, McNeil & Milenkovic, 1993; Van Zomeren & Brouwer, 1994).

Sustained attention or vigilance refers to the ability to maintain a consistent behavioral response to infrequent stimuli (e.g., looking for a target letter on a computer screen while letters are sporadically flashed across the screen). Arousal refers to the physiological correlates of vigilance, such as heart rate, blood pressure and salivary cortisol level. Selective attention allows one to focus and prioritize certain stimuli while inhibiting irrelevant, competing stimuli (e.g., listening for words belonging in a target category while competing tonal stimuli are presented). Divided attention enables an individual to attend and respond simultaneously to multiple stimuli (e.g., listening to a lecture while taking notes).

The previous research conducted with the aphasic population has lead to the development of an attentional processing model of aphasia whereby some of the aphasia symptoms are thought to be a product of or exacerbated by attention deficits (Connor, Albert, Helm-Estabrooks & Obler, 2000; McNeil, Odell & Tseng, 1991; Murray, 1999, 2002). Attention deficits have been found to affect language performance in many PWA. For example, the manipulation of the stimulus presentation rate (e.g., fast presentation) and physical placement of a stimulus (e.g., in far right visual field) have been found to adversely affect performance in persons with aphasia (Brookshire, 1971; Coslett, 1999). In addition, PWA have demonstrated significant disruptions in lexical-semantic and syntactic aspects of auditory processing (Murray, Holland & Beeson, 1997; Tseng et al., 1993) and lexical-semantic, syntactic and pragmatic aspects of verbal output (Murray, Holland & Beeson, 1998) when the attentional demands of language tasks are increased (e.g., with the presence of distractors).

Another type of attention impairment sometimes displayed by individuals with aphasia is right neglect or inattention to stimuli presented on the right side of the body. Right neglect may confound a PWA's performance in a variety of language tasks such as picture naming, reading, writing, and following commands that involve identifying items on the right side of the body. In a study conducted by Coslett (1999) the language performance of PWA was improved when the language stimuli was presented in the left versus right hemisphere. Likewise, Crosson (2000) found that PWA demonstrated more success in a naming treatment protocol when the stimulus pictures were presented in the patient’s left space or when an action was performed with their left arm while naming.

While the attentional model of aphasia proposes that attention deficits can intensify aphasia symptoms it does not necessarily insist that all aphasia symptoms can be reduced to or explained by attention deficits. Instead, it emphasizes the importance of determining which behaviors might be the result of attentional versus pure linguistic factors.

There have been several studies indicating that attention deficits are commonly associated with chronic aphasia (Erickson, Goldfinger & LaPointe, 1996; Murray, 2000; Tseng, McNeil & Milenkovic, 1993). However, there are relatively few studies that have investigated the potential effects of treatment of attention impairments in conjunction with traditional aphasia therapy

(Helm-Estabrooks, Connor & Albert, 2000; Murray, Keeton & Karcher, 2006; Sturm & Willmes, 1991; Sturm, Willmes, Orgass & Hartje, 1997). An exception is an earlier study conducted by Sturm and Willmes (1991) in which they administered a series of computerized attention tasks to 27 left-hemisphere brain damaged individuals with aphasia and 8 right-hemisphere brain damaged individuals. The subjects participated in 14 attention training sessions in which they responded as quickly and accurately as possible by pressing a response key to varied colored visual target signals or differently pitched acoustic signals presented via a computer. In one of the computerized training programs the subjects indicated their response by pressing a key pad when a target colored symbol matched one of the symbols from a multiple choice set of four configurations. In addition, a battery of 10 psychometric tests was utilized to assess the efficacy of the training as well as generalization to non-treated functions. The battery consisted of special test versions of the training tasks that differed from the training procedures with respect to type and speed of stimulus presentation, attention tests for alertness, selective attention and vigilance, and unrelated cognitive tasks such as reasoning and identification of verbal similarities. Results of the study showed that both treatment groups improved on the trained attention tasks but there was only modest generalization of the training effects to more general cognitive functions as measured by the verbal and non-verbal cognitive tests. The authors hypothesized that the lack of generalization, especially for the cognitive tasks, may have been the result of the type of focal lesion presented by the subject in the study. For example, the PWA had low scores on two verbal tests in the psychometric test battery and the right hemisphere brain damaged subjects performed poorly on the two non-verbal reasoning tasks. The language and non-verbal reasoning impairments were thought to mask the potential benefits of the attention training tasks. In addition, modest generalization to untrained attention domains was observed only when the computer tasks were more “functional” (e.g., a photographic safari task in which subjects pressed a key to take photos of certain animals, people or objects) and when basic attention functions such as arousal and sustained attention were targeted. The subjects with aphasia had more difficulty with complex attention tasks requiring a quick choice between several stimuli and response alternatives. The authors believed that this finding supported the hypothesis that the left hemisphere is involved in more complex reaction tasks (Dee & van Allen, 1973).

More recently, Helm-Estabrooks, Connor & Albert (2000) studied the effects of treating attention deficits using their Attention Training Program (ATP; 2000) with 2 chronic mixed nonfluent individuals with aphasia as measured by the Aphasia Diagnostic Profiles (ADP: Helm-Estabrooks, 1992). After two months of twice-weekly therapy both patients exhibited improvements on the ATP tasks as well as improvements in nonverbal reasoning and modest gains in auditory comprehension. However, after 23 weeks post-therapy their auditory comprehension improvements had deteriorated although both patients retained their nonverbal reasoning gains.

In a similar treatment study, Murray, Keeton & Karcher (2006) utilized the Attention Process Training-II (Sohlberg, Johnson, Paule, Raskin & Mateer, 2001) to test the effects of an attention treatment program on the cognitive-linguistic recovery of an individual with mild conduction aphasia and attention and working memory deficits. The investigators found that with treatment the subject improved on the trained attention tasks but made only small gains in auditory comprehension, attention for untrained tasks and memory. Subsequently, neither the PWA nor his wife reported observable improvements in daily attention or communication skills.

As noted above, previous studies that have investigated the effects of attention training programs on aphasia indicated that improvements may be limited to trained attention skills whereas gains in other cognitive-linguistic functions are less likely. This may be due to the complexity of the individual's attention deficit (e.g., the presence of impairments in selective and divided attention) or perhaps the presence of additional cognitive impairments (e.g., working memory and processing speed).

Treatment of Aphasia in Individuals with Concomitant Memory Deficits

As previously outlined, attention and executive function skills require extensive frontal lobe activation when task demands are complex. Sufficient short-term and working memory may also be necessary for completion of these complex tasks. In addition, complex language tasks such as verbal word fluency and spontaneous picture description require frontal lobe involvement for task initiation, attention, generation, and organization. The various types of memory discussed in the literature will be outlined in this section with examples of tasks of assorted complexity that have been used to measure each memory type.

Many theories of memory consider both the structure of the memory system and the processes that operate within that structure. 'Structure' refers to the way the memory system is organized and 'process' refers to the activities occurring within the memory system. Memory theorists (e.g., Atkinson & Shiffrin, 1968) have described the basic structure of the memory system and labeled it the "multi-store approach". In the multi-store approach three types of memory stores are proposed: sensory stores, short-term store and long-term store. The sensory stores are modality specific (e.g., vision, hearing) and they hold information very briefly. A short-term memory store is of very limited capacity (only about seven digits can be remembered) and is highly fragile as any type of distraction can cause forgetting of the target item(s). A long-term memory store has an essentially unlimited capacity and can hold information over extremely long periods of time (e.g., all learned experiences, including language and rules of language).

Baddeley and Hitch (1974) proposed that the concept of short-term memory be replaced with that of working memory. Working memory is thought to consist of several, short-term buffers or temporary storage components that temporarily hold and manipulate information and an executive system that directs and monitors information storage and manipulation within the buffers (Baddeley, 2003; Kane, Bleckley, Conway & Engle, 2001).

Memory processes affect the likelihood that a targeted piece of information will reach long-term storage. Attentional and perceptual processes at the time of learning are thought to determine what information is stored in long-term memory (Craik & Lockhart, 1972). Rehearsal, cueing, and the determination of distinctive features or personal relevance are examples of processes that strengthen the transfer of information to long-term memory.

The study of amnesia has lead to the development of new ways of looking at memory. Research on amnesic subjects has been of value in testing existing theories of long-term memory. Theorists are increasingly inclined to use memory data from both amnesic patients and normal subjects in the development of their memory theories. The assumption that there is a single long-term memory system has been rejected by most theorists (Cohen & Squire, 1980; Schacter, 1987; Tulving, 1972; Vargha-Kardem, Gadian, Watkins, Connelly, Van Paesschen & Mishkin, 1997).

Tulving (1972) was the first to draw a distinction between episodic and semantic memory. He defined episodic memory as one's memory for events or episodes occurring at a given time or place, and semantic memory as one's general knowledge about the world or storage of factual information. Schacter (1987) studied the effects of conscious (explicit) and unconscious (implicit) awareness on memory performance with amnesic patients. Amnesic patients were found to have impairments with explicit memory (e.g., cued recall tasks) but intact implicit memory (e.g., word completion or sentence completion tasks). Cohen and Squire (1980) proposed a memory system theory based on the distinction between declarative knowledge and procedural knowledge. Declarative knowledge refers to knowing “what”, and covers both episodic and semantic memory. Procedural knowledge corresponds to knowing “how”, and refers to the ability to perform skilled actions such as, how to ride a bicycle without the involvement of conscious recollection. Declarative memory corresponds closely with explicit memory and procedural memory to implicit memory.

For purposes of this study, a brief review of some of the research associated with long-term, short-term, and working memory, as it relates to the study of aphasia, will be discussed. Researchers have been investigating memory function, especially long-term and short-term memories, in adults with aphasia for over three decades. Therefore, there is sufficient evidence indicating that many PWA have impaired memory systems in addition to their language comprehension and production impairments (e.g., Beeson, Bayles, Rubens, & Kazniak, 1993; Burgio & Basso, 1997; Caspari, Parkinson, LaPointe & Katz, 1998; DellaBarba, Frasson, Mantovari, Gallo, & Denes, 1996; Francis, Clark, & Humphreys, 2003; Gordon, 1983; Haarman, Just & Carpenter, 1997; Martin & Feher, 1990; Martin & Saffran, 1997; Risse, Ruben, & Jordan, 1984; Mayer & Murray, 2002; Warrington & Shallice, 1969). For example, both Risse et al. (1984) and Beeson et al. (1993) conducted studies in which they asked PWA and normal age matched controls for immediate recall of a word list during ten learning trials and then after a 60-minute delay after the last learning trial. Words recalled on later learning trials and after the delay were believed to be stored in long-term memory. Both studies found that patients with anterior (e.g., frontal lobe, anterior deep white matter) lesions had more severe verbal long-term memory deficits than when compared to those patients with posterior (e.g., parietal lobe, superior and middle temporal gyri) lesions. Beeson and colleagues (1993) utilized a guided semantic cueing strategy whereby verbal category cues were used if a subject failed to freely recall items from a category list (e.g., "which one was the flower?"). The authors found that even with cueing the patients with anterior lesions demonstrated poor retrieval from their long-term memory stores. However, with cueing, patients with posterior lesions improved to the level of the normal control group. Executive function deficits were thought to be the cause of the long-term memory impairments in the subjects with anterior lesions. In contrast, a study conducted by Burgio & Basso (1997) found both verbal short and long-term, as well as, spatial short and long-term memory were impaired in left hemisphere damaged patients, regardless of the type of aphasia or site of lesion. Similarly, DellaBarba et al. (1996) found that long-term memory abilities in aphasia were not dependent on lesion site but instead on whether the individual could make semantic associations among the items to be recalled.

Some studies in aphasia have reported impaired short-term memory for both auditory and visual-verbal material and have identified factors that may influence the incidence and severity of these deficits. For example, Martin and Feher (1990) found that subjects with fluent aphasia, like the non-brain injured subjects, were better at recalling easy-to-articulate (e.g., words without consonant cluster) one syllable words, versus difficult-to-articulate (e.g., words containing a consonant cluster) one syllable word lists, thereby, indicating the use of an articulatory rehearsal process. Conversely, ease of articulation had no effect on the short-term memory performance of their subjects with nonfluent aphasia (indicating that they were not rehearsing). The authors concluded that short-term memory deficits in aphasia may reflect problems with articulatory rehearsal or may be the result of a reduced capacity for phonological representation.

Martin and Saffran (1997) found that on word list recall tasks, individuals with aphasia with phonological deficits showed a strong primacy effect (e.g., recall of words from the beginning of a list indicating storage at the semantic level), whereas PWA with semantic deficits showed an enhanced recency effect (e.g., recall of words from the end of a list, indicating storage at phonological levels). The authors concluded that different memory profiles reflected different memory strategies. The subjects with phonologic deficits relied more on the integrity of their lexical-semantic system, whereas subjects with semantic impairments were more dependent on their phonological systems.

Researchers have also examined working memory skills in PWA. For example, Caspari et al. (1998), found a relation between working memory, as measured by modified listening and reading versions of the Daneman and Carpenter's (1980) Reading Span Task, and performance on standard reading and aphasia tests in subjects with varying levels of aphasia severity. The authors proposed that the ability of PWA to comprehend language was predictable from their working memory capacities.

The working memory system is thought to have a crucial role in the short-term storage and manipulation of graphemic (printed letters) representations before the actual selection of letter(s) and initiation of writing occurs. Studies have shown that individuals may have impairments at this graphemic buffer level resulting in an abnormally rapid rate of decay of information (Miceli, Silveri & Caramazza, 1985; Hillis & Caramazza, 1995). Damage to the graphemic buffer will affect all writing tasks including written naming, writing to dictation, spontaneous writing and delayed copying. One of the hallmark features of deficits to the graphemic buffer is its effect on word length. Shorter words tend to be more easily written as opposed to words of greater length due to the increased demand on the storage capacity or working memory system for longer words. Damage to this graphemic buffer tends to result in the loss of information about the identity and serial ordering of letters. Therefore, spelling errors may consist of letter omissions, substitutions, transpositions and additions. Hillis and Caramazza (1987) conducted a single-subject study for the treatment of impairment at the graphemic buffer level in an individual with dysgraphia. They describe the case of a subject with a mild expressive aphasia and persistent spelling impairment, or dysgraphia. The subject's single-letter spelling errors primarily occurred at the ends of words during all spelling tasks, indicative of damage to the graphemic buffer. Due to the fact that the subject had a preserved graphemic output lexicon (graphemic or letter representation) and sound-to-letter conversion system, the authors selected a treatment that could utilize both skills. The subject was trained to recheck the spellings of printed words and to self-correct them when able. Treatment strategies included focusing on the ends of words and sounding out each word when attempting to write. The subject was responsive to this treatment method to the point where he was able to self-correct spelling errors in written narratives. This study depicts the successful use of compensatory strategies for the treatment of working memory deficits in an individual with dysgraphia.

Recently, investigators looked at the effects of treating working memory deficits in adults with aphasia and achieved mixed results (Francis, Clark, & Humphreys, 2003; Mayer & Murray, 2002). Francis et al. (2003) used a sentence repetition task for treating working memory in a 69 year-old female with auditory comprehension deficits at the sentence level secondary to aphasia. During the course of her 12-week treatment the length of the sentences that were repeated gradually increased from 2-word constructs to 6-7 word, complex constructs. After the treatment phase the authors reported improvements in auditory memory tasks such as digit span backwards (but not digits forward) and sentence repetition. In addition the subject's sentence comprehension improved which was the initial goal of the treatment program. Francis and colleagues concluded that the subject's working memory improved as a result of the treatment course but her short-term memory (e.g., storage component only) did not. To explain the improvements with the working memory system the authors provided three sources of evidence: 1) the improvement with digit span backward but not forwards. Backwards digit span is believed to rely on working memory whereas forward span relies more on passive verbal short-term memory (Turner & Engle, 1989); 2) there was no change in nonword repetition which is thought to rely on verbal short-term memory (Gathercole, 1995); and, 3) the improvement in sentence repetition favored the recall of verbs (noun recall was intact at pretesting) which suggests the use of a strategy to focus attention on the "important" or "content" words of the sentence. In addition, there was no recency effect in sentence repetition after treatment, which might be expected if short-term memory (as opposed to working memory) had improved. Francis and colleagues concluded that the results of their study offered some proof that working memory deficits can be helped through a direct treatment approach and that specific treatment of working memory may help comprehension in some patients.

Mayer and Murray (2002) conducted a single-subject study in which they treated a working memory deficit in a 62-year old male with fluent aphasia and acquired alexia secondary to a left-hemisphere CVA. An alternating-treatment-plus-baseline design was used. The subject received two treatments within each 2-hour session and the order of treatments was randomized across sessions. The two treatments used included one that consisted of a modified version of Beeson's (1998) Multiple Oral Rereading, which addressed text-level reading rate and comprehension, and the second treatment focused on the working memory deficit. The working memory treatment tasks consisted of an experimental cognitive treatment, which the authors referred to as

Sequenced Exercises for Working Memory (SEW). The SEW required that the subject perform two tasks: 1) judging the grammaticality of a sentence and, 2) identifying the semantic category that matched the final word of the sentences in a set with 2-6 sentences per set. Task complexity became greater by increasing the number of semantic categories to be identified for each set of sentences. Results of the study, based on post-treatment testing, showed improvements in reading speed and accuracy, processing speed, lexical-semantic working memory abilities and reading comprehension up to grade 12 levels of complexity. However, there were negligible gains with reading comprehension of high level complex sentences and paragraphs. There were no significant differences in the rate or extent of changes in reading skills after treatment with either the modified Multiple Oral Rereading or Sequenced Exercises for Working Memory. In other words, both treatments resulted in similar changes in the subject's reading of the probe passages. Despite the somewhat encouraging post-treatment data the subject did not report functional gains in his reading ability (e.g., with newspapers or books). To explain the lack of generalization, the authors suggest that neither treatment mode (modified MOR, SEW) was sufficient to correct the subject's underlying visual and selective attention deficits. However, they point out that the study provides evidence that treatment of underlying cognitive impairment (e.g., working memory) may facilitate some aspect of reading (e.g., rate).

Treatment of Executive Function Deficits in the TBI Population

Acquired traumatic brain injury (TBI) can adversely affect communicative competence. While there is often only a small reported incidence of aphasia in TBI patients (e.g., 1.7% to 2.2%; Heilman, Safran & Geschwind, 1971; Constantinovici, Arseni, Iliescu, Debrota & Gorgia, 1970) the majority of the discourse deficits appear to be related to impairments of pragmatics (Nicholas & Brookshire, 1995; Chapman, 1997). Discourse processing involves the interaction of linguistic and related cognitive abilities such as, organizational ability, memory, executive function and attention, and is often impaired in persons with severe brain injury. This difficulty often results in poor retention of information relayed in conversation and an inability to sustain organization of the information. Thus, both oral and written expression may be incoherent or fragmented (Chapman, Watkins, Gustafson, Moore, Levin & Kufera, 1997; Schwartz, 1995). The exact relationship between non-linguistic cognition and language in the TBI literature continues to be explored. However, most of the evidence supports non-linguistic cognitive components as the primary source of communication breakdown with this population (Hagen, 1981; Prigatano, 1986; Schwartz, 1995; Snow, Douglas & Ponsford, 1998; Turkstra & Holland, 1998; Ylvisaker, 1992).

There have been several studies that have examined the effect of treatment for pragmatic language disorders with the TBI population. One such study was conducted by Snow, Douglas and Ponsford (1998) in which they followed the conversational discourse abilities of 24 individuals with traumatic brain injury for a minimum of two years post-injury. The authors found that pragmatic discourse deficits persisted over time. In fact, in approximately one-third of their sample the discourse skills deteriorated. Snow et al., (1998) attributed this finding to associated deficits in executive function and reduced social support for the TBI individuals. More specifically, the relationship between the incidence of executive function impairment and poor discourse skills were thought to be substantially accounted for by underlying deficits in executive skills such as planning, organizing and self-monitoring. Consequently, the subjects were verbose, disorganized and tangential during conversational speech.

Impairments of executive function such as planning, initiating and regulation of behavior are commonly associated with injury of the frontal lobes and their widespread neural connections and these impairments can have a negative impact on communication abilities. For example, the TBI individual may have reduced topic maintenance and turn-taking and incidences of inappropriate verbal comments (McDonald, 1993; Sohlberg & Mateer, 2001). Patients with left frontal brain damage may have difficulty implementing internal and external verbal mediation during rehearsal or actual task performance (Cicerone & Giacino, 1992; Luria, 1982; Luria, Pribram & Homskaya, 1964). Skills-based training is one method that has been utilized for addressing the communicative deficits of traumatic brain injured patients with associated executive function and memory impairment (Brotherton, Thomas, Wisotzek & Milan, 1988; Helfenstein & Wechsler, 1981). However, there is conflicting evidence regarding its effectiveness when treating pragmatic language deficits in some young adults with traumatic brain injury. Helfenstein and Wechsler (1981) found the skills-based method helpful in improving communication skills in a group of individuals with traumatic brain injury. In their study individuals with TBI participated in a communication skills training program and their communication skills were compared to a control group who received “non-therapeutic attention treatment”. The training required the TBI patients to review and process videotaped interactions of themselves and a therapist as well as to practice targeted skills such as initiation, topic management, turn-taking, verbal organization and listening skills. Results of the study indicated that the skills-based training group benefited from training and improved their pragmatic communication skills of topic maintenance, initiation, use of social greetings and eye contact, use of questions of the listener to reduce monologue behavior and turn-taking during conversation during role-playing performances that was videotaped to allow for later assessment by associated staff members who were unaware of individual group placement. Brotherton, Thomas, Wisotzek & Milan (1988) conducted a social-skills training study with a group consisting of four head-injured subjects. The study use single-case methodology in the form of a multiple-baseline- across-behaviors design with four replications. Pragmatic language deficits (e.g., initiating conversation) were identified by every subject along with their family members and served as target behaviors for each individual's training sessions. Approximately ten scenarios were then written for each subject's pragmatic problem situation (e.g., conversation with friend at a bus stop). Each session began with a 15-minute "free interaction" or unstructured conversation with the subject and two therapists followed by enactment of the ten scenarios. All training sessions were videotaped for subsequent review and rating by the individual participant and two psychology students who were blind to the research study. The subjects were rated using a 31-item social skills behavior scale which included the following categories: speech fluency, voice quality, topic interest, statement orientation (positive or negative), facial expressions, eye contact and body gestures. Results showed that three of the four subjects demonstrated observable improvements for the targeted pragmatic-social skills with evidence of generalization across situations and maintenance of gains at follow-up one year later. The authors proposed that the lack of training effect for one of the subjects (the youngest of the group; age 20) was due to poor motivation and resistance which was observable at onset of the study. Brotherton and colleagues concluded that despite lingering cognitive deficits (e.g., memory) the social skills training program can be successfully utilized to remediate pragmatic language deficits secondary to severe brain injury. Interestingly, the examiners discovered that even when the subjects were unable to verbally recall their target behaviors, they nonetheless demonstrated performance gains, thereby proving that this population type can acquire new social behaviors with training and practice in "real-life" situations.

Aphasia and Augmentative and Alternative Communication Devices

Substitutive theories of language rehabilitation are based on compensatory strategies that involve adjusting the individual's level of response or using alternate means to help the PWA respond (Luria, 1970; Rothi, 1992). Examples of compensatory strategies are: a) the utilization of intact written language skills when verbalization is not possible; b) elimination of all environmental distractions when attempting to participate in one-to-one conversation; or, c) the implementation of various augmentative-alternative communication (AAC) devices such as a picture communication board (Bellaire et al., 1991; Bruce & Howard, 1987; Sohlberg & Mateer, 2001).

Augmentative-alternative communication devices are frequently used as substitutive means for individuals who cannot verbalize due to speech-language impairments. In the early stages of recovery the medical speech-language pathologist may try to incorporate the use of a picture communication board with patients who have a moderate-severe expressive aphasia. Training may involve the identification of target items using a simple 3-6 item picture board during structured communication tasks. For example, once the patient is able to identify target items successfully in response to their verbal names, training may then focus on identification of the targets by their functional use. Finally, the PWA may be asked to point to items on the board in response to questions during unstructured conversational tasks. Whereas some patients with moderate-severe expressive aphasia may demonstrate the ability to use a simple picture communication board during structured therapy sessions, many may not have the ability to generalize these skills to natural settings (Bellaire et al., 1991; Kraat, 1990). This often results in the eventual dismissal of the communication board by the patient, family and therapist.

In the recent past, researchers have investigated the functional use of augmentative-alternative communication (AAC) devices with moderate to severe nonfluent adults with aphasia (Bellaire et al., 1991; Coelho, 1991). Coelho (1991) studied manual sign acquisition in two participants with aphasia. Training was administered in two conditions using twelve iconic signs that represented various food items. The first setting was the structured clinic, and the second setting was a simulated restaurant. Although the subjects learned and used the signs in both settings, only one participant generalized sign use to a natural setting. Furthermore, observations and family report indicated that neither subject had increased sign usage during daily communication post-therapy.

In another study, Bellaire, Georges & Thompson (1991) used a picture communication board training model to examine the acquisition, generalization and maintenance of an AAC device. Two individuals with severe nonfluent Broca's aphasia were trained to use a 15-item picture communication board in a clinical setting and a natural setting. A multiple-baseline across behaviors design was used to evaluate the participant's ability to point to target pictures on the boards across each study phase. In the clinic setting, treatment involved the training of pointing responses through the use of cues, models or physical assistance. If there was no generalization of concepts, two programs to promote carry-over were implemented. The programs involved role-playing scenarios in either the treatment room or a natural setting. An acquisition of target items by both subjects occurred, but there was no generalization to the natural setting for either subject.

There may be several reasons for poor generalization of the trained picture board items to functional contexts which tend to be highly complex tasks. Some researchers speculate that lack of carry-over may be due to the fact that the PWA views the AAC device as unnatural or has a poor acceptance of the device (Jacobs, Drew, Ogletree & Pierce; 2004). Alternatively, the lack of generalization may relate to impaired non-linguistic cognitive skills, particularly executive function skills. The successful implementation of any therapy technique may rely on the individual's executive skills for the initiation, planning and carry-over of strategies to functional communication contexts, especially in novel situations

Summary

Non-linguistic cognitive deficits of executive function, attention and memory are often associated with aphasia. The degree of linguistic and non-linguistic impairment may depend on the extent of the frontal lobe damage. Task complexity may also determine the likelihood of successful performance, especially in individuals with aphasia. Language tasks of increased difficulty level in an unstructured setting are likely to require more frontal lobe activation as well as recruitment of the supporting frontal networks (Burgess & Shallice, 1996; Maly, Turnheim, Heiss & Gloning, 1977). Therefore, it is likely that PWA as well as executive function impairment will have significant difficulty with communication during tasks requiring the use of complex semantic and syntactic structure in informal, “functional” therapy situations (e.g., placing an order in a restaurant or using a picture communication board).

People with aphasia often have difficulty communicating via verbal and nonverbal means. They often learn to use an alternative communicative mode successfully in structured therapy activities, but may be unable to demonstrate its use in a novel, unstructured situation. Deficits in attention, memory, processing speed and executive function have also been observed in PWA. It is likely that linguistic and non-linguistic functions are not totally independent of each other and that both are used during communication, especially when the implementation of new concepts or strategies is warranted during complex tasks.

Statement of the Problem

To date there has been little research involving the incidence and possible treatment effects of deficits of executive function in persons with aphasia. More specifically, research focused on the effects of frontal lobe impairment on the functional and generalized use of AAC devices is sparse. Knowledge of existing non-linguistic cognitive deficits in an individual with aphasia may allow the speech-language pathologist to design a treatment plan that addresses the aphasia and executive function impairments simultaneously. This may have a positive effect on the PWA's functional communication in unstructured settings.

Research Questions

This study will address the following research questions:

1) Do adults with left frontal lobe lesions perform significantly worse than matched healthy volunteers in a novel route-finding activity, a story retelling task, and selected tests of executive function?

   Null hypothesis: Adults with left frontal lobe lesions do not perform significantly worse than matched healthy volunteers in a novel route-finding activity, a story retelling task, and selected tests of executive function.

2) What is the relationship between speech and language dysfunction and level of executive function in adults with left frontal lobe lesions?

   Null hypothesis: There is no relationship between speech and language dysfunction and level of executive function in adults with left frontal lobe lesions.

3) Is there a relationship between level of executive function and performance in a novel route-finding activity of moderately high non-linguistic complexity in adults with left frontal lobe lesions?

Null hypothesis: There is no relationship between level of executive function and performance in a novel route-finding activity of moderately high non-linguistic complexity in adults with left frontal lobe lesions.

4) Is there a relationship between level of executive function and performance in using a linguistically-based AAC device in adults with left frontal lobe lesions?

   Null hypothesis: There is no relationship between level of executive function and performance in using a linguistically-based AAC device in adults with left frontal lobe lesions.

Hypotheses

1) It is predicted that adults with left frontal lesions will perform significantly worse than matched healthy volunteers in a novel route-finding activity, a story retelling task, and selected tests of executive function.
2) It is predicted that there will be a strong correlation between speech and language dysfunction and executive function impairment in adults with left frontal lobe lesions.
3) It is predicted that degree of executive function impairment will determine the level of success in performing a complex, unstructured, non-linguistic task (i.e., novel route-finding) in adults with left frontal lobe lesions.
4) It is predicted that the severity of executive function impairment will determine the level of performance during unstructured or structured, simple or complex communication tasks using a picture/word board (AAC).
5) It is hypothesized that individuals with executive function impairment and aphasia will perform better during structured AAC tasks of low complexity as compared to unstructured AAC tasks of high complex

Chapter II: Methods

The purpose of this study was to examine the relationship between executive function and performance on selected linguistic and non-linguistic tasks in persons with aphasia (PWA) and left frontal lobe lesions. The methods used for data collection and analyses are addressed in this chapter. The topics to be discussed include the subjects, instrumentation, experimental procedures, research design, and data analysis procedures.

Subjects

Thirty volunteers participated in this research study. Group 1 (n=15) consisted of adults with the diagnosis of cerebral vascular accident (CVA) affecting the left frontal lobe and/or adjacent subcortical structures in the left hemisphere. Group 2 (n=15) consisted of healthy volunteers, matched pairwise to Group 1 in handedness, socio-economic status, gender, age and educational level. (See Table 1 for the individual subject characteristics.) This relatively small sample size was due to the difficulty in locating and recruiting neurologically impaired persons who met the criteria for inclusion. However, many researchers in the field of speech-language pathology have conducted studies of clinical significance using a similar sample size (e.g., Beeson, et al., 1993; Doyle, Goldstein & Bourgeois, 1987; Erickson, Goldfinger & LaPointe, 1996; Hinckley et al., 2001; LaPointe & Erickson, 1991; Murray, 2000; Murray et al., 1997; Saffran, Berndt & Schwartz, 1989; Van Mourik et al., 1992).

Table 1

Subject Characteristics. Mean standard deviation (S.D.) and range for 15 persons with aphasia (PWA) and 15 control subjects (C): Gender, Age and Educational Level

PWA	**Gender**	**Age**	**Ed***	**C**	**Gender**	**Age**	**Ed**
1	M	61	21	1	M	64	20
2	M	59	16	2	M	56	18
3	M	45	16	3	M	43	16
4	F	65	18	4	F	68	18
5	F	63	16	5	F	67	16
6	M	38	12	6	M	34	12
7	F	60	15	7	F	60	14
8	F	80	18	8	F	76	18
9	M	43	12	9	M	43	14
10	F	52	14	10	F	53	15
11	F	56	16	11	F	56	16
12	M	60	16	12	M	60	16
13	M	42	15	13	M	44	15
14	F	65	10	14	F	64	12
15	M	48	14	15	M	53	14

Note: * Educational level in years

Mean		55.8	15.3			56	15.6
SD		11.2	2.7			11.4	2.3
Range		38-80	10-21			34-76	12-20

All subjects met the following inclusionary criteria: a) right-hand dominant; b) 30-80 years of age; c) English as a primary language; d) functional auditory and visual acuity (with or without corrective device); e) greater than or equal to ten years of education; and, f) mobility sufficient to use a pointing board. Exclusionary criteria were as follows: a) no history of developmental learning or cognitive deficits; b) no history of substance abuse within the past six months; c) no history of psychiatric illness requiring hospitalization; d) no current use of psychotropic medications; and, e) no current major medical illness that may have interfered with ability to complete study tests.

Group 1 met the additional inclusionary criteria of: a) greater than or equal to six months post-stroke; b) aphasia present, as diagnosed by a certified speech-language pathologist; c) no history of central nervous system injury other than stroke or transient ischemic attack (TIA) affecting the left frontal lobe; and, d) ability to pass a communication board screening task (described below). Group 2 met the following exclusionary criterion: No history of injury or illness affecting the central nervous system.

All subjects were referred to this study by their medical doctor or speech-language pathologist, or were identified by word of mouth in the community. Medical history was obtained via clinical report, and developmental history and aphasia treatment history were obtained via questionnaire (see Appendix A).

Materials

Screening Measures

To ensure that each subject from Group 1 possessed the basic auditory comprehension and visual skills necessary to use a 12-item picture/word board, a spoken word-to-picture matching task was administered. All subjects scored 83% or better during 2 of 3 communication board exposures.

Vision and hearing were further tested using the visual fields screening subtest from the Arizona Battery for Communication Disorders of Dementia (ABCD; Bayles & Tomoeda, 1993) and a pure tone audiometric screening at 500, 1000 & 2000 Hz. Each subject from Group 1 passed the screenings. In addition, all subjects passed the ABCD speech discrimination task with a score of 70% or greater (Bayles & Tomoeda, 1993; see Appendix B).

The Communication Activities of Daily Living-2 (CADL-2; Holland, Frattali & Fromm, 1999) was administered to subjects in Group 1 as a screening tool to assess their functional communication skills as they try to communicate information via verbal, gesture, or picture/words in simulated daily life activities. The evaluation of communication success is based on both verbal and nonverbal responses. For purposes of this study a Stanine Score of 5 or less is considered to be a functional communication impairment. In this study 10 of the 15 individuals with aphasia had a Stanine Score of 5 or less. (See Table 2 for the results).

Selected portions of the Western Aphasia Battery (Kertesz, 1982) were administered to determine the presence, type, and severity of the aphasia, as well as the presence or absence of apraxia in each subject from Group 1. An Aphasia Quotient (AQ) was calculated for each subject, and each was assigned to a diagnostic category based on performance in four language subtests: spontaneous speech, auditory comprehension, repetition, and naming (see Table 2). There was no evidence of limb apraxia in any of the PWA. Although two of the fifteen subjects earned apraxia subtest scores below 8.0 out of a possible 10, this was due to difficulties performing the oral apraxia component.

Table 2

Subject characteristics: Age, Gender, *Western Aphasia Battery* – Aphasia Quotient (AQ), Aphasia Type, *Peabody Picture Vocabulary Test* (PPVT) Stanine Score, *Communicative Abilities in Daily Living-2* (CADL-2) Stanine Score.

Subject	Age	Gender	AQ	Aphasia Type	PPVT	CADL-2
1	61	M	86.2	Anomic	6	8
2	59	M	65.4	Broca	5	6
3	45	M	91.4	Anomic	5	7
4	65	F	26.0	Broca	3	4
5	63	F	64.0	Broca	3	5
6	38	M	22.0	Broca	3	3
7	60	F	82.8	Anomic	4	8
8	80	F	27.3	Conduction	1	3
9	43	M	48.6	Broca	2	4
10	52	F	92.2	Anomic	2	7
11	56	F	83.6	Anomic	3	7
12	60	M	16.6	Broca	1	4
13	43	M	82.5	Anomic	3	5
14	65	F	69.2	Anomic	4	5
15	48	M	35.8	Broca	3	4

*Note: WAB/AQ - Total possible = 100; CADL-2 – Total possible raw score = 100

The Peabody Picture Vocabulary Test (PPVT III; Dunn & Dunn, 1997) was administered to subjects from Group 1 as a mode for estimating pre-morbid intelligence level. The PPVT consists of 204 picture plates, each with four pictures, one plate for each word with the words arranged in order of difficulty. The subject points to the picture most like the stimulus word which is spoken by the examiner or shown on a printed card. The PPVT items span both very low levels of mental ability and levels considerably above average adult ability. Points for passed items were counted and entered into tables giving a standard raw score, percentile and age equivalent score. Stanine scores of 4-6 are considered in the average range, scores between 7-8 are considered moderately high, a score of 9 is extremely high, a score between 2-3 is considered in the moderately low range and a score of 1 is in the extremely low range. Five of the fifteen PWA had a Stanine Score in the average range. Eight of the fifteen PWA scored in the moderately low range and two of the fifteen PWA had a Stanine Score of 1 placing them in the extremely low range. Both of the individuals with a Stanine Score of 1 had a college degree (4-6 years of college). The low Stanine Scores of these individuals may reflect the severity of their auditory comprehension deficit. In fact, Smith (1997) found that the PPVT may be the best measure of the PWA's residual vocabulary, rather than their premorbid level of intelligence.

A brief measure of verbal working memory was administered to all subjects in Group 1. Each subject was presented with a single page incorporating nine black and white line drawings representing 1-2 syllable common words. The subjects were instructed to point to a series of pictures in the order spoken aloud by the examiner. This modification of the Digit Span Test from the Wechsler Adult Intelligence Scale-III (WAIS III; Wechsler, D., 1997) and Digits Forward from the Wechsler Memory Scale-III (WMS-III; Wechsler, D., 1997) was used because many persons with aphasia are unable to repeat digits or words. This task provided information about each subject's verbal working memory and visual perception. All of the subjects demonstrated difficulty with this modified working memory task in that none were able to point to the 6 items in the picture pointing span task. According to test norms for the Digits Forward (WMS; Wechsler, 1997) a score of 6 or greater is normal to above normal, a score of 5 is marginal to normal, 4 is considered borderline, and, a score of three is in the impaired range (Miller, 1956; Ardila, & Rosselli, 1989). When asked to point to a 2-picture span, 73% of the PWA demonstrated the ability to do so; 47% of the subjects could point to a 3-picture span; 20% a 4- picture span and, 6% a 5-picture span. Thus, only 6% of the subjects scored in the marginal-normal range and 20% in the borderline range. Eighty percent of PWA scored in the impaired range. However, the norms are for verbal repetition, and the pointing response may place increased demands on verbal working memory as compared to verbal repetition. All subjects demonstrated the ability to visually scan the picture board in all four visual quadrants to perform this memory task.

Experimental Measures

Executive Function. The following measures of executive function were administered to subjects from Group 1:

1. The Symbol Trails subtest from the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001) was used to assess the executive function skills of planning, working memory and mental flexibility without placing large demands on the language system. In this test there are two learning trials used in preparation for the test items. In trial one the examinee is to draw lines connecting circles of increasing size. In trial two the examinee is required to draw lines that connect alternating circles and triangles and then finally connecting alternating circles and triangles of increasing size. The test has a 3-minute time limit. The maximum possible score is 10 points.

2. The Mazes subtest from the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001) was administered to assess executive function skills involved in planning a course of action, rejecting/inhibiting incorrect choices and correcting errors when made. In this test, two mazes of two levels of difficulty are used. The goal of both is to draw a continuous line through the maze without entering any dead-ends or crossing any line. The maximum possible score for each maze is 4 (for a correct solution) for a total of 8 points. One point is subtracted each time the subject's line travels at least halfway up an incorrect path but is self-corrected.

3. The D-KEFS Tower Test (Delis, Kaplan & Kramer, 2001) was used to assess planning, generative thinking, fluency, strategy initiation and use, rule adherence and inhibition of impulsive or perseverative responses in Group 1 participants. The object of the Tower Test is to

move disks of various sizes from small to large across three pegs to build a designated tower in the fewest number of moves possible. In constructing the target towers, the subject is required to follow two rules: a) move only one disk at a time and, b) never place a larger disk over a smaller disk. Each trial begins with the examiner's presentation of the disks on the pegs in a predetermined starting position and displaying a picture that shows the ending position of the disks (i.e., the tower to be built). As the subject moves the disks to match the target tower, the examiner records the number of moves to completion, the item-completion time, and the final achievement (correct or incorrect tower).

4. The Design Fluency Test (Delis, Kaplan & Kramer, 2001) was used as another measure of planning, generative thinking, fluency, strategy initiation and use, rule adherence and inhibition of impulsive or perseverative responses in Group 1. This test measures the subject's ability to draw as many different designs as possible in one minute. The subject is presented a page with rows of boxes with each containing an array of dots and is instructed to draw a different design in each box using only four lines to connect the dots. There are 3 Conditions. In Condition 1: Filled Dots, the response boxes contain only filled dots, and the subject is asked to draw the designs connecting those dots. In Condition 2: Empty Dots Only, the response boxes contain both filled and unfilled dots and the subject is instructed to connect only the unfilled (empty) dots and to inhibit the previous response of connecting the filled dots. In Condition 3: Switching, the boxes contain both filled and unfilled dots and the subject is required to draw the designs by alternately connecting filled and empty dots. Condition 1 is a basic test of design fluency, Condition 2 measures both design fluency and response inhibition, and Condition 3 assesses both design fluency and cognitive flexibility.

5.The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay & Curtiss, 1993) was administered to assess Group 1 subjects' ability to form abstract concepts, to shift and maintain set and to utilize feedback. The WCST consists of four stimulus cards and 128 response cards that depict figures of varying forms (crosses, circles, triangles, or stars), colors (red, blue, yellow or green) and numbers of figures (one, two, three, or four). At the onset of the task, four stimulus cards with the following characteristics are placed before the subject: one red triangle, two green stars, three yellow crosses, and four blue circles. The subject is then handed a deck of 64 response cards and instructed to match each consecutive card from the deck with one of the four stimulus cards and is given feedback each time as to whether he or she is right or wrong. The correct sorting principle (or category) is never told. Once the subject has made a specified number of consecutive "correct" matches to the initial sorting principle the sorting principle is changed without warning, requiring the subject to use the examiner's feedback to develop a new sorting strategy. The WCST proceeds in this manner through a number of shifts in set among the three possible sorting categories (color, form and number).

6. The Executive Function Route Finding Task (Boyd & Sauter, 1994) was used as a non-linguistic functional activity of daily living (ADL) task that requires the subject to locate a target office in the hospital/clinic given a map in addition to printed and verbal instructions. The target room was marked with a yellow star. As described by Boyd and Sauter (1994), performance was evaluated on a 4-point scale (1=lowest score; 4=highest score) with a maximum possible points of 24 (see Appendix E). Areas evaluated included: 1) Task understanding; 2) Incorporation of information seeking; 3) Retaining directions; 4) Error detection; 5) Error correction; and, 6) On-task behavior. A summary of all tasks administered to Group 1 is listed in Appendix F.

Subjects from Group 2 completed the following measures of executive function from the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001): a) The Symbol Trails subtest and, b) Mazes subtest. In addition, the Executive Function Route Finding Task (Boyd & Sauter, 1994) was administered to subjects in Group 2 (see Appendix G for a summary of tasks administered to Group 2).

Communication Board Tasks. Three communication board tasks were administered to subjects in Group 1. The relative effects of task complexity and structure on subjects' learning and functional use of a picture/word board were compared. Tasks of low complexity and high structure are thought to require less frontal lobe recruitment than highly complex, unstructured tasks (Stuss, 2006). As described below, Group 2 subjects completed two of the three communication board tasks.

Three separate picture boards were used in this study, and the word frequency of the stimulus items was matched across the three boards. Board 1 was the same board that was used in the communication board screening task described above. Stimuli for boards 2 and 3 were taken from the CLQT (Helm-Estabrooks, 2001) and ABCD, (Bayles & Tomoeda, 1993), respectively. These two sources were used because the stories were of approximately the same length. The stimuli from the CLQT were incorporated into original digitally-taped story stimuli created by the examiner. The procedure for the communication board experimental tasks was as follows:

1. Baseline Story Retelling Task: The purpose of this task was to evaluate each subject's use of the communication board in story retelling after only very minimal exposure to the board. At the beginning of Session 2, each subject was presented with Board 2 and asked to identify each of the target pictures on the board in response to its corresponding spoken name. Then a 1-2 minute digitally-taped (DVD) story was shown to the subject. Immediately following the end of

the DVD, the subject was asked to convey the story through speech, gesture and/or the pointing board. The examiner made every effort not to interfere with the subject's story retelling. The examiner recorded the subject's pointing, gestural and verbal responses during each communicative attempt. The scoring of each subject's performance was based on a scoring system developed by Purdy (1992). Six variables are defined in this scoring system: three address symbol usage in each of the three communication modalities, and three address the individual's attempts to switch to nonverbal alternatives when a verbal attempt fails. Switching behavior was investigated because it is a component of self-monitoring and initiation, both part of executive function processes (see Appendix D). The Story Retelling Task using Board 2 was presented again during Session 3 in an attempt to compare subject's performance between sessions using the same picture pointing board.

2. Communication Board Exposure Task: Later in Session 2, the subject received training on the use of a communication board. The board used for training was the same as used in the Session 1 screening task (Board 1). Training for use of the communication board consisted of: 1) spoken word-to-picture matching (high structure/low complexity); 2) identification of the picture by description or function (high structure/ high complexity); and, 3) using the pointing board during structured conversation (low structure/high complexity). In addition, to obtain a sample of the subject's ability to communicate in a low structure and low complexity situation data was scored using the Greeting Section from the CADL-2. (See Table 3).

Table 3

Communication skills were analyzed with Group 1 subjects under the following conditions: low structure/low complexity (LS/LC), high structure/low complexity (HS/LC), low structure/high complexity (LS/HC) and high structure/high complexity (HS/HC).

Low Structure/Low Complexity **Greeting Section (IV) of <u>CADL</u>**	***High Structure/Low Complexity*** **Spoken word-to-picture matching task**
Low Structure/High Complexity **Use of pointing board during conversation**	***High Structure/High Complexity*** **Identification of picture by description or function**

The exposure task began with an introduction to the pictures on the communication board. A 12x14 picture board was divided into a 4 x 3 grid that contained colored pictures representing 12 target concepts (see Appendix C). The word for each concept was printed above the appropriate picture. The examiner named the concept and pointed to the corresponding picture on the communication board. All 12 pictures were reviewed in this manner. Then the examiner asked the subject to point to a target picture when given the spoken word, as a measure of comprehension of the 12 pictures. A plus/minus scoring system was used (maximum score = 12 points).

The second phase of the communication board exposure task involved identification of each picture by description or function (i.e., “Which item would you point to if you were thirsty?”). The third phase of the communication board exposure task was a structured conversation in which the examiner asked specific questions that allowed the subject to correctly respond verbally, by pointing to a corresponding picture or by gesture (i.e., Examiner: “How did you get here today?”). When the subject responded verbally or by gesturing, the examiner showed the subject the item on the picture board that could also convey that concept. A plus/minus scoring system was used (maximum score = 10 points).

3. The Experimental Story Retelling Task. The purpose of this task was to assess each subject's use of the communication board for story retelling, specifically after a 5-7 day interval following training in the use of a communication board. At the beginning of Session 3 (or Session 2 for healthy volunteers), each subject was presented with a new communication board (Board 3). The examiner introduced the board by having the subject point to each of the 12 target pictures in response to the corresponding spoken name. Then a 1-2 minute digitally-taped story (Bayles & Tomoeda, 1993) was presented.

Immediately following the DVD, the subject was asked to retell the story using verbal output, gestures or the picture/words on Board 3. The picture board was readily available to the PWA as it was placed next to them. The individuals in the Control Group were instructed to utilize the picture pointing board as much as possible when retelling the story. The same task procedures and scoring were used as in the Baseline Story Retelling Task and Story Retelling Task using Board 2.

General Procedures

This study required 3 separate sessions for each subject in Group 1. The estimated length of each session was as follows: a) Session 1 = 75 minutes; b) Session 2 = 90 minutes; and, c) Session 3 = 75 minutes (see Appendix F). All subjects were tested individually in a quiet room in a hospital or clinical setting or, when necessary, in the subject's home. Breaks from the testing or experimental treatment tasks were offered as necessary to each subject in an attempt to reduce fatigue. Only two sessions were required for each subject in Group 2: a 40-minute session and a 25-minute session (see Appendix G). All experimental measures for each subject in the study were completed within a 2-4 week period. In an attempt to reduce possible sequencing effects, Group 1 subjects were randomly assigned to one of two test sequences outlined in Form A and Form B (see Appendix H).

Test-Retest and Scoring Reliability

Test-retest reliability for the experimental functional communication board task and the novel route-finding task was determined by administering the tasks a second time to three subjects chosen at random from Group 1. This required a follow-up session with each of these subjects, and the time interval between task administrations ranged from 12-20 weeks. Due to the small sample size, a description of comparative results is presented (See Table 4). Reliability was very high for the novel route finding task and communication board retelling task when counting the number of switches to the nonverbal mode. It was slightly lower for the communication board retelling task when counting the number of symbols correctly used on the communication board.

Table 4

Test-retest reliability. Mean, standard deviation (SD) and range for 3 randomly chosen subjects with aphasia for: route-finding task (EFRT); Communication Board #3-Story Retelling/counting number of symbols correctly used (SCU); Communication Board #3-Story Retelling/number of opportunities to switch to nonverbal mode (SW).

	EFRT		SCU		SW	
Subj.	trial 1	trial 2	trial 1	trial 2	trial 1	trial 2
1	24/24	24/24	10/10	10/10	6/6	5/5
2	24/24	24/24	9/10	8/10	0/2	0/3
3	23/24	23/24	7/10	6/10	0/6	0/5
Mean	0.97	0.97	86.7	80	0.33	0.33
S.D.	0.02	0.02	15.3	20	0.57	0.57
Range	0.04	0.04	30	40	1	1

Inter-rater reliability was determined for the experimental functional communication board task using Board 3, and for the novel route-finding task by rescoring the digitally-taped performance of the first 8 subjects (4 PWA and 4 Control). The tapes were reviewed by two unbiased, certified speech-language pathologists. Prior to the unbiased raters' review, a training session was provided to discuss the scoring system for the DVD story retelling task and the route-finding task. In addition, the raters applied the scoring systems using a preliminary mock DVD of two separate story retelling scenarios and two separate route finding scenarios. A comparison of scores between the primary investigator and the two unbiased certified speech-language pathologists was conducted using an ANOVA. Inter-rater reliability was high on the novel route-finding task (r=.80) and the functional communication board task (r=.93).

Chapter III: RESULTS

Based upon a review of the literature, a disruption to executive function skills and to language skills was predicted to occur in the stroke patients included in this study. As described in Chapter One, the executive function, linguistic, and non-linguistic tasks used in this study were designed to assess the effect of possible impaired executive function and possible impaired language skills on the use of AAC boards in structured and unstructured tasks, and on a novel route-finding task. The performance of persons with aphasia (PWA) and control subjects on these tasks was examined relative to the four research questions posed in Chapter One.

Research Question 1. Do adults with left frontal lobe lesions perform significantly worse than matched healthy volunteers in a novel route-finding activity, a story retelling task, and selected tests of executive function?

Null Hypothesis: Adults with left frontal lobe lesions do not perform significantly worse than matched healthy volunteers in a novel route-finding activity, a story retelling task, and selected tests of executive function.

A route-finding activity was used as a measure of performance in a functional activity of daily living that had relatively low linguistic demands and that involved low structure and high complexity. Performance on the Executive Function Route-Finding Task (EFRT) was compared between the persons with aphasia (PWA) group and the control group. The control group (mean = 1) performed better than the PWA group (mean = 0.925), and paired *t*- tests showed this to be a significant difference ($t = -2.28$, $df = 14$, $p = .038$).

Two measures of executive function from the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001) were administered to all subjects. The control group achieved significantly better scores on the Mazes subtest of the CLQT as compared to the PWA group (t =

-3.49, *df* = 14, *p*=.003). There was also a trend toward better performance by the control group on the Symbol Trails subtest of the CLQT as compared to the PWA group in this small sample (*t* = -2.08, *df* = 14, p=.055).

In order to measure the subjects' ability to use an AAC board in a functional context, a story retelling task was administered. In this task, the subject was given communication Board 3 to retell a story taken from the Arizona Battery for Communication Disorders of Dementia (ABCD; Bayles & Tomoeda, 1993). Subject performance in this task was scored using two methods. The first consisted of calculating the number of successful switches from the verbal mode to the nonverbal mode (e.g., picture board or gesture). Table 5 presents the number of successful and unsuccessful switches from verbal to nonverbal mode for the PWA and Control Groups.

Table 5

Story Retelling-Board 3 – Modality Switches: Number of target symbols (N=10). Mean, standard deviation (SD), and range of the number of modality switches (SW) made, and the number of opportunities to switch (Opp) of 15 persons with aphasia (PWA) and control (C) subjects.

PWA	Successful		Unsuccessful		Total		C	Successful		Unsuccessful		Total	
	SW	*Opp*	*SW*	*Opp*	*SW*	*Opp*		*SW*	*Opp*	*SW*	*Opp*	*SW*	*Opp*
1	6	6	0	6	6	6	1	9	11	0	11	9	11
2	0	4	0	4	0	4	2	9	11	0	11	9	11
3	0	2	0	2	0	2	3	10	10	0	10	10	10
4	10	10	2	10	12	10	4	10	10	0	10	10	10
5	1	9	0	9	1	9	5	7	7	0	7	7	7
6	9	11	0	11	9	11	6	9	11	0	11	9	11
7	0	2	0	2	0	2	7	10	10	0	10	10	10
8	9	11	2	11	11	11	8	10	10	0	10	10	10
9	4	8	0	8	4	8	9	10	10	0	10	10	10
10	1	3	0	3	1	3	10	9	11	0	11	9	11
11	2	4	0	4	2	4	11	10	10	0	10	10	10
12	5	15	0	15	5	15	12	10	10	0	10	10	10
13	5	11	0	11	5	11	13	10	10	0	10	10	10
14	0	6	0	6	0	6	14	10	10	0	10	10	10
15	8	12	1	12	9	12	15	10	10	0	10	10	10
Total	**60**	**114**	**5**	**114**	**65**	**114**		**143**	**151**	**0**	**151**	**143**	**151**
Mean	**4**	**7.6**	**.33**	**7.6**	**4.3**	**7.6**		**9.5**	**10**	**0**	**10**	**9.5**	**10**
SD	**3.7**	**4.1**	**.72**	**4.1**	**4.3**	**4.1**		**.83**	**.96**	**0**	**.96**	**.83**	**.96**
Range	**0-10**	**2-15**	**0-2**	**2-15**	**0-12**	**2-15**		**7-10**	**7-11**	**0**	**7-11**	**7-10**	**7-11**

For the PWA, 92% of the total number of attempts to switch (N=65) were successful; 8% were unsuccessful. Given the opportunity to switch modality the PWA switched modes 57% (N=114) of the time. 100% of the total number of switches to the nonverbal mode were successful (N=143) in the normal group; 0% were unsuccessful. Given the opportunity to switch modality the normal individuals switched to the nonverbal mode 95% of the time. A paired *t*-test comparing the PWA to the Control Group shows a significant difference in performance (t = -5.2, df = 14, p=.00013).

The second method of scoring the Story Retelling Task-Board 3 consisted of tallying the total number of target symbols correctly used spontaneously when retelling the ABCD story. Table 6 displays the total number of target symbols used correctly in each modality (communication board, communication board + verbal, verbal, and gesture). The PWA Group preferred to use the verbal mode (mean=4.1) more than the communication board (mean=2.7) compared to the Control Group which used the communication board (mean=7.5) more than the verbal mode (mean=0.2). A paired *t* – test comparing the performance of the PWA with the Control Group showed a significant difference in achievement (t = -3.85, df = 14, p=.002) with the Control Group spontaneously using more of the target symbols correctly to retell the ABCD story.

Table 6

Story Retelling with Board 3. Number of symbols correctly used spontaneously (N=10). Response modes include a communication board (CB), gesture (G), verbal + communication board (CB+V) and verbal (V). The Persons with Aphasia (PWA) and Control (C) groups are presented.

PWA	**CB**	**CB+V**	**V**	**G**	**Total**	**C**	**CB**	**CB+V**	**V**	**G**	**Total**
1	0	6	4	0	10	1	8	1	0	0	9
2	0	0	7	0	7	2	9	0	0	0	9
3	0	0	8	0	8	3	0	10	0	0	10
4	7	0	0	3	10	4	9	1	0	0	10
5	0	0	5	1	6	5	1	6	3	0	10
6	9	0	0	0	9	6	9	0	0	0	9
7	0	0	9	0	9	7	10	0	0	0	10
8	9	0	0	0	9	8	10	0	0	0	10
9	1	2	4	1	8	9	10	0	0	0	10
10	0	1	8	0	9	10	1	8	0	0	9
11	1	1	7	0	9	11	10	0	0	0	10
12	5	0	0	0	5	12	9	1	0	0	10
13	1	4	2	0	7	13	9	1	0	0	10
14	0	0	7	0	7	14	9	1	0	0	10
15	8	0	0	0	8	15	9	0	0	1	10
Mean	2.7	.93	4.1	.33	8.1		7.5	1.9	0.2	0.7	9.7
SD	3.7	1.8	3.5	.82	1.4		3.6	3.3	0.77	0.26	0 .46
Range	0-9	0-6	0-9	0-3	5-10		0-10	0-10	0-3	0-1	9-10

Research Question 2. Is there a relationship between speech and language dysfunction and level of executive function in adults with left frontal lobe lesions?

Null Hypothesis: There is no relationship between speech and language dysfunction and level of executive function impairment in adults with left frontal lobe lesions.

The Western Aphasia Battery (WAB) was administered to determine the severity and type of aphasia. For each PWA, an Aphasia Quotient (AQ) was calculated based on the subscores of fluency, auditory comprehension, repetition, and verbal naming. The AQ from the WAB was then compared to the following executive function tests: the Cognitive Linguistic Quick Test-Symbol Trails (CLQT/ST) & Mazes (CLQT/M); the Wisconsin Card Sort Test (WCST); and, the Delis-Kaplan Executive Function System-Towers (D-KEFS/T) & Design Fluency (D-KEFS/DF). See Table 7 for each subject's language and executive function test scores.

Table 7

Language and Executive Function Tests for persons with aphasia (PWA): Mean, Standard Deviation (SD), and Range for WAB Aphasia Quotient (AQ) as well as subtests of fluency (FL), auditory comprehension (AC), Repetition (R), and verbal naming (N); and, the following executive function tests: CLQT/Symbol Trails (ST) raw score, CLQT/Mazes (M) raw score, WCST Total Number Correct, D-KEFS Towers (T) Achievement Raw Score & Design Fluency (DF) Design Accuracy/Raw Score.

	WAB					***EF tests***				
Subj.	FL	AC	R	N	AQ	CLQT/ST	CLQT/M	WCST	DKEFS/T	DKEFS/DF
1	.90	1	.58	.93	.86	1	1	.53	.63	.92
2	.65	.77	.41	.79	.65	1	1	.57	.43	.66
3	.90	.99	.98	.80	.91	.80	1	.56	.87	.86
4	.25	.75	.02	.03	.26	.70	1	.34	.53	.77
5	.65	.70	.66	.54	.64	.30	.63	.26	.37	.65
6	0	.81	.05	.24	.22	1	.88	.50	.43	.46
7	.70	1	.88	.86	.83	1	1	.42	.43	.96
8	.40	.55	0	.02	.27	.80	.50	.51	.33	.78
9	.85	.85	.92	.91	.49	1	1	.59	.37	.73
10	.95	.97	.84	.90	.92	1	.50	.57	.33	.69
11	.90	.91	.58	.89	.84	1	.50	.40	.43	.75
12	.05	.59	.08	.06	.17	.90	.88	.24	.37	.82
13	.90	.93	.67	.73	.83	.10	.50	.56	.40	.50
14	.85	.85	.92	.91	.88	.70	.50	.48	.37	.79
15	.25	.84	.12	.23	.36	.60	0	.24	.23	.44
	WAB								D-KEFS	
	FL	AC	R	N	AQ	CLQT/ST	CLQT/M	WCST	Tow	DF
Mean	.61	.83	.51	.60	.61	.79	.73	.45	.43	.72
S.D.	.33	.14	.37	.36	.28	.27	.30	.12	.15	.16
Range	0-95%	55-100%	0-98%	2-93%	17-92%	10-100%	0-100%	24-59%	23-87%	44-96%

The Pearson Correlation Coefficient was used to compare the WAB/AQ and the executive function tests (Cohen, 1988). Details are presented in Tables 8 and 9 below. There was not a significant Correlation Coefficient between the WAB/AQ and the CLQT - Symbols Trails subtest (r= -0.04; p=0.89) or the CLQT–Mazes subtest (r= -0.003; p=0.99). Also, there was not a significant correlation between the WAB/AQ and the D-KEFS–Towers Test (r=0.35; p=0.197) or the D-KEFS–Design Fluency (r= 0.32; p=0.25). There was a trend toward significance in the correlation between the WAB–AQ and the WCST (r=0.46; p=0.085).

Table 8

Western Aphasia Battery (WAB) subtests: Aphasia Quotient (AQ), Auditory Comprehension (AC), Verbal Naming (VN) and the Wisconsin Card Sort Test (WCST) based on the following raw scores (N=128): Total Number Correct (TNC), Perseverative Responses (PR), Nonperseverative Errors (NPE), Categories Completed (CC;N=6). The following data is presented: Mean, Standard Deviation (SD), and Range.

	WAB			WCST			
Subject	**AQ**	**AC**	**VN**	**TNC**	**PR**	**NPE**	**CC**
1	.86	1	.93	.53	.17	.32	.50
2	.65	.77	.79	.57	.29	.17	.50
3	.91	.99	.80	.56	.36	.13	.50
4	.26	.75	.03	.34	.64	.13	.33
5	.64	.70	.54	.26	.93	.04	0
6	.22	.81	.24	0.5	.37	.17	.50
7	.83	1	.86	.42	.38	.26	.17
8	.27	.55	.02	.51	.48	.13	.33
9	.49	.85	.91	.59	.34	.06	.17
10	.92	.97	.90	.57	.24	.22	.67
11	.84	.91	.89	0.4	.21	0.4	.17
12	.17	.59	.06	.24	.96	.04	0
13	.83	.93	.73	.56	.26	.20	0
14	.88	.85	.91	.48	.20	.32	.17
15	.36	.84	.33	.24	.21	.57	0
Mean	**0.61**	**0.83**	**0.60**	**0.45**	**0.40**	**0.21**	**0.27**
S.D.	**0.28**	**0.14**	**0.36**	**0.13**	**0.25**	**0.15**	**0.23**
Range	**.17 - .92**	**.55 – 1**	**.02 - .93**	**.24 - .59**	**17 - .96**	**.04 -.57**	**0 -.67**

When specifically comparing the PWA's Aphasia Quotient, auditory comprehension and verbal naming scores from the WAB to the WCST scores for the number of perseverative errors, nonperseverative errors, and categories completed, it was interesting to note that there was a significant correlation between the number of perseverative errors and the Aphasia Quotient score (r=-.53; p-value=.04), as well as the WAB subtest scores for auditory comprehension (r=.69; p-value=.004) and verbal naming (r=.61; p-value=.02). Many of the PWA had difficulty changing set despite cues from the examiner that their answers were not part of the rule. Therefore, there were many perseverative errors by the PWA. There was not a significant correlation between the auditory comprehension, verbal naming and Aphasia Quotient scores when compared to the WCST scores for nonperseverative errors and number of categories completed. However, a comparison between the verbal naming scores and the total number correct on the WCST showed a significant correlation (r=.54; p-value=.04).

Table 9

Western Aphasia Battery (WAB): Aphasia Quotient (AQ), Auditory Comprehension (AC) and Verbal Naming (VN) subtests in correlation to the Wisconsin Card Sort Test (WCST), raw scores that include: Total Number Correct (TNC; N=128), Perseverative Responses (PR), Nonperseverative Errors (NPE), and Number of Categories Completed (CC; N=6). Correlation Coefficient (r) and p-values are presented (alpha <.05)

WAB	**WCST**				
Aphasia Quotient	**TNC**	**PR**	**NPE**	**CC**	
r =		**0.46**	**-0.53**	**0.27**	**0.22**
p-value =	**0.08**	**0.04**	**0.34**	**0.44**	
WAB	**WCST**				
Auditory Comprehension	**TNC**	**PR**	**NPE**	**CC**	
r =	**0.43**	**0.69**	**0.44**	**0.30**	
p-value	**0.11**	**.004**	**0.09**	**0.28**	
WAB	**WCST**				
Verbal Naming	**TNC**	**PR**	**NPE**	**CC**	
r =	**0.54**	**0.61**	**0.25**	**0.19**	
p-value	**0.04**	**0.02**	**0.37**	**0.49**	

The D-KEFS Towers Test and Design Fluency were compared to the auditory comprehension and verbal naming subtests from the WAB. The Towers Test achievement raw score, move accuracy score and rule violation ratio score were compared to the WAB - Aphasia Quotient, auditory comprehension scores and verbal naming scores (see Table 10).

Table 10

This table includes the Mean, Standard Deviation (S.D.), and Range scores for the Western Aphasia Battery (WAB), D-KEFS Towers Test (T) and Design Fluency (DF) for the persons with aphasia (PWA). The WAB scores include the Aphasia Quotient (AQ), Auditory Comprehension (AC; raw score), Verbal Naming (VN; raw score). The D-KEFS includes the Towers Test (T) Achievement (ACH; raw score), Move Accuracy Ratio (MAR; raw score), and Rule Violation per Item Ration (RV/I; raw score). The D-KEFS DF includes the raw score for Design Accuracy (DA).

	WAB			D-KEFS			
PWA	**AQ**	**AC**	**VN**	**T/ACH**	**T/MAR**	**T-RV/I**	**DF/DA**
1	.86	1	.93	.63	1.94	.11	.92
2	.65	.77	.79	.43	2.0	.11	.66
3	.91	.99	.80	.87	1.09	0	.86
4	.26	.75	.03	.53	1.64	1.6	.77
5	.64	.70	.54	.37	0.8	2.1	.65
6	.22	.81	.24	.43	1.4	.33	.46
7	.83	1	.86	.43	.94	.88	.96
8	.27	.55	.02	.33	1.2	3.5	.78
9	.49	.85	.91	.37	1.6	.44	.73
10	.92	.97	.90	.33	1.0	.33	.69
11	.84	.91	.89	.43	1.64	.11	.75
12	.17	.59	.06	.37	2.2	.66	.82
13	.83	.93	.73	.40	1.6	.80	.50
14	.88	.85	.91	.37	0.8	.22	.79
15	.36	.84	.33	.23	0.82	2.1	.44
Mean	**0.61**	**0.83**	**0.60**	**0.43**	**1.38**	**0.89**	**0.72**
S.D.	**0.28**	**0.14**	**0.36**	**0.15**	**0.46**	**1.0**	**0.16**
Range	**.17-.92**	**.55-1**	**.02-.93**	**.23 - .87**	**.8 - 2.2**	**0 – 3.5**	**.44 - .96**

There was a significant correlation between the rule violation scores and the WAB/Aphasia Quotient (r=-.53; p-value=.05), the auditory comprehension scores (r=-.63; p-value=.01), and verbal naming scores (r=-.66; p-value=.007). Many of the subjects had difficulty planning their moves and remembering the rules for moving the tower pieces; therefore, they perseverated on making the same errors. There was not a significant correlation when comparing the WAB/Aphasia Quotient, WAB/auditory comprehension and WAB/verbal naming to the Towers Test achievement score, move accuracy score, or the Design Fluency accuracy scores (see Table 11).

Table 11

Western Aphasia Battery (WAB) scores for persons with aphasia (PWA): Aphasia Quotient (AQ), Auditory Comprehension (AC) and Verbal Naming (VN) subtests in correlation to the D-KEFS Towers Test (T) raw scores that include: Achievement Score (ACH), Move Accuracy Ratio (MAR), Rule Violation per Item Ratio (RV/I) and the D-KEFS Design Fluency (DF) – Design Accuracy (DA) raw score. Correlation Coefficient (r) and p-values (alpha <.05) are presented.

WAB	D-KEFS			
Aphasia Quotient	**T/ACH**	**T/MAR**	**T-RV/I**	**DF/DA**
r =	**0.35**	**-0.26**	**-0.52**	**0 .32**
p-value =	**0.197**	**0.35**	**0.05**	**0.25**
WAB	**D-KEFS**			
Auditory Comprehension	**T/ACH**	**T/MAR**	**T-RV/I**	**DF/DA**
r =	**0.42**	**-0.19**	**-0.63**	**0.15**
p-value =	**0.12**	**0.50**	**0.01**	**0.60**
WAB	**D-KEFS**			
Verbal Naming	**T/ACH**	**T/MAR**	**T-RV/I**	**DF/DA**
r =	**0.23**	**-0.12**	**-0.66**	**0.25**
p-value =	**0.40**	**0.66**	**0.007**	**0.37**

Many of the individuals with aphasia had difficulty with the WCST and the Towers Test in that they tended to perseverate on errors and found it difficult to plan and execute moves successfully. However, it does not appear that aphasia severity can consistently predict performance on tests of executive function in these participants.

Research Question 3. Is there a relationship between level of executive function and performance in a novel route-finding activity in adults with left frontal lobe lesions?

Null Hypothesis: There is no relationship between level of executive function and performance in a novel route-finding activity in adults with left frontal lobe lesions.

Five standardized tests of executive function (described above) were administered to the PWA. The Pearson Correlation Coefficient was used to compare the executive function test scores to the PWA performance scores on the Executive Function Route Finding Task (EFRT). The EFRT is a non-linguistic task of relatively moderate complexity. See Table 12 for detailed results. There was no correlation between the EFRT and the CLQT/ST (r=-.21; p=0.46), CLQT/M (r=-0.25; p=0.36), WCST (r=-0.15; p=0.60), D-KEFS/DF (r=0.29; p=0.29), or D-KEFS/Towers Test (r=0.01; p=0.96). Thus, it appears that performance on standardized tests of executive function could not predict performance on the novel route-finding task.

Table 12

Novel Route-Finding Task (EFRT) and Executive Function Test scores for persons with aphasia (PWA): Mean, Standard Deviation (SD), Range, Correlation Coefficient (r), and p-value (p) for Executive Function Route-Finding Task (EFRT) and selected standardized tests of executive function: Cognitive Linguistic Quick Test (CLQT)-Symbol Trails (ST; raw score); CLQT-Mazes (M; raw score); Wisconsin Card Sorting Test (WCST) -Total number correct; D-KEFS/Towers Test (T)-Achievement Score (raw score); and D-KEFS/Design Fluency (DF)-Design Accuracy (raw score).

Subj.	**EFRT**	**CLQT/ST**	**CLQT/M**	**WCST**	**D-KEFS/T**	**D-KEFS/DF**
1	1	1	1	.53	.63	.92
2	.75	1	1	.57	.43	.66
3	1	.80	1	.56	.87	.86
4	.75	.70	1	.34	.53	.77
5	1	.30	.63	.26	.37	.65
6	.63	1	.88	.50	.43	.46
7	1	1	1	.42	.43	.96
8	.79	.80	.50	.51	.33	.78
9	1	1	1	.59	.37	.73
10	1	1	.50	.57	.33	.69
11	1	1	.50	.40	.43	.75
12	1	.90	.88	.24	.37	.82
13	1	.10	.50	.56	.40	.50
14	.96	.70	.50	.48	.37	.79
15	1	.60	0	.24	.23	.44
Mean	0.92	0.79	0.73	0.45	0.43	0.72
SD	0.13	0.28	0.30	0.13	0.15	0.16
Range	63-100%	10-100%	0-100%	24-59%	23-87%	44-96%
r		-0.21	-0.25	-0.15	0.01	0.30
p-value		**0.46**	**0.36**	**0.60**	**0.96**	**0.29**

Research Question 4. Is there a relationship between level of executive function and performance in using a linguistically-based AAC device in adults with left frontal lobe lesions?

Null Hypothesis: There is no relationship between level of executive function and performance in using a linguistically-based AAC device in adults with left frontal lobe lesions.

The PWA group was presented with three opportunities to view a digitally-taped story and to retell it with the help of a picture communication pointing board. The first opportunity occurred during Session 2 with communication picture board 2 (story retelling 2), before the communication board exposure and training sessions. A baseline score was obtained using Purdy's (1992) scoring system. The number of successful switches from verbal to nonverbal modes as well as the number of symbols on the communication board that were correctly used were recorded when retelling the digitally-taped story. In Session 3, after the communication board exposure tasks and a 1 week delay, the PWA were given another opportunity to view the same DVD from Session 2 and retell the story with communication board 2. The baseline story retelling score was compared to the second attempt to retell story 2. Story retelling using a different DVD and communication board (3) also occurred during Session 3. See Table 13 for a comparison of the subject' scores.

Table 13

Comparison between Story Retelling baseline with board 2, second trial with board 2, and story retelling with board 3. Modality switches and the number of symbols spontaneously used correctly (SCU) on each board are compared. Number of target symbols (N=10). Mean, standard deviation (SD), and range for the total number of modality switches (SW) made, the total number of opportunities to switch (Opp) and number of correctly symbols used (SCU).

	Baseline			**Story Retell-2**			**Story Retell-3**		
SUBJ.	***SW***	***OPP***	***SCU***	***SW***	***OPP***	***SCU***	***SW***	***OPP***	***SCU***
1	2	10	6	1	5	8	6	6	10
2	0	10	5	0	6	7	0	4	7
3	0	10	7	0	4	8	0	2	8
4	8	13	7	10	10	10	12	10	10
5	0	6	7	1	11	5	1	9	6
6	0	14	3	10	13	7	9	11	9
7	0	10	5	1	7	7	0	2	9
8	5	15	5	6	11	7	11	11	9
9	6	8	9	6	8	9	4	8	8
10	1	11	5	3	5	9	1	3	9
11	1	5	8	8	8	10	2	4	9
12	3	17	3	4	16	4	5	15	5
13	3	9	7	7	14	7	5	11	7
14	0	10	5	0	10	5	0	6	7
15	7	13	7	7	14	7	9	12	8
Total	**36**	**161**	**89**	**64**	**142**	**110**	**65**	**114**	**121**
Mean	**2.4**	**10.7**	**5.9**	**4.3**	**9.5**	**7.3**	**4.3**	**7.6**	**8.1**
SD	**2.8**	**3.2**	**1.7**	**3.7**	**3.7**	**1.8**	**4.3**	**4.1**	**1.4**
Range	**0-8**	**5-17**	**3-9**	**0-10**	**4-16**	**4-10**	**0-12**	**2-15**	**5-10**

Overall, the PWA group's ability to correctly use a targeted symbol on the communication board when retelling each story increased from a total score of 89 (for the baseline story) to a total score of 121 (for story retell 3). The total number of switches from verbal to nonverbal mode increased in number (e.g., 36 to 64) between the baseline scoring and second trial with board 2. There was not a significant difference in the number of switches to nonverbal mode when comparing Story Retelling 2 with Story Retelling 3 (both of which occurred in Session 3).

A communication board exposure task was used to help the PWA become familiar with the implementation of the communication board during the upcoming experimental story retelling task, as well as, to compare the PWA's ability to use a picture board during high and low linguistically complex tasks in a high or low structured setting. The “Greeting” section of the CADL was used to assess the PWA’s ability to respond in a low complexity/low structured setting. All of the subjects with aphasia responded appropriately with a greeting during this portion of the test (N=15; 100%).

A spoken word-to-picture matching task was used with the 12-item picture pointing board to assess the PWA’s ability to correctly respond during a high structured/low complexity task. The scores ranged from 75-100% with a mean score of 94%. To assess ability to respond during a high structured/high complexity task the PWA were asked to identify a picture on the picture pointing board by description (e.g., Which item is used to make a car run?). Individual scores range from 50-100% with a mean score of 86%. To assess the PWA’s ability to respond with the picture pointing board during a low structured/high complexity task the individuals were asked to answer specific questions during conversation (e.g., What would you get if you were thirsty?) Individual subject scores ranged from 27-91% with a mean score of 67%. Task scores indicate that language tasks of increased complexity in an unstructured setting tend to be more difficult for individuals with aphasia.

Table 14

Communication Board Exposure Task: PWA mean scores during communication tasks of Low structure/Low Complexity, High Structure/Low Complexity, Low Structure/High Complexity and High Structure/High Complexity.

Low Structure/Low Complexity	**High Structure/Low Complexity**
Greeting (CADL-2) Mean score = 100%	Spoken Word-to-Picture Matching Mean Score = 94% Range = 75-100%
Low Structure/High Complexity	**High Structure/High Complexity**
Board Use During Conversation Mean Score = 67% Range = 27-91%	Identify Picture by Description Mean Score = 86% Range = 50-100%

To determine if there was a correlation between performance during the communication board exposure tasks (AAC) and the PWA's executive function skills a Pearson Correlation Coefficient was utilized. The low structured/high complexity (LS/HC), conversational task, consisted of a possible total score of 10 correct. The number of targeted pictures items used correctly to respond to the task questions was compared to the individual's test scores on the CLQT-Symbol Trails and Mazes, the WCST, and the D-KEFS-Tower Test and Design Fluency. There was a significant correlation between the low structure/high complexity scores and the raw score or total number correct on the Wisconsin Card Sorting Test (r=.51; p-value=.05). There was a trend toward correlation between the total number correct using the AAC and the D-KEF Towers Test (r=.45; p-value=.09). There was no significant correlation between the total number of symbols used on the communication board during the low structure/high complexity task and the CLQT subtests and the D-KEF Design Fluency subtests (see Table 15).

Table 15

Use of AAC in a Low Structure-High Complexity (LS/HC)-Conversational Task compared to EF tests in persons with aphasia (PWA): Number of targets correctly used on the AAC (N=11) are compared to EF test scores of accuracy. Executive Function tests include the CLQT/ST (Raw Score), CLQT/M (Raw Score), WCST (Total Number Correct), D-KEFS/Tower (Achievement Raw Score) and D-KEFS/Design Fluency (Design Accuracy-Raw Score).

PWA	LS/HC	CLQT/ST	CLQT/M	WCST	D-KEFS/T	D-KEFS/DF
1	0.91	1	1	0.53	0.63	0.92
2	0.64	1	1	0.57	0.43	0.66
3	0.82	0.80	1	0.56	0.87	0.86
4	0.64	0.70	1	0.34	0.53	0.77
5	0.64	0.30	0.63	0.26	0.37	0.65
6	0.55	1	0.88	0.50	0.43	0.46
7	0.73	1	1	0.42	0.43	0.96
8	0.27	0.80	0.50	0.51	0.33	0.78
9	0.82	1	1	0.59	0.37	0.73
10	0.82	1	0.50	0.57	0.33	0.69
11	0.91	1	0.50	0.40	0.43	0.75
12	0.36	0.90	0.88	0.24	0.37	0.82
13	0.82	0.10	0.50	0.56	0.40	0.50
14	0.82	0.70	0.50	0.48	0.37	0.79
15	0.36	0.60	0	0.24	0.23	0.44
r =		**0.08**	**0.28**	**0.51**	**0.45**	**0.29**
p =		**0.77**	**0.31**	**0.05**	**0.09**	**0.30**

To determine if there was a correlation between performance on the high structured/low complexity (HS/LC), spoken word-to-picture matching task (N=12), and the PWA's executive function skills a Pearson Correlation Coefficient was calculated. There was no significant correlation between the CLQT - Symbols Trails and Mazes subtests, the WCST, or the D-KEFS – Towers and Design Fluency subtests and performance on the AAC device when pointing to the picture that corresponded to the item named by the examiner (see table 16).

Table 16

Use of AAC in High Structure/Low Complexity (HS/LC) Task-Spoken word to picture matching scores are compared to EF tests in persons with aphasia (PWA): Number or targets correctly used on the AAC (N=12) are compared to executive function test scores of accuracy. Executive function tests include: CLQT/Symbol Trails (ST)T; CLQT/Mazes (M); WCST; D-KEFS/Tower Test (T); and D-KEFS/Design Fluency (DF).

PWA	HS/LC	CLQT/ST	CLQT/M	WCST	D-KEFS/T	D-KEFS/DF
1	1	1	1	0.53	0.63	0.92
2	1	1	1	0.57	0.43	0.66
3	1	0.8	1	0.56	0.87	0.86
4	0.83	0.7	1	0.34	0.53	0.77
5	1	0.3	0.63	0.26	0.37	0.65
6	0.83	1	0.88	0.50	0.43	0.46
7	1	1	1	0.42	0.43	0.96
8	0.75	0.8	0.5	0.51	0.33	0.78
9	0.92	1	1	0.59	0.37	0.73
10	1	1	0.5	0.57	0.33	0.69
11	1	1	0.5	0.40	0.43	0.75
12	0.83	0.9	0.88	0.24	0.37	0.82
13	1	0.1	0.5	0.56	0.40	0.50
14	1	0.7	0.5	0.48	0.37	0.79
15	1	0.6	0	0.24	0.23	0.44
r		**-0.16**	**-0.17**	**0.13**	**0.14**	**0.009**
p-value		**0.60**	**0.55**	**0.64**	**0.61**	**0.9**

A Pearson Correlation Coefficient was conducted to analyze the relationship between the PWA's performance using the AAC when identifying the picture by description (N=10), high structure/high complexity (HS/HC) task, and executive function skills. There was not a significant correlation between the D-KEFS Towers Test scores and the high structure/high complexity task (r=.42; p-value=.12). There was no significant correlation between the HS/HC task and scores on the CLQT – Symbol Trails and Mazes, WCST, or D-KEFS Design Fluency (see table 17).

Table 17

Use of AAC in High Structure/High Complexity (HS/HC) Task-Identification of picture by description scores are compared to EF tests in persons with aphasia (PWA)**:** Number of targets correctly used on the AAC (N=10) are compared are compared to executive function test scores of accuracy. Executive function tests include: CLQT/Symbol Trails (ST); CLQT/Mazes (M); WCST; D-KEFS/Tower Test (T); and, D-KEFS/Design Fluency (DF).

PWA	**HS/HC**	**CLQT/ST**	**CLQT/M**	**WCST**	**D-KEFS/T**	**D-KEFS/DF**
1	1	1	1	0.53	0.63	0.92
2	0.9	1	1	0.57	0.43	0.66
3	1	0.8	1	0.56	0.87	0.86
4	0.9	0.7	1	0.34	0.53	0.77
5	0.8	0.3	0.63	0.26	0.37	0.65
6	0.8	1	0.88	0.50	0.43	0.46
7	0.9	1	1	0.42	0.43	0.96
8	0.7	0.8	0.50	0.51	0.33	0.78
9	0.7	1	1	0.59	0.37	0.73
10	0.8	1	0.50	0.57	0.33	0.69
11	1	1	0.50	0.40	0.43	0.75
12	0.5	0.9	0.88	0.24	0.37	0.82
13	1	0.1	0.50	0.56	0.40	0.50
14	1	0.7	0.50	0.48	0.37	0.79
15	0.9	0.6	0	0.24	0.23	0.44
r		**-0.20**	**-0.10**	**0.29**	**0.42**	**0.01**
p-value		**0.47**	**0.71**	**0.30**	**0.12**	**0.97**

To determine the possible influence of the PWA's auditory comprehension, auditory word recognition, verbal naming and fluency on their performance during the various AAC exposure tasks, a Pearson Correlation Coefficient was conducted. There was a strong correlation between scores on the WAB-Auditory Comprehension subtests (raw score) and the following AAC tasks: LS/HC (board use during conversation task); HS/LC (spoken word-to-picture matching task); and, HS/HC (ID picture by description) with all p-values <.003. There was a strong correlation between the WAB-Auditory Comprehension/Word Recognition subtest and the HS/LC task and HS/HC task with both p-values < .002. When comparing the WAB-Verbal Naming subtest scores with the AAC task performance a Pearson Correlation Coefficient indicated a strong relationship with p-values of <.03 for the LS/HC, HS/LC, and HS/HC tasks. There was also a strong correlation between the WAB-Fluency subtest scores and the LS/HC, HS/LC and HS/HC AAC tasks with all p-values <.03. Thus, it appears that the integrity of the PWA's linguistic skills often predicted the degree of success during performance on the communication board pointing tasks.

To investigate the possible influence of auditory comprehension, verbal naming and fluency on the PWA's ability to retell the digitally-taped stories (story 2 & 3), a Pearson Correlation Coefficient was completed. For story retelling using Board 2 the total number of correctly used symbols and the number of successful switches to the nonverbal mode divided by the number of opportunities to switch was compared to the WAB – Auditory Comprehension, Verbal Naming and Fluency subtest scores. There was not a correlation between the number of correctly used symbols and the Auditory Comprehension (r=.45; p-value-.09) and Fluency (r=.32; p-value=.25) scores. There was not a correlation between the number of successful switches and the Verbal Naming subtest scores (r=.31; p-value=.27).

In addition, a comparison of Auditory Comprehension, Verbal Naming and Fluency subtest scores with performance on the experimental story-retelling task using Board 3 was conducted. A Pearson Correlation Coefficient showed that there was not a significant correlation between the number of correctly used symbols on the AAC and the WAB-Auditory Comprehension scores (r=.41; p-value=.12). When comparing the proportion of successful switches to the nonverbal mode, with the WAB subtests there was not a significant correlation between the Verbal Naming (r=.49; p-value=.07) and Fluency (r=.39; p-value=.15) subtests. Although the relative strength or weakness of the individual's auditory comprehension and verbal expression abilities would seem to influence AAC competency, these comparisons were not statistically significant.

Interestingly, during the story retelling tasks with Board 2 and 3 five of the 15 individuals with aphasia did not utilize any particular sequential order when retelling the stories. In addition, these five PWA had a mean WAB-Aphasia Quotient of 25.6 (Range=17-36) and severe expressive aphasia. When attempting to retell story 2, PWA #4 was able to sequence 2/10 picture symbols correctly. However, the remaining PWA did not demonstrate any correct order when sequencing the pictured items to retell the story (0/10 correct). Four of these five subjects displayed perseverative errors as well (Mean=3). There was a slight increase in successful sequential ordering of symbols when retelling story 3. Four of the five subjects had at least 1 correct sequencing event (Mean=1.75; Range=1-3). However, perseverative errors persisted with 5/5 subjects (Mean=2.8; Range=1-5). Thus it appears that, the more severe the aphasia the greater the prevalence of sequencing impairment and perseverative errors.

Chapter IV: Discussion

This research study was focused on the possible relationship between executive function skills and linguistically and nonlinguistically-based activities in a group of persons with aphasia secondary to left frontal lobe infarct. Based upon a review of the literature, it was hypothesized that tasks of low structure would be more difficult than tasks of high structure for these individuals, and that tasks of high complexity would be more difficult than tasks of low complexity. Thus, it was predicted that tasks both low in structure and high in complexity would be particularly difficult for these individuals. Comparisons have been drawn between PWA and normal control subjects across a variety of executive function, linguistic tasks and non-linguistic tasks, and this has led to several conclusions about PWA and control group performance in this study. In this chapter, these conclusions are discussed as they relate to previous research and to the particular conditions of this study.

Fifteen persons with aphasia (PWA) and 15 normal control subjects were tested. Several measures of executive function were completed, along with the following experimental procedures: the linguistically-based tasks involving use of a simple picture pointing board to answer questions or to retell a short story; and, the non-linguistically-based task involved using a picture map to locate a targeted room in the therapy building. The performances of the PWA and control group have been compared between groups and within the PWA group, and these findings are interpreted within the context of the research questions that were posed in Chapter One.

Research Question 1: Do adults with left frontal lobe lesions perform significantly worse than matched healthy volunteers in a novel route-finding activity, a story retelling task, and selected tests of executive function?

The Executive Function Route Finding Task (Boyd & Sauter, 1994) was designed to be used in a naturalistic setting while using a standardized assessment tool to evaluate the executive function skills of initiation, planning, organizational skills and integration of information. The authors of this test originally intended it to be a relatively difficult task with high complexity in that the participants were required to find the predetermined destination within a building complex with a minimum of five choice points and one change in floor level. Graphic signs were to be used by the participants as well as a map and the examinees were encouraged to ask hospital personnel or visitors for help as needed. Due to the presence of aphasia which resulted in compromised reading comprehension and a high incidence of impaired mobility with many of the subjects in the current study, the EFRT was simplified. The subjects did not have to change floors to locate the targeted room and there was one choice point instead of five. Thus, the original complexity of the task was reduced, and the task complexity was low relative to the executive function tasks used in this study. Nevertheless, the original 4-point rating scale was utilized during this study to measure the degree to which the subject was dependent on the examiner for: 1) task comprehension; 2) seeking information; 3) remembering instructions; 4) detecting errors; 5) correcting errors; and, 6) maintaining “on-task” behavior.

The control group scored higher than the individuals with aphasia on the 24-point rating scale. One of the differences in performance between the two groups was that the PWA often wandered “aimlessly”, perseverated on errors or could not easily detect their mistakes. The Control group did not require any assistance and were able to complete the task with 100% accuracy.

The Cognitive Linguistic Quick Test (Helm-Estabrooks, 2001) was designed to be utilized with PWA because of its non-linguistic presentation. The Symbols Trails subtest assesses planning, working memory and mental flexibility in three circumstances of increased difficulty. There was a trend toward a statistically significant difference in performance between the PWA and the Control group. Both groups demonstrated the ability to remember the rules and could effectively plan their moves during this relatively brief test. The Mazes subtest of the CLQT requires the executive function skills of planning, inhibiting incorrect choices and error correction. The control group completed the mazes with significantly fewer errors than the PWA group. Many of the PWA were unable to complete the maze in the allotted time, apparently due to poor planning skills.

Performance when retelling a short, digitally-taped story from the Arizona Battery for Communication Disorders of Dementia (Bayles & Tomoeda, 1993) was compared across the PWA and control groups. The individuals with aphasia were instructed to retell the digitally-taped story in detail using any means of communication (e.g., verbal, gestures, picture board) while the control group was specifically instructed to use the picture pointing board when retelling the story. Task performance was scored in two ways: ability to switch from the verbal mode to nonverbal mode, when necessary; and, 2) ability to correctly use the target symbols on the picture pointing board. There was a significant difference between the PWA and control groups in ability to switch to a nonverbal mode to convey the story accurately. In addition, the control group spontaneously used more of the target symbols on the board correctly compared to the PWA group. Two patterns of behavior were observed in the PWA: a) they persisted in using the verbal mode more than a nonverbal mode even though they deleted important components of the story; and, b) they consistently looked at the picture board when attempting to verbally retell the story even though they did not point to the appropriate symbol to relay the concept. It is likely that the picture pointing board helped some individuals in the PWA group to retrieve and organize the concepts when retelling the story. Furthermore, due to the readily available picture pointing board there was less demand on the PWA to initiate an alternate mode of communication. Interestingly, as noted below, five members of the PWA group were still unable to organize and sequence the story.

Research Question 2: What is the relationship between speech/language dysfunction and level of executive function in PWA due to left frontal lobe lesions?

Comparison of the Aphasia Quotient Score (WAB; Kertesz, 1982) to the five standardized executive function tests of limited linguistic complexity (CLQT-Symbol Trails, Mazes; WCST; D-KEFS-Towers Test & Design Fluency) in the PWA group showed a statistically insignificant relationship between the WAB/AQ and the WCST, CLQT-Symbol Trails & Mazes, Towers Test and Design Fluency subtests. To determine the possible influence of various receptive and expressive language components on tasks requiring executive function activation an in-depth analysis was completed comparing the Auditory Comprehension (AC), Verbal Naming (VN) and Aphasia Quotient (AQ) scores from the WAB to the WCST-Perseverative Error Score. A significant correlation was found between the WAB-AQ, AC and VN scores and the number of perseverative errors when attempting to determine the appropriate rule for each category group in the WCST. Most of the subjects in this study found the WCST to be difficult in that they had trouble determining the rule for each category and the complexity of the task was compounded when the rule changed. This high complexity usually resulted in the perseveration of errors secondary to the PWA's inability to shift behaviors. Results of this study are consistent with other studies that have shown that individuals with brain injury (specifically frontal lobe injury) have trouble completing categories and have frequent perseverative responses (Heaton, 1981).

It is of interest to note that this perseverative behavior was also observed with the PWA group during communicative tasks. For example, the PWA repeatedly attempted to verbalize a concept using an incorrect word during conversation, apparently lacking the ability to identify this ineffective pattern of communication and/or the ability to self-correct. This perseverative tendency was particularly pronounced during non-structured conversational tasks.

There was a significant correlation between the WAB-Verbal Naming scores and the Total Number Correct on the WCST. This has two implications. First, that successful performance on the WCST may rely to some degree on linguistic mediation or processing (Keil & Kaszniak, 2002). Due to the complexity and novelty of the WCST it may place an increased demand on the PWA's comprehension, which may result in a misunderstanding of the task instructions. Secondly, the more severe the expressive aphasia the poorer the performance on the WCST. Performance may be related to the extent of the lesion. The larger the area of infarct within the gray and white matter the greater the likelihood of language and cognitive impairment.

When comparing the Towers Test-Number of Rule Violation Score to the WAB-AQ, AC and VN scores a significant correlation was found. It seemed that the PWA had difficulty planning their moves and remembering the rules for moving the tower pieces therefore they perseverated on erroneous move patterns. As previous studies have indicated (Burgio & Basso, 1997; Caspari, et al, 1998; Francis et al, 2003; Mayer & Murray, 2002) short-term and working memory may often be compromised in PWA. In addition, impairments in novel planning, problem solving and rule adherence have been attributed to frontal lobe damage in individuals with aphasia (Glosser & Goodglass, 1990). Therefore, it is possible that the PWA in this study had difficulty with the mental manipulation of the task rules (working memory) while trying to successfully move the Tower pieces to duplicate the target design. In addition, concomitant deficits with planning and problem solving may have compounded the PWA's ability to successfully complete the Towers Test. In other words, task inefficiency was likely due to impairments of memory and planning.

In conclusion, the statistical analyses conducted with this sample size of 15 PWA indicates that the severity of the individual's aphasia may not always predict performance on executive function tasks. However, as previously mentioned many of the individuals with a severe expressive aphasia repeatedly attempted to verbalize information in an unsuccessful manner (i.e., the listener did not comprehend the message). They appeared to lack the ability to generate an alternate method for communication, to self-monitor and to self-correct their pattern especially during casual, unstructured communication attempts. Based on this observation, it may be that some of the executive function tests currently used in the literature are not sensitive enough to detect impairments in individuals with aphasia. They may lack the "ecological validity", or the ability to obtain a strong correlation between results gathered in a controlled experimental condition and with those obtained in a naturalistic setting (Tupper & Cicerone, 1990). The problem with many "laboratory experimental studies" may be that they do not always capture all of the novelty and unexpected influences that can occur in more naturalistic communicative settings. Recently, Donovan, Kendall, Heaton, Kwon, Velozo & Duncan (2008) addressed the need for the development of a measure of functional cognition (the ability to accomplish everyday activities that rely on cognitive ability e.g., conveying information, planning activities). Their goal was to expand upon traditional neuropsycholgical assessment of cognitive impairment by identifying relevant domains for an ecologically valid measure of functional cognition for stroke survivors. They identified 10 domains (language, reading/writing, numeric calculation, visuospatial function, social use of language, attention, executive function, memory, emotional function and limb praxis) to be used in developing a computer adaptive measure of functional cognition. The authors also stressed the importance of the development and utilization of tools that are reflective of activities of daily living such as the World Health Organization International Classification of Functioning Disability and Health States (ICF; 2001) activity measure. The ICF distinguishes body structure and impairment from activity and participation (e.g., function and successful fulfillment of life roles). Patient reported outcome measures are another method for obtaining patient functional activity perspectives. Perhaps the use of more patient/family questionnaires regarding functional communication and performance during activities of daily living and/or observational performance tasks might be more revealing about the integrity of the individual's executive function system.

There are several commonly used patient and/or caregiver rating scales that are specific to executive function abilities. The following are some examples: 1) The Dysexecutive Questionnaire (DEX; Wilson, Alderman, Burgess, Emslie & Evans, 1996). This 20-item survey contains questions related to the patient's initiation, planning and functional problem solving; 2) The Brock Adaptive Functioning Questionnaire (BAFQ; Dywan & Segalowitz, 1996). This survey provides for self and caregiver reporting on 12 scales designed to evaluate the patient's level of executive function within a daily context; and, 3) Profiles of the Executive Control System (PRO-EX; Braswell, Hartry, Hoornbeck, Hohansen, Johnson, Shultz & Sohlberg, 1993). The PRO-EX scale is designed to be completed by caregiver or staff members. It contains a rating scale of goal selection, planning, sequencing, initiation, executive time-sense, awareness of deficits and self-monitoring.

Question 3: Is there a relationship between level of executive function and performance in a novel-route finding activity in adults with left frontal lobe lesions?

The executive function test scores from the CLQT-Symbols Trails & Mazes, the WCST, and the D-KEFS Tower Test & Design Fluency were compared to the PWA's performance on the EFRT. There was no significant correlation between any of the executive function tests and the Executive Route-Finding Task. As previously mentioned, the reason for this finding may be due to the simplification of the task to accommodate the PWA's auditory/reading comprehension and mobility impairments. However, it is of interest to report that the individual subjects with the poorest scores on the EFRT showed working memory scores of less than or equal to 3 indicating an impaired working memory system. These individuals failed to use their map consistently, frequently passed the target without attending to a yellow star marking the target door and needed more verbal cues from the examiner. This pattern of behavior is consistent with the results of previous executive function studies that examined the influence of attention allocation on task performance (e.g., Stuss, 2006; Norman & Shallice, 1986), the incidence of working memory deficits and the generation and application of strategies (Keil & Kaszniak, 2002) for the successful completion of a novel task. These researchers suggested that the frontal lobes and their supporting networks have specific roles for completing various attentional tasks that are dependent on the type and complexity of the task at hand. That is, these researchers have suggested that the more novel and complex the task, especially when environmental distractions are present, the greater the demand for frontal lobe activation.

Question 4: Is there a relationship between level of executive function and performance in using a linguistically-based AAC device in PWA secondary to frontal lobe lesions?

Two hypotheses were addressed in regard to this research question: 1) that the severity of the EF impairment would determine the level of performance during unstructured, simple and complex tasks using an AAC device; and, 2) that persons with aphasia and executive function impairment would perform better on low complexity/high structure tasks (spoken word-to-picture) compared to high complexity/low structured (conversational) tasks.

In an attempt to determine the PWA's initial competency level for using a simple picture communication board, a baseline score was obtained during Session Two. The subjects viewed a 1.5 minute digitally-taped story based on the CLQT Story Retelling Task using communication board 2. Immediately following the DVD presentation they were instructed to retell the story using any communicative method they desired. Their performance was scored by looking at the number of times they switched to a nonverbal method when their attempts to verbalize the concept failed, and by looking at the number of times they spontaneously used a correct symbol to retell a concept. During Session 3, a repeat presentation of the CLQT Story occurred after three AAC exposure tasks. The exposure tasks were designed to help the aphasic individuals become more familiar with the picture pointing boards presumably making the implementation of the AAC more familiar and natural. A comparison was made between scores obtained from the baseline story retelling with board 2 and the second trial using board 2. The total number of switches from verbal to nonverbal mode increased between the baseline story retelling task and the second trial with Story Retelling using board 2. Therefore, it appears that the more practice the PWA had using the AAC device under similar circumstances the easier it was to change from verbal to nonverbal mode when attempts to verbalize were ineffective. In addition, during Session 3, the PWA viewed a new digitally-taped story, based on the ABCD Story Retelling Subtest. Once again, they were asked to retell the story immediately following the presentation by using any mode of communication. A picture pointing board was placed in front of the PWA for use as needed. An analysis of symbol usage showed that there was a progressive increase in the number of symbols correctly used when comparing baseline story retelling performance to this third story retelling task. There was no significant correlation between the number of successful switches when using board 2 (CLQT-Story Retelling, second trial) compared to board 3 (ABCD, Story Retelling). In the former comparison the increased in symbol usage may have been due to the repeated exposure to tasks with similar demands.

In an attempt to investigate the PWA's ability to perform during linguistic tasks of high and low complexity in structured and unstructured settings, a communication board exposure task was implemented. Raw scores were obtained during tasks of low complexity/low structure (e.g., "Greeting" portion of CADL), low complexity/high structure (e.g., word to picture matching), high complexity/high structure (e.g., ID picture by function), and high complexity/low structure (e.g., answering questions during conversation). Results from this analysis indicated that the individuals with aphasia and executive function impairment performed better with tasks of low complexity in a structured setting. These findings support Stuss' Fractionation and Integration Theory (2006) whereby task demand dictates the amount and extent of frontal lobe activation. The frontal and posterior lobes are recruited for tasks of high complexity and they must be adaptable for successful task completion. According to Stuss (2006), this adaptability means that the frontal lobe attentional processes are not exclusively linked to one cognitive domain such as memory or language. Instead multiple cognitive domains may be simultaneously recruited to complete tasks of high complexity.

In the current study, a strong correlation was found between the low structure/high complexity task (conversational task) and the WCST (total number correct). This correlation may be representative of the WCST's requirement for independently forming abstract concepts. There was a moderate correlation between both the low structure/high complexity task and the high structure/high complexity task, and the D-KEFS Tower Test. However, no correlation was found between the high structure/low complexity task (spoken word-to-picture match) and any of the executive function tests. The majority of the PWA reported that they found this task to be very easy and test scores were high for each PWA in the study.

Detailed analyses of the influence of auditory comprehension, auditory word recognition, verbal naming and fluency on performance during the AAC exposure tasks indicated that the relative strength or weakness of the individual's linguistic capabilities often predicted success when utilizing an AAC device. Subsequently, this study showed a nonsignificant but moderate correlation between the PWA's auditory comprehension, verbal naming and fluency scores (WAB) and the individual's ability to efficiently retell both stories 2 and 3 with the picture pointing boards. Thus, the number of moderate to high correlations found indicates that there is some degree of relationship between severity of aphasia and successful implementation of an AAC device. Furthermore, as Stuss (2006) indicated, the severity of one's aphasia may depend on the extent of frontal and frontal-subcortical circuit damage. This frontal-subcortical circuit is also paramount for successful completion of complex executive function tasks.

For five of the subjects who were diagnosed with severe expressive aphasia, there was evidence of sequencing impairment, along with difficulties in inhibiting irrelevant behaviors and shifting behaviors between concepts and actions. These individuals who had the most difficulty in correctly sequencing the symbols to retell the stories also were extremely perseverative. These difficulties may have been the result of multiple disruptions to the individual's executive function system. Deficits in working memory, attention, language, planning, organizing, regulation of behavior and application of successful strategies for effective communication were apparent in this subset. As previous studies have shown, damage to the left middle cerebral artery distribution system may not only lead to aphasia but may also affect the PWA's executive functioning (Albert et al, 1981; Keil & Kaszniak, 2002; and, Nolte, 1993). The left frontal regions of the brain usually involving Broca's area, the supplementary motor area or connecting tissue can result in expressive aphasia (Keil & Kaszniak, 2002). Subsequently, the bilateral prefrontal lobes are widely connected to cortical and subcortical regions. Numerous studies have linked this large fronto-subcortical system with impairments in planning, sequencing, organizing, attention and inhibition of prepotent or automatic response tendencies (Dempster, 1993; Karatekin et al., 2000; Mesulam, 1990; Stuss & Benson, 1986). Left-sided lesions of the dorsomedial thalamus have been associated with deficits in verbal processing, impaired memory, decreased response initiation and inhibition, decreased judgment and perseverative behaviors (Baumgartner & Regard, 1993). In a study conducted by Damasio (1994), the ability to monitor and modify one's behavior to implement compensatory strategies was found to be reliant on interactions between the frontal and parietal lobes.

Conclusion

The results of this study did not consistently show a significant correlation between executive function and the PWA's ability to communicate effectively using verbal and nonverbal methods. Perhaps the lack of consistent support for the influence of executive function skills on functional communication capabilities is due to the relatively small sample size utilized in this study and the possibility that the executive function tests assess other skills in addition to executive function (e.g., memory, attention). For example, Spreen & Strauss (1998) reported that the WCST not only assesses the client's ability to form abstract concepts, shift and maintain set and utilize feedback but successful performance on the test also requires intact attention and working memory skills. In addition to being recognized as a test of problem solving and planning, the D-

KEFS Towers Test has been described as a sensitive assessment of self-monitoring/inhibition, memory and processing speed (Yockim, Baldo, Kane & Delis, 2009).

Previous researchers have found that test performance may not always be the best method for detecting evidence of executive function impairment, because standardized tests typically provide an external structure for the patient. This structure may reduce test sensitivity to detection of any executive function impairments (Shallice & Burgess, 1991). Real-life tasks may have greater ecological validity. For example, Norris and Tate's study (2000) with 36 neurologically impaired subjects (19 TBI; 17 MS) found that the ecological validity of the Behavioral Assessment of the Dysexecutive Syndrome (BADS) was superior to standard executive tests (WCST, Trail Making Test, Rey-Osterreith Complex Figure Test, Porteus Maze, Cognitive Estimation Test, and Controlled word Association Test) for predicting competency in role functioning (e.g., ADL & advanced ADL). For predicting how the individual may perform in functional contexts, some researchers have suggested that observation and family reports may be more revealing (Lezak, 1982; Norris & Tate, 2000; Ylvisaker and Szekeres, 1989). Lezak (1982) points out that standardized testing by its very nature compensates for the many debilitating executive impairments that the head-injured population incurs. The individual that typically has difficulty setting goals, planning and monitoring activities, and motivating themselves to initiate activity are told by the examiner what to do and when during testing. Subsequently, patients that have difficulty with attention or inhibition may perform well in the highly structured and distraction-free environment of the examination room. For these reasons, individuals with executive function impairment often perform better during formalized assessment than they may in the home, school or work setting. Lezak stresses the importance of using a combination of observation, interview, metacognitive questionnaires, and standardized executive function tests when assessing head-injured patients.

The informal procedures that were not part of this experiment but surrounded the implementation of the study support this hypothesis. For example, during informal conversation with subjects 2, 3, 4, 5, 6, 8, 12, and 15 in the current study it was noted that they rarely initiated the use of an alternate communication mode when verbal attempts failed to relay their intended message. However, during this study the subjects did not have significant trouble switching to an AAC device because they were instructed to do so and the picture pointing board was placed in front of them for easy access (though they did attempt with significantly lower frequency that the control group). Structure was provided in some manner throughout the experiment unlike unpredictable conversational exchanges that might be encountered throughout the PWA's day.

The current study provides some preliminary data about the relationship between executive function skills and performance during linguistic and non-linguistic activities. Similar to Purdy's (1992) study comparing PWA's linguistic competency using an AAC device to performance on standardized test of executive function, a strong correlation was not observed between the two measures. However, data from Purdy's research and the current study indicate some degree of relationship. The difficulty that many PWA have in successfully using an AAC device in an unstructured setting appears to be due to compounding factors related to the individual's linguistic competency and also to the need for outside structure and direction. Future studies should incorporate patient/family questionnaires regarding performance when communicating complex ideas as well as performance during advanced activities of daily living (e.g., preparing meals, shopping, driving) to supplement the executive function test performance.

There are several clinical implications of this study. First, the PWA needed structure to complete the experimental communication tasks and the picture pointing boards provided that structure in that the symbols necessary for relaying the targeted concept were provided for the subjects. As previously noted above, informal (unstructured) conversational tasks between the examiner and PWA frequently resulted in incomplete delivery of the intended message on the part of the PWA. When the PWA was unable to retrieve the intended word(s) they discontinued their communication attempt. They did not spontaneously initiate an alternative mode of communication. Therefore, it is possible that specifically training symbol acquisition and then providing multiple functional opportunities for symbol usage will lead to increased initiation of the AAC device. Secondly, there may have been other factors besides executive function skills that influenced the communicative competence of the subjects with aphasia. For example, McNeil, Odell & Tseng (1991) found that attention and pragmatic skills often affect communicative competence. Baddeley and Hitch (1974) suggested that there was a strong correlation between working memory and executive function competence. Therefore, it makes sense that speech-language pathologists assess cognition and language simultaneously as part of their diagnostic protocol. This may be done informally and/or formally during treatment sessions, ideally in collaboration with a neuropsychologist. In addition, cognitive skills should be assessed in structured as well as unstructured settings. The information obtained from standardized assessment, patient/family questionnaires and informal observations may result in a more effective treatment plan that enhances the PWA's ability to learn compensatory strategies as well as to implement the strategies independently outside the therapy room.

Ongoing studies that analyze the effectiveness of treating aphasia along with concomitant cognitive deficits will continue to shed light on the impact of cognitive-linguistic influences with functional communication in and outside of the therapy setting. As mentioned above, there have not been any treatment studies that specifically look at the effect of simultaneously treating executive function deficits and language impairments. However, previous studies (mentioned above) have shown some success when simultaneously treating attention and working memory with auditory and reading comprehension (Francis et al., 2003; Helm-Estabrooks et al., 2000; and, Mayer & Murray, 2002). Interestingly, post-treatment generalization was fair to poor for many of the targeted cognitive-linguistic areas.

Appendix A

Communication Board (AAC device) and Background Questionnaire

Subject Code:

Education:

Medical History:

Developmental History:

Aphasia Treatment History:

Current Medications:

Speech/Language Diagnosis (Group 1 only):

1. What type of alternative communication device (picture communication board, alphabet board, electronic device) have you used in the past?
2. Did you find the device helpful?

3. How often did you use the device?
   a) Every day
   b) Less than once a week?
   c) More than once a week?
   d) Less than once a month?
   e) More than once a month?
   f) Other

4. If the device is not used often, what would you say was the primary reason?

Appendix B

(ABCD; Bayles & Tomoeda, 1993)

SPEECH DISCRIMINATION SCREENING:

INSTRUCTIONS: "I am going to say some words. Listen closely and tell me if the words are the same. If the words are exactly the same, say "yes". If they are not the same, say "no". For example, listen to these words: THAT VAT. Do they sound the same? Now listen to these words: DOG DOG. Do they sound the same?"

SCORING: One point is awarded for each correct discrimination. One repetition is permitted.

INTERPRETATION: In order to pass the screening, subject must be able to accurately discriminate at least 70 percent of the items.

1. bare dare (N)
2. past fast (N)
3. home home (Y)
4. thin shin (N)
5. sharp sharp (Y)
6. cheap jeep (N)
7. gave gave (Y)
8. day they (N)
9. town town (Y)
10. zip zip (Y)
11. gum gum (Y)
12. vase face (N)
13. bat pat (N)
14. hop hop (Y)
15. vote boat (N)
16. cheese cheese (Y)
17. soil foil (N)
18. vine vine (Y)

Appendix C

List of stimulus pictures for training board #1: (HF words = 7; MF/LF words = 5)

Car	Hit
Boy	Eat
Gasoline	Drink
Cold	Coat
Mad	Snow
Tire	Sleep

List of stimulus pictures for training board #2: (taken from CLQT; Helm-Estabrooks, 2001. HF words = 7; MF/LF words = 5)

Woman	Pocket
Man	Handkerchief
Ring	Cup
Birthday	Day
Night	Smile
Searched	
Cry	

List of stimulus pictures for training board #3: (taken from ABCD, Bayles & Tomoeda,

1993. HF words = 7; MF/LF words = 5)

Lady	Phone
Wallet	Happy
Store	Fell
Money	Comb
Little Girl	Bed
Home	Check-Out Counter

Appendix D

The variables for scoring during the Structured Conversation Task and Story

Retelling Task(Purdy, 1992):

1. Conv Spon = total number of target symbols correctly used spontaneously;
2. Conv Cue = total number of target symbols correctly used following a cue;
3. Conv Mode = number of target symbols correctly used in each modality;
4. Success Switch = ratio of the number of successful attempts to switch modalities to the number of opportunities to switch. A successful switch is described as correct use of a target symbol following a failed attempt;
5. Unsucc Switch = ratio of the number of unsuccessful attempts to switch modalities to the number of opportunities to switch. An unsuccessful switch is described as a purposeful, but incorrect attempt to communicate following a failed attempt. Random or undifferentiated gesturing is not considered a purposeful attempt, and will be scored as unsuccessful;
6. Total Switch = ratio of the total number of successful and unsuccessful modality switches to the number of opportunities to switch.

The *number of opportunities* to switch modalities will be determined utilizing the following equation (Purdy, 1992):
Total opportunities = (number of opportunities in the spontaneous condition) + (number of opportunities in the cued condition) which equals (N – number of correct verbal responses) + ((N-Conv Spon) – Conv Cued).
For example: Total opportunities = (20-7) + ((20-10) -6)
= 13 + (10-6)
= 13 + 4
= 17

In this example, the subject correctly responded with 7 correct verbal symbols spontaneously. Therefore, the number of opportunities to switch in the spontaneous condition was 13 (20 – 7). He/she spontaneously switched to a nonverbal mode 3 times, so his/her total number of accurate symbols used spontaneously (Conv Spon) was 10 (7+3). Following a cue, he/she responded correctly spontaneously (Conv Cued) 6 times. Therefore, the number of opportunities following a cue was 4 (10-6). Thus, the total number of opportunities possible to switch modalities was 17 (13+4).

Appendix E

Executive Function Route-Finding Task (EFRT; Boyd & Sauter; 1994)

Client's Code Symbol: ______________________________ Date: _____________

Instructions: "I am going to give you an exercise that involves finding an unfamiliar office/room, _______________. I will give you this map to help you. (This room will have a bright yellow star attached to the door; therapist shows the star to client). How you do this is up to you. I will go with you but cannot answer questions about how to find _____________. I want you to do this exercise as quickly and efficiently as possible. Before you begin, I would like you to try and tell me what I have asked you to do."

Scoring System:

I. Task Understanding

1. Failure to grasp nature of task despite several elaborations.
2. Faulty understanding of important element requiring specific or explanatory cuing and elaboration (e.g., "How am I supposed to know where it is?").
3. Distorts peripheral detail requiring slight clarification or a nonspecific cue (e.g., "Can you tell me where it is?").
4. Shows a clear grasp or asks for clarification appropriately (e.g., "Can I get someone to take me there?"). Initiates task spontaneously.

II. Incorporation of Information Seeking

1. Aimless wandering.
2. Follows a hunch without gathering information first (unless shows prior knowledge of destination) or exhaustive door-to-door search.
3. Gathers information before commencing search, but without appraisal of information source.
4. Shows judgment in use of information sources (e.g., selects staff over clients; clarifies confusing directions; verifies information with another person).

III. Retaining Directions (functional memory)

1. Continual forgetting of directions or name of destination and failure to use suggested means of compensating (e.g., note taking) unless cued repeatedly.
2. Needs repeated nonspecific cuing or provision of concrete strategy for coping with memory deficits.
3. Forgets detail(s) but compensates after nonspecific cue (e.g., "How might you keep yourself from forgetting the destination?").
4. Paraphrasing or clarification sufficient for remembering, spontaneous compensation (e.g., note taking).

IV. Error Detection (self-monitoring)

1. Continued errors without self-detection even after repeated examiner cues.
2. Some spontaneous awareness of errors, but more instances of cuing required.
3. Some cuing required, but more instances of spontaneous error detection shown.
4. Verifies correctness independently when appropriate; may exploit incidental information (e.g., signs) to prevent errors.

V. Error Correction (troubleshooting)

1. Helpless or perseverative behavior.
2. Inefficient strategy (e.g., returns to original information source).
3. Seeks help immediately once aware of error.
4. Reasons efficiently (e.g., looks for signs; considers where he or she may have erred in following directions to self-correct independently).

VI. On-Task Behavior

1. Must be held to task in ongoing fashion (e.g., distractible, stimulus-bound).
2. Digression from task requiring cues to redirect attention to task needed.
3. Incidental behaviors (e.g., small talk) interfere with efficiency.
4. Any incidental behaviors (e.g., waving to a friend) do not hinder performance observably.

Contributory Problems

Emotional
___Indifference, lack of effort
___Frustration, intolerance
___Self-criticism; depression
___Defensiveness
___Thought disturbance
___Euphoria, mania
___Other

Communication
___Speech reception
___Expressive speech
___Reading ability
___ Writing ability
___Other

Interpersonal
___Self-consciousness, shyness
___Social skills
___Setting context for requested information
___Flirting
___Interrupting
___Other

Perceptual
___Visual acuity
___Auditory acuity
___Right/left confusion
___Neglect
___Other visuospatial problem

Appendix F

Procedure Overview for Group 1

Session 1

1. Review and complete consent form procedures
2. Questionnaire
3. Communication board screening task using Board 1 (Estimated time for all preliminary procedures = 15 minutes. If subject passes the communication board screening, testing will begin).

Test	Estimated Time
1. Hearing screening with audiometer	5 mins.
2. Speech discrimination task (ABCD)	5 mins.
3. Communication Activities of Daily Living-2	30 mins.
4. Visual fields screening (ABCD)	5 mins.
5. Picture pointing span test	5 mins.
6. Peabody Picture Vocabulary Test (PPVT)	10 mins.

Session 2

Test	Estimated Time
1. Baseline Story Retelling Task using Board 2	10 mins.
2. Western Aphasia Battery and Apraxia Subtest	40 mins.
3. Communication board exposure task using Board 1	30 mins.
4. Selected subtests of the Cognitive Linguistic Quick Test	10 mins.

***5-7 day delay period before session 3**

Session 3

Test	Estimated Time
1. Story Retelling Task using Board 2	10 mins.
2. D-KEFS: Design Fluency	5 mins.
3. Wisconsin Card Sorting Test	20 mins.
4. D-KEFS: Tower Test	15 mins.
5. Executive Function Route-Finding Task	15 mins.
6. Story Retelling Task using Board 3	10 mins.

Appendix F

Procedure Overview for Group 2

Session 1	Estimated Time
1. Review signed consent form and medical/developmental hx	10 mins.
2. Selected subtests of the CLQT	20 mins.
3. Story Retell Task with Board 2	10 mins.
.	

*5-7 day delay period before session 2

Session 2	
1. Story Retell Task/DVD with Board 3	10-15 mins.
.	
2. Executive Function Route Finding Task	10 mins.

Appendix G

Sequence of Executive Function Tests and Experimental Board Tasks (Group 1)

Session 2

Form A

1. Baseline digitally-taped story retell task (Board 2)
2. Selected subtests of the Cognitive Linguistic Quick Test
3. Western Aphasia Battery and Apraxia Subtest
4. Experimental communication board exposure task (Board 1)

Form B

1. Baseline DVD story retell task (Board 2)
2. Western Aphasia Battery and Apraxia Subtest
3. Selected subtests of the Cognitive Linguistic Quick Test
4. Experimental communication board exposure task (Board 1)

Session 3

Form A

1. Story Retell Task/DVD (Board 2)
2. D-KEFS: Tower Test
3. Wisconsin Card Sorting Test
4. D-KEFS: Design Fluency
5. Executive Function Route Finding Task
6. Story Retell Task/DVD (Board 3)

Form B

1. Story Retell Task/DVD (Board 2)
2. Executive Function Route Finding Task
3. D-KEFS: Design Fluency
4. D-KEFS: Tower Test
5. Story Retell Task/DVD (Board 3)
6. Wisconsin Card Sorting Test

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ABSTRACT

COMMUNICATIVE COMPETENCE IN PERSONS WITH APHASIA: THE IMPACT OF EXECUTIVE FUNCTION

by

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August 2010

Advisor: Dr. Margaret Greenwald

Major: Speech-Language Pathology

Degree: Doctor of Philosophy

The purpose of this study was to examine the relationship between executive function and performance on selected linguistic and non-linguistic tasks in persons with aphasia secondary to left frontal lobe lesions.

A group of fifteen persons with aphasia (PWA) completed three communication board tasks of varying levels of complexity and structure. The subject's functional use of the picture/word communication board was tested during a Story Retelling task. In addition, the PWA's executive function skills were examined using six nonverbal tests. The PWA group performance scores were compared to that of the neurologically healthy control group.

Results demonstrated that the control group performed significantly better than the PWA group during 2 of the 3 executive function tests. In addition, the control group was more proficient at switching modalities and spontaneously using the target symbols correctly on the picture communication board compared to the PWA group during a story retelling task. There was no significant correlation found when comparing the PWA's language skills and executive function using standardized tools. However, during many of the executive function tests the PWA tended to consistently demonstrate the following error types: perseveration, poor planning

and decreased memory of task rules. When given picture pointing board tasks of high and low complexity during a highly structured or relatively unstructured environment, the PWA consistently performed better with the low complexity tasks in a structured environment. While the study showed that aphasia severity can not consistently predict performance on tests of executive function there were some noteworthy behavioral patterns observed during both the executive function and communication board tasks. The PWA demonstrated difficulty with planning, mental flexibility and self-monitoring. In addition, response accuracy was usually dependent on the provision of task structure.

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