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# VERB USE IN ALS

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Abstract

Selective verb impairment on discourse tasks exist in individuals with aphasia, and neurodegenerative diseases like Alzheimer's disease and primary progressive aphasia. No research to date has examined verb use in individuals with ALS on discourse tasks. The purpose of this study was to examine the nature of verb impairment in individuals with ALS for discourse tasks, including the Cookie Theft Picture description task from the Boston Diagnostic Aphasia Examination and a topic directed interview (TDI).The ALS and control participants did not differ significantly on the total number of verbs, regular and irregular verb production on both the tasks. However, ALS participants were significantly different compared to control participants on the number of places of verb argument production for the picture description task. The ALS participants produced fewer Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments than controls. The ALS participants and controls did not differ significantly on the number of places of verb argument production for the TDI task. In addition, a significant difference in the number of places of verb argument was obtained between the picture description and TDI tasks for ALS participants indicating that verb usage differs according to discourse task. The results of the study indicate verb use problems in the early stages of ALS. Further research across a longitudinal sample is warranted to explore the nature of verb impairment.

*Keywords:* amyotrophic lateral sclerosis (ALS), regular verbs, irregular verbs, verb argument structure, picture description, topic directed interview (TDI).

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# Introduction

Amyotrophic lateral sclerosis (ALS) was first described by Charcot in the nineteenth century as a disorder, which mainly involved the motor neuron. ALS is a neurodegenerative disorder that causes progressive injury and cell death of lower motor neurons of the brainstem and spinal cord, and of upper motor neurons of the cerebral cortex. It is the third most common adult-onset neurodegenerative disease (Brockington, Ince & Shaw, 2006).

The incidence of ALS is uniform across populations of Caucasian origin particularly in Western Europe and North America (Canada and USA) (Cronin, Hardiman & Traynor, 2007). The incidence rate, i.e., number of new diagnoses in a given time frame of ALS is estimated to be 2/100,000 people per year (ALS Society of Canada, 2008). ALS normally affects individuals in their fifth and sixth decades (Strong, 2003). The disease has a peak incidence between 50 and 70 years of age, with men more commonly affected than women at a ratio of about 1.6/1.0 (Eisen & Krieger, 1998; Mitchell & Borasio, 2007). Although ALS demonstrates a male predominance, this difference in frequency between the sexes diminishes with increasing age and decreases in postmenopausal women (Norris, Shepherd & Deny, 1993; Rudnicki, 1999). ALS is a fatal disease and eighty percent of people with ALS die within two to five years of diagnosis (ALS Society of Canada, 2008). The cause of death in ALS is usually due to progressive respiratory failure or broncho-pneumonia (Brockington, Ince, & Shaw, 2006). However, 20% of individuals with ALS survive longer than 5 years and ten percent of those affected may live 10 years or longer (ALS Society of

Canada, 2008 ; Shoesmith & Strong, 2006). Approximately 2,500 to 3,500 Canadians over 18 years of age currently live with ALS (ALS Society of Canada, 2008).

There are three distinct forms of ALS: Classic sporadic ALS, familial ALS, and Western Pacific ALS (Mitsumoto, Chad, & Pioro, 1998). Classic sporadic ALS is the most common form and is non-familial. It constitutes about 90% to 95% of all ALS cases. Symptoms include muscle weakness, muscle atrophy, fasciculations, spasticity, and overactive reflexes (Kazandjian, 1997).

Familial ALS (FALS) is clinically indistinguishable from sporadic ALS and occurs in 5% to10% of all ALS cases. FALS is typically autosomal dominant (Mitchell & Borasio, 2007; Strong, 2006). In 20% to 30% of all FALS cases, variable mutations of Cu/Zn superoxide dismutase (SOD1) occur on chromosome 21q (Mitsumoto, 2006). Apart from SOD1 mutations, other genetic risk factors include chromosome 3p11.2 linked CHMP2B (charged multivesicular protein) mutations (31-34) and chromosome 14q11.2 linked angiogenin/VEGF mutations. FALS is not sex predominant, and typically has a younger age of onset and lower extremity involvement at onset (Mitsumoto, Chad, & Pioro, 1998). Earlier onset of FALS is more likely when the abnormal gene is inherited from male ancestors than from female ancestors who express the disease. In contrast to sporadic ALS, FALS can occur equally in both men and women. Symptoms more often begin in the legs. Individuals with FALS survive an average of 1 to 2 years (Mitsumoto, Chad & Pioro, 1998).

The third form of ALS, the Western Pacific variant, has a 50 to 150 fold higher incidence in the western Pacific Ocean region than in other parts of the world. Three major genetic loci have been identified: the Chamorro people on islands of Guam, Rota, and Tinian in the Marianos chain of Micronesia, Japanese villagers in the Hobara and Kozagawa districts on the Kii Peninsula of Honshu Island in Japan; and the Auyu and Jakai people living inland on the coastal plain of southern West New Guinea, Indonesia (Mitsumoto, Chad, & Pioro, 1998). The islands of Guam are recognized as the site of a remarkable concentration of cases of ALS, with a prevalence estimated to be 420/100,000 (Perl, 2006). Although Western Pacific ALS resembles sporadic ALS clinically, it is a distinct disease because of the Parkinsonism-dementia complex that often is associated with it (Mitsumoto, Chad, & Pioro, 1996).

*Clinical Features of ALS*

ALS is characterized and defined by the presence of abnormalities of upper motor neurons of the cerebral cortex, and lower motor neurons of the brainstem and spinal cord. The involvement of upper motor neurons (UMNS) is indicated by the incongruous presence of active or bristle tendon jerks in a wasted limb, the presence of a Hoffman or a Babinski sign, spasticity and clonus (Brockington et al., 2006). Lower motor neuron degeneration causes muscle weakness, muscle atrophy, fasciculations and muscle cramps (Mitsumoto, Chad & Pioro, 1998).

ALS manifests in either a limb type of onset or a bulbar-onset. Most frequently, ALS symptoms begin bilaterally in the limbs (i.e., limb onset) (Mitsumoto, Chad & Pioro, 1998). Individuals who display limb onset exhibit weakness/clumsiness of the hands, difficulty raising their arms, foot drop, and spasticity of the legs. Twenty-one percent of the individuals with ALS present with bulbar-onset (Strong, 2006). Individuals who present with bulbar-onset complain of initial difficulties with speech and swallowing. They also present with a mixed dysarthria (i.e., combination of both flaccid and spastic dysarthria), sialorrhea (drooling), aspiration and pseudobulbar signs (Brockington et al., 2006; Mitsumoto et al., 1998). Forty-three percent of the individuals with ALS can exhibit characteristics due to involvement of the corticobulbar tracts. In these instances, they show poor emotional control, often characterized by spontaneous or unmotivated crying and laughter in addition to bulbar signs such as stiffness in enunciation, mastication and deglutition (Belsh & Schiffman, 1996; Mitsumoto et al., 1998).

Other clinical features of most forms of ALS include unusual weight loss (ALS cachexia), fatigue, foot and hand deformities due to loss of muscle mass and tone, and loss of respiratory muscle strength (Mitsumoto et al., 1998). There also is involvement of head musculature that results in difficulty among individuals holding their head in an upright position. Moreover, most individuals with ALS exhibit orthopnea, dyspnea, morning headaches, anorexia and daytime somnolence (due to nocturnal $CO_2$ retention) (Brockington, 2006). A small

proportion of individuals complain of sensory impairment like parasthesia and focal pain, ocular palsy, bladder and bowel dysfunction, and decubiti (Mitsumoto, 1998).

*ALS and Cognition*

Historically ALS was considered to be largely restricted to motor neurons while cognition was thought to be intact. Aran (1850) first described a patient who was perfectly conscious of his condition, could remember the most precise details of his disease, and all in all had normal functions except those of movement. Poloni, Capitiani, Mazzini and Ceroni (1986) concluded that cognitive impairment in ALS was "a discrete, seldom occurring event". Their comments can be attributed to using tests that were not sensitive to frontal lobe functioning (i.e., WAIS, digit span, spatial span on a block-tapping test, a prose memory test, and a paired-word learning test) (Bak & Hodges, 2007). More recently however, ALS has been recognized as a multisystem disorder (Strong 1999). Cognitive impairment, but not dementia, has been demonstrated in a substantial proportion of individuals with ALS and who also show deficits on tests of executive function (Abrahams, Leigh, & Goldstein 2005). Hudson (1981) identified 26 cases of sporadic ALS associated with dementia in addition to 10 cases of familial ALS in which ALS was associated with either dementia or parkinsonism. He also observed frontal and fronto-temporal cortical degeneration with neuronal loss, spongiform degeneration prominently within layers 1, 2 and 3, and degeneration of the substantia nigra and the globus pallidus.

Early studies by Gallassi et al. (1985, 1989) demonstrated slight but definitive cognitive impairment with the exception of memory in individuals with ALS. Gallasi and colleagues demonstrated that regions in the cerebral cortex beyond the upper motor neuron (UMN) and lower motor neuron (LMN) were involved in ALS. Iwasaki, Kinoshita, Ikeda, Takamija and Shiojima (1990) concluded that along with other generalized cognitive impairments in individuals with ALS, there are deficits in immediate and delayed logical memory systems and process.

David and Gillham (1986) reported mild degrees of cerebral atrophy in patients with ALS through CT scans. Their findings provide evidence that ALS extends beyond motor neurons. Recent neuroimaging studies have shown reduced regional cerebral blood flow (rCBF) activation in prefrontal cortex of the frontal lobe, insular cortex and anterior thalamus (Abrahams et al., 1995). Reduced rCBF also was found in frontal and anterior temporal cortices (Talbot et al., 1995; Ludolph et al., 1989; Ohnishi et al., 1991). MRI and SPECT studies have shown frontal atrophy with loss of pyramidal neurons in the upper cortex (Abe, Fujimira, Toyooka, Sakoda, Yorifuji, & Yanagihara, 1997), mild atrophy in the anterior lobe (Abe, 2008) and cortical degeneration in the precentral gyrus (Kiernan & Hudson, 1994).

PET studies also have provided substantial evidence for frontal lobe dysfunction in ALS. Ludolph and colleagues (1992) found reduced glucose metabolism in the frontal cortex and in subcortical structures such as the caudate

nucleus and the thalamus. Kew et al. (1993) showed reduced regional cerebral blood flow (rCBF) in the parahippocampal gyrus, the anterior thalamic nuclear complex and the rostral anterior cingulate cortex. Results also showed abnormalities along the limbo-thalamic cortical pathways.

The majority of studies to date on ALS and cognitive impairment have provided growing evidence for the existence of cognitive impairment in ALS. The studies mainly involved the administration of neuropsychologial tests that are sensitive to frontal (executive) functions. Iwaski et al (1990) showed that individuals with ALS exhibited lower scores compared to controls on the Mini-Mental State Examination (Folstein, McHugh, & McHugh, 1975). The neuropsychological tests revealed deficits in verbal and non-verbal fluency tasks (Ludolph et al., 1992; Racowicz & Hodges, 1998), working memory (Portet, Cadillac, Touchon, & Camu, 2001), cognitive flexibility (Strong et al., 1999), and sustained attention (Abe et al., 1997). Deficits also were found in recognition memory for words and faces, visual perception, reasoning, word generation, word fluency (Abrahams et al., 2000; Strong et al., 1999) and executive functions such as planning, organizing, and self-monitoring (Talbot et al.,1995). Impaired performance on the Wisconsin Card Sorting Test (WCST) (Strong et al., 1999) and visual memory tasks (Mantovan et al., 2003) also were shown in individuals with ALS. Moreover individuals with bulbar onset ALS were found to have greater cognitive impairment than those who exhibit limb onset (Strong et al.,

1999). It is estimated that cognitive impairment is seen in almost 50% of individuals with ALS (Strong, Lomen-Hoerth, Caselli, Bigio & Yang, 2003).

*Frontotemporal Lobar Dementia (FTLD) and ALS*

Cognitive symptoms accompanying ALS have been recognized and described since the late 19th Century although, as noted above, not uniformly agreed upon to exist in ALS (Bak & Hodges, 1999; Murphy et al., 2006). ALS has been associated with Parkinson-Dementia Complex (PDC) in the Guamnian Chammaro population. Parkinson-Dementia Complex (PDC) has also been found in Western-Pacific type of ALS. A specific association between ALS and frontal lobe impairment has been postulated with symptoms including emotional changes, memory, language and general intellectual problems, prominent bulbar features, and bilateral frontal and/or temporal lobar atrophy suggestive of fronto-temporal lobar degeneration (FTLD) (Neary et al., 1990; Abrahams et al., 1996; Kew et al., 1993; Abe et al., 1997; Talbot et al., 1995; Massman et al., 1996).

FTLD is defined as "a behavioural syndrome marked by profound alterations in personality and social conduct, inertia and loss of volition or social disinhibition, with relative preservation of memory. Progression is a key component. Speech output is reduced with economical, stereotypic utterances, sometimes echolalia and ultimately mutism" (Strong, 2008, p. 324). In FTLD, memory impairments are consistent with deficits of frontotemporal executive functions rather than a specific deficit of retention wherein individuals exhibit concreteness of thought, perseverant responses and impairments in abstraction,

planning, set shifting and organizational skills (Strong, 2008). Individuals with FTLD exhibit impairment with working memory and mental flexibility (Freedman et al., 2003). Gregory et al., (2002), found significant deficits in social cognition in individuals with FTLD. ALS-frontotemporal dementia (ALS-FTD) is estimated to occur in 3% of the sporadic cases and 15% of the familial type (Bak & Hodges, 2001; Lomen-Hoerth & Murphy, 2005).

FTLD is the neuropathological correlate of the majority of individuals with FTD. To be consistent with the terminology used in the current literature, the use of the term FTD in this document will be restricted to the overall clinical spectrum of frontotemporal dementia including its three clinically recognized variants; (1) the behavioural variant FTD (FTD-bv), (2) progressive nonfluent aphasia (PNFA) and (3) semantic dementia (SD). Interestingly, the most common type is the behavioural variant. It can occur either in isolation or can be associated with cognitive impairment. It is characterized by insidious onset, altered social conduct, impaired regulation of interpersonal conduct, emotional blunting and loss of insight (Strong, 2008).

The behavioural variant has three subtypes which includes one subtype characterized by overactivity, disinhibition, and distractability (disinhibited type), a second subtype characterized by apathy, inertia and loss of volition (apathetic type) and a third subtype characterized by stereotype ritualistic behaviour and conformity to routine (stereotypic type) (Strong, 2008).

The second variant of FTD is a progressive nonfluent aphasia (PNFA) characterized by insidious onset and gradual progression, nonfluent spontaneous spoken language, agrammatism, phonemic paraphasias, anomia, stuttering, poor repetition, early preservation of word meaning, alexia and agraphia (Neary et al., 1998; Strong, 2008).The non-fluent primary progressive aphasia is sometimes the primary clinical diagnoses in individuals who eventually develop ALS-FTD (Hillis et al., 2004). The third subtype of FTD is semantic dementia (SD) which is characterized by loss of meaning for words, impaired recognition of faces and objects, repetitive behaviours with compulsive quality, changes in eating habits and hyperactivity to neutral sensory stimuli (Neary et al., 1998; Strong, 2008).

Although the behavioural variant of ALS (ALS-bv) is the most commonly seen type, individuals diagnosed with it rarely meet the full criteria for the diagnosis of FTD-bv (Strong, 2008). Hence, ALS-behavioural impairment (ALSbi) is used to describe the subgroup of patients who meet partial criteria. The ALSbi is most commonly reflective of the disinhibited behaviours type with clinical features such as blunting of emotions, prominent apathy, lack of apparent concern for disability or appearance, social disinhibition, over-reactivity to sensory stimuli, gluttony, and behavioural sterotypes (Strong, 2008).

The diagnosis of ALSbi requires that individuals meet at least two non-overlapping supportive diagnostic features from either the Neary criteria (i.e., decline in personal hygiene and grooming, mental rigidity and inflexibility, distractibility and impersistence, hyperorality and dietary changes, perseverative

and stereotyped behaviour, utilization behaviour) and/or Hodge's criteria (i.e., loss of insight, disinhibition, restlessness, distractibility, reduced empathy or unconcern for others, lack of foresight or planning, impulsiveness, social withdrawal, apathy or loss of spontaneity, reduced verbal output, verbal stereotypes or echolalia, verbal or motor perseveration, poor self-care, gluttony and hyperactivity). The presence of two behavioural abnormalities should be supported from at least two sources from among a patient interview/observation, caregiver report, or structured questionnaire/interview (Strong et al., 2008).

An ALS-cognitive impairment (ALSci) subgroup is described in individuals with ALS who do not meet the Neary criteria for FTD but who do exhibit deficits in one or more of verbal and design fluency, verbal reasoning, visual attention, initiation of random movements, problem solving and executive functions (Murphy et al., 2007; Strong et al., 2008). To be diagnosed with ALSci, the individual must demonstrate cognitive impairment on standardized neuropsychological testing at or below the 5$^{th}$ percentile, compared to age and education-matched norms, on at least two distinct cognitive tests sensitive to executive functioning. The assessment of cognitive impairment requires careful delineation of comorbidities to ensure that the cognitive impairment is not better explained by other comorbid conditions (Strong et al., 2008).

*The Cognitive Spectrum in ALS*

Although there is clear and mounting evidence about the existence of cognitive impairment in ALS, findings in the literature are inconsistent about its

prevalence. Cognitive impairments in ALS that are reported in literature range from subtle or mild to moderate and even to severe levels (Abe et al., 1997; Gallasi et al., 1985; Roinghutz et al., 2005; Rottig et al., 2006; Strong et al., 2003). Appel, Ringholtz, and Schulz (2005) studied cognitive performance of 279 individuals with ALS and 129 control participants. They used four methods to assess and to compare cognition including (1) the Mini Mental Status Exam (MMSE) scores, (2) neuropsychological testing cut-off scores, (3) cluster analysis and (4) clinical evaluations based on patient interviews and exam, family interviews, and cognitive testing. They found that approximately 50% of the individuals exhibited some degree of cognitive impairment, 30% of the individuals showed mild impairment with no dementia, while 20% of the individuals displayed a moderate to severe cognitive impairment. They concluded that patterns of cognitive dysfunction in individuals with ALS represent heterogeneity in the range and in the extent of executive, language, and behavioral dysfunctions.

Neuroimaging studies have established the concept of a clinical and anatomic continuum between ALS and FTLD. However, the key question of whether individuals with ALS develop neuropsychological evidence of FTLD prior to or subsequent to progression of disease is still unclear. Abraham and colleagues (2005) studied 20 individuals with ALS at a 6-month interval and found that individuals with ALS had slower word retrieval toward the end of the 6-month interval. Strong and colleagues (1999) studied individuals with ALS over 6-months and found progression of cognitive impairment for both bulbar-onset

and limb-onset individuals. Robinson et al. (2006) concluded that there is a continuum of cognitive impairment over a 6-month period and that the cognitive impairment exists in several domains. Inconsistent findings with progression of cognitive impairment have been reported when individuals with ALS were studied for 12-month and 18-month periods (Kilani et al., 2004; Schreiber et al., 2005).

*Language in ALS without Cognitive Impairment or Dementia*

Language processing in individuals with ALS without cognitive impairment (CI) or dementia has not been studied in depth but rather as one part of general cognitive testing (Cobble, 1998). Recent literature has shown subtle but consistent language deficits in individuals with ALS (Abrahams et al., 2005; Cobble, 1998). The most commonly reported language deficit in individuals with ALS without CI or dementia is word retrieval problems (Abrahams et al., 2000, 2004; Cooper, 2008; Mantovan et al., 2003; Racowicz & Hodges, 1998; Strong et al., 1999). Other language deficits include reduced single-word vocabulary comprehension (Strong et al., 1999), moderate auditory comprehension impairment (Mantovan et al., 2003), and verbal and semantic paraphasias on confrontation and generative noun naming (Cooper, 2008; Strong et al., 1998). Impaired performance on the Test of Syntactic Comprehension (TROG) (Racowicz & Hodges, 1998), deficits in verbal fluency, letter fluency and confrontation naming also are evident (Abrahams et al., 2000, 2004; Cooper, 2008; Hanagasi et al., 2002; Mantovan et al., 2003; Ringholz et al., 2005; Strong et al., 1999;).

Cobble (1998) studied language characteristics in individuals with ALS. She administered a range of language tasks including confrontation naming, semantic processing, auditory comprehension of complex sentences, spelling and reading single words. She found auditory comprehension problems of linguistically complex stimuli, spelling errors and word finding difficulties. She also found that although naming deficits were seen on the Graded Naming Test, her participants did not exhibit overt word finding difficulties in everyday conversation. She concluded that subtle language impairment was present in some individuals with ALS that could be revealed only by formal tests sensitive to language.

Abrahams and colleagues (2005) used fMRI to study confrontation naming in individuals with ALS. They found that word retrieval was slow but that it did not affect verbal fluency. They attributed this to deficits in higher cognitive functions. However, they also found evidence supporting the hypothesis of language problems among individuals with ALS. They found slowed retrieval times in the computerized sentence completion task over a 6-month period.

Discourse analysis of spoken and written outputs of individuals with ALS using samples from a topic-directed interview (TDI) and the Cookie Theft picture description task (Goodglass & Kaplan, 1983) at baseline and then again at 6-months revealed that individuals with ALS produced significantly fewer self-corrected utterances compared to controls (Strong et al., 1999). However, it

remains uncertain whether language deficits are a common but under recognized feature of individuals with ALS without CI or dementia (Bak & Hodges, 2004).

*Language in individuals with ALS and Dementia*

Language deficits in individuals with ALS with suspected dementia have received less attention compared to changes in behaviour and fronto-executive functions (Bak & Hodges, 2003). Many individuals with ALS with dementia exhibit impairments in language functions (Haley & Raymer, 2000). The most frequently noted mentioned language characteristic described in individuals with ALS with dementia is reduced verbal output, often leading to complete mutism (Bak & Hodges, 2001; Cooper, 2008; Neary et al., 1990). Constantinidis (1987) and Meyer (1929) described another constellation of language symptoms including perseverations, echolalia and use of stereotypic expressions. Other language disturbances such as word retrieval deficits on confrontation naming, category naming and letter fluency, impaired comprehension for both complex sentences and single word semantic processing tasks, reading and writing difficulties also have been reported more recently (Caselli et al., 1993; Cobble, 1998; Doran et al., 1995; Haley and Ramer, 2000; Ricowicz and Hodges, 1998). Doran, Xuereb, and Hodges (1995) found that individuals with ALS with dementia showed significant auditory comprehension problems.

Anomia, impaired language comprehension, semantic paraphasias, and spelling errors also have been reported in individuals with ALS-FTD (Bak & Hodges, 1997, 2004; Caralleri & DeRenzi, 1994; Deymeer, Smith, DeGirolami, &

Drachman, 1989; Mitsuyama & Takamiya, 1979; Neary et al., 1990; Ferrer et al., 1991; Gentileschi et al., 1999; Racowicz & Hodges, 1998). On tests of verbal repetition, individuals with ALS-FTLD ranged from normal, mildly impaired to echolalic (Cavelleri & DeRenzi, 1994; Neary et al., 1990; Peary et al., 1992; Snowden et al., 1996). Although naming and comprehension are impaired for both nouns and verbs, a consistently larger impairment was noticed in verbs on both naming and comprehension task (Bak & Hodges, 2001, 2003; Bak et al., 2001; Hillis, 2004). Neuroimaging studies have confirmed the involvement of language areas like Broadman areas 44 and 45 in individuals with ALS-FTLD (Bak & Hodges, 2004).

Bak and Hodges (2004) found that language deficits can be an early and a prominent feature of individuals with ALS with dementia. They also stated that language deficits could be unrelated to a dementia and that the language impairment could be more pronounced than what is expected on cognitive tests. It remains to be established whether language deficits such as selective verb impairments can be observed in individuals with ALS and whether problems with verbs can function as an early indicator of language deficits in individuals with ALS with dementia or without dementia.

*Verb Naming Deficits in ALS*

Selective deficits or dissociability of noun and verb processing have been recognized for centuries (Linnaeus, 1745; Vico, 1744) mostly in individuals with strokes and tumors (Berndt et al., 1997; Caramazza & Hillis, 1991). These

selective deficits have been interpreted by some researchers as evidence for separate neural systems underlying different word classes (Hillis, Tiffiash, & Caramazza, 2002) and by others who attribute the differential problems to semantic differences in visual processing (Breedin, Saffran & Schwartz, 1998). Givon (1984) stated that both perspectives might seem mutually exclusive in that nouns and verbs can share a common linguistic framework because their syntactic characteristics are derived from their functional attributes. Caramazza and Hillis (1991) studied the performances of two individuals with brain-damage who showed modality specific deficits in verbs with oral and written production. They concluded that grammatical-class distinctions (e.g., nouns vs. verbs) are redundantly represented in the phonological and orthographic output lexical components.

Differential word retrieval difficulties for both nouns and verbs are commonly observed among individuals with acquired, focal brain damage such as aphasia (Goodglass, 1993). Miceli et al. (1984) studied the performances of individuals with agrammatism and individuals with anomia on confrontation-naming tasks. They found that participants with agrammatic aphasia retrieved nouns better than verbs whereas those with anomic aphasia retrieved verbs better than nouns. A double dissociation was revealed wherein those with agrammatism vs. anomic aphasia exhibited lesions in different cortical areas. Damasio and Tranel (1993) studied three individuals with selective naming deficits. Two individuals with noun retrieval deficits had lesions in the left

anterior/middle temporal lobe and the third patient with verb retrieval deficits suffered a lesion in the left frontal region. They concluded that there are separate neuroanatomical systems for noun and verb retrieval. Damiele et al. (1994) compared naming performance and lesion location and found converging evidence that the left frontal lobe is responsible for verb retrieval and the left temporal lobe is responsible for noun retrieval. Thus, action words (verbs) may be represented in neural circuits that also subserve motor planning whereas concrete object words (nouns) may depend on cortical regions with connections to sensory areas (Damasio & Tranel, 1993; Pulvermueller, 1999). However, results from recent studies have shown selective deficits in verb naming relative to nouns that have been associated with left hemisphere frontal cortical lesions. Lesions in left frontal cortices often are associated with verb deficits in individuals with a wide variety of neurological disorders such as stroke (Berndt, Mitchum, Haendiges & Sandson, 1997; Miceli, Silveri, Villa & Caramazza, 1984), FTD (Cappa et al., 1998) and other neurodegenerative diseases (Bak, O'Donoven, Xuereb, Boniface, & Hodges 2001; Daniele, Giustolisi, Silveri, Colosimo & Gainotti, 1994), including progressive supranuclear palsy and Alzheimer's disease (Grossman et al., 1996).

Verb deficits have been studied extensively in specific types of aphasia such as non-fluent aphasia with agrammatism (Kim & Thompson, 2000, 2004; Miceli, Silveri, Villa & Caramazza, 1984, 2000, 2004; Miceli, Silveri, Nocentini & Caramazza., 1988; Thompson, Lange, Scheider & Shapiro, 1997). Researchers

have examined the influence of syntactic argument structure properties of verbs whereas other investigators have examined semantic feature properties of verbs. Results from both 'camps' of researchers have shown that the syntactic and semantic attributes of verbs influence their production in individuals with non-fluent aphasia (Breedin, Saffron, & Schwartz 1998; Kim & Thompson, 2000, 2004; Thompson et al., 1997). Kim and Thompson (2000, 2004) examined the effects of syntactic representation of verbs; that is, the number of arguments during verb retrieval, in individuals with stroke-based agrammatism. They found that participants were more accurate naming one-place verbs (verbs that take one argument such as *sleep,* as in *The man is sleeping*) vs. two-place verbs (verbs that take two arguments such as *push,* as in *The man is pushing the cart*). They also found that participants are more accurate naming two-place verbs than with three-place verbs (verbs that take three arguments, such as *The woman is putting the book on the table*). Kim and Thompson hypothesized that the rising difficulty could be due to the greater number of arguments which add more syntactic information and render the verbs more complex. Shapiro and colleagues found that a verb's lexical properties directly affect sentence processing; that is, as the verb becomes more complex in terms of the number of different argument structure arrangements possible, the processing load increases in the immediate temporal vicinity of the verb. For example, the verb *fix* allows only one, two-place argument structure (Agent-Theme, as in *John fixed the car*), whereas the verb *send* allows both a two-place structure (Agent-Theme,

as in *John sent the flowers*) and a three-place structure (Agent-Theme-Goal, as in *John sent flowers to his wife*. When embedded in simple NP-V-NP structures, *send*, for example, yields a greater processing load than *fix*.

Breedin and colleagues (1998) examined verb production among individuals with non-fluent aphasia based on the semantic complexity of verbs. They found that their participants were better at retrieving complex verbs vs. simple verbs. They defined complex verbs as those that have elaborate semantic representations with each verb's meaning decomposed into smaller related elements (e.g., *run*).They defined simple verbs as those that have a simple semantic representation with a lower degree of decomposition into related elements (e.g., *go*). They attributed this finding to the elaborate semantic representations of complex verbs.

Kim and colleagues (2004) studied verb deficits in individuals with fluent aphasia. Three verb elicitation contexts were used; (1) single-word confrontation naming, (2) sentence completion, and (3) narrative production. They found that in the single-word confrontation naming content, all participants named nouns better than verbs. In addition, all participants made more errors on two-place verbs than one-place verbs, suggesting greater difficulty naming verbs associated with more arguments. The hierarchy of verb difficulty observed in the naming task also was found in the narrative task. They reported that participants' verb retrieval in the sentence completion task was not influenced by the effect of semantic complexity. Rather, the participants produced a large number of verbs

that were not semantically related to the target verb. In the narrative task, participants used a small repertoire of verbs further suggesting impaired verb retrieval.

A selective impairment of verb use also has been demonstrated in neurodegenerative diseases like Alzheimer's disease (AD) (Grossman et al., 1996). Grossman and colleagues (1996) compared participants with AD with normal controls on judgments of verb meaning using a triadic comparison task (e.g., multiple-choice word-picture matching task for nouns and verbs, analyses of semantic naming errors and nature of misnamed verbs and analyses of individual performance profile) They found that individuals with AD were significantly more impaired for verbs than for nouns on confrontation naming and word- picture matching tasks vs. controls. They also found a difference in patterns of semantic naming errors for verbs and nouns in individuals with AD. Individuals with AD produced significantly more semantic, descriptive, and unrelated errors than phonemic errors vs. controls. The participants with AD also produced significantly fewer superordinate substitutions during confrontation naming with verbs vs., nouns. Individual AD participant analysis revealed that only the subgroup of individuals with AD who had semantic memory impairment exhibited disproportionate difficulty with verbs compared with nouns and this was associated with their production of superordinate semantic substitution errors only on noun but not on verb naming. The authors concluded that semantic memory impairment was responsible for the selective verb impairment. In a

related study, Grossman et al. (1997) studied the pattern of acquisition of semantic meaning and the argument structure of a new verb in individuals with AD vs. normal controls. They used real verbs with very-low-frequency of occurrence (i.e., "wamble"). The form class of the verb was assigned to "wamble" depicted in the usage, for example "The bees wamble to their hive". The argument structure of this sentence is associated with a verb of self-motion (i.e., a noun phrase – verb – prepositional phrase construction that maps onto a verb argument structure that includes an agent, an action, and a goal). The initial exposure to the verb occurred in a naturalistic fashion not involving an explicit pairing of its novel phonological shape with a formal definition. The method involved a sentence-picture matching task and a multiple choice task where the real meaning of the verb was provided repeatedly to the participants (e.g., the written sentence "The bees wamble to their hive" was matched with a picture depicting the same). The post exposure testing involved a sentence comprehension task with measures including sentence grammaticality judgments, picture classification and thematic role judgments. The sentence grammaticality judgment task required the participants to make judgments of the grammatical appropriateness of sentences. The picture classification task assessed participants' appreciation of the meaning of the word "wamble" and generalization of possible agents involved such as insects, birds, non-human mammals and humans. The thematic role judgment task required the participants to judge the coherence of sentences. These sentences manipulated selection

restrictions associated with the agent, the direction, and the goal of the new verb "wamble". For the agent element of the stimulus, they probed with an animate and movable object, an inanimate but movable object, or an inanimate object. For the direction they probed with a preposition indicating a trajectory toward a target, a trajectory beyond a target, and a nonspatial preposition. For the goal, they probed using a picture of a home that was appropriate for the agent, a non-home target associated with the agent, and a location that was not likely associated with the agent. Grossman et al. found that individuals with AD were unable to acquire the meaning-related information associated with the new verb but were relatively successful in understanding the form class associated with the new verb. The authors attributed the participants' word learning difficulty to selectively compromised memory and to selectively compromised lexical processing that interferes with the acquisition of particular aspects such as the argument structure (including understanding the thematic roles and selection restrictions placed on the word). They also found supporting evidence for compromised semantic processing in individuals with AD (Chan et al., 1993; Chertkow et al., 1989; Grossman & Mickanin, 1994; Hodges et al., 1992; Mickanin et al., 1994) and found significant difference between individuals with AD vs. controls in judgments of argument structure. They concluded that individuals with AD are compromised in their appreciation of the linguistic aspects of word meaning.

The Grossman et al. studies (1996, 1997) showed a partial dissociation between semantic and grammatical aspects of verbs among and between participants with AD vs. controls. Robinson et al. (1996) reported no correlation between verb confrontation naming and sentence comprehension in individuals with AD. They concluded that verbs are associated with a richer set of grammatical rules compared to nouns and this burden could cause the selective impairment of verbs in individuals with AD. It is less likely that individuals with AD can understand information such as the argument structure or sentence frame associated with a verb to compensate for verb naming ability (Devine et al., 1996).

Devine et al. (1996) studied verb naming deficits in individuals with AD. The investigators used three approaches to assess the relative roles of semantic processing and lexical retrieval in individuals with AD for naming verbs. In the first approach, they administered a multiple-choice word-picture matching task for verbs and nouns. The second approach involved analysis of the semantically related naming errors and the nature of the misnamed verbs in AD. The third approach involved analyses of individual performance profiles. The participants evaluated line drawings depicting 20 familiar actions and 20 familiar objects labeled by 20 frequency matched nouns and verbs, according to form class-sensitive norms (Francis & Kucera, 1982). The line drawings were taken from published tests of object naming (Kaplan, Goodglass, & Weintraub, 1983) and the Action Naming Test (Obler & Albert, 1986). They found that individuals with

AD were more impaired vs. controls in their confrontation naming and word-picture matching of verbs than of nouns suggesting that semantic memory limitations play a role in naming difficulty in AD. The participants with AD showed a different pattern of semantic substitution errors for verbs vs. nouns. They concluded that verb-naming impairment in AD is due in part to impaired semantic processing. However, Fung et al. (2001) found evidence that individuals with AD were more accurate in naming and making judgments for action-verbs when presented as words or animations. However, when line drawings of actions were shown for naming, performance deteriorated significantly showing semantic memory impairment.

Selective verb impairment has also been demonstrated in subtypes of FTD such as non-fluent progressive aphasia (NFPA) (Hillis, Oh & Ken, 2004; Thompson et al., 1997). Hillis et al. (2004) studied oral and written naming of nouns and verbs in individuals with NFPA, fluent PPA and ALS-FTD. They found that individuals with NFPA and ALS-FTD were significantly more impaired on verb naming than on noun naming and significantly more impaired on oral naming than written naming. They concluded that separate neuroanatomical areas are essential for processing oral and written word forms of verbs and nouns. In a longitudinal study by Thompson et al. (1997), she and colleagues analyzed language samples collected yearly for up to 11 years post-onset of symptoms from 4 subjects presenting with NFPA. They compared the narrative samples collected with individuals with agrammatic Broca's aphasia and non-

brain damaged individuals. They found that individuals with NPPA exhibited two patterns of language decline. The first type resembling that of individuals with agrammatism (i.e., impaired verb production, decline in verb accuracy and complexity, increased noun/verb ratio, impaired production of closed-class elements, and impaired production of correct argument structures with difficulty seen as the number of arguments). The second type was characterized by advancing word-retrieval difficulties.

Other investigators have shown that grammatical categories have a neuroanatomical basis (Shapiro et al., 2001). Action words are thought to be represented in neural circuits that sub-serve motor planning while concrete object words may depend on cortical regions with connections to sensory areas (Damasio & Tranel, 1993; Pulvermuller, 1999). Selective deficits in producing verbs relative to nouns have been associated with left hemisphere frontal cortical lesions (Shapiro et al., 2001).

Lu et al. (2002) studied noun and verb naming in individuals with left anterior temporal lobectomy (LATL) and right anterior temporal lobectomy (RATL). They found that individuals with LATL performed poorer vs. RATL individuals on both the Boston Naming Test (BNT) (i.e., nouns) and the Action Naming Test (ANT) (i.e., verbs). The individuals with LATL were impaired on verb naming vs. noun naming, whereas the individuals with RATL demonstrated an equal performance on both verb and noun naming. They concluded that the left anterior temporal dysfunction disrupts more fundamental semantic

representation of concepts involving movement plan and monitor use and as opposed to interrupting naming processes alone.

Neuroimaging studies in neurologically normal participants have been completed to explore the role for the left prefrontal cortex in verb processing (Shapiro et al., 2001). Studies using positron emission tomography (PET) and fMRI showed that verb generation tasks recruit left prefrontal and medial frontal cortex as well as a patchwork of other regions in the left temporal, parietal and occipital lobes (Peterson, Fox, Posner, Mintom, & Raichle, 1988, 1989; Raichle et al., 1994; Wise et al., 1991). An fMRI study by Thompson et al. (2004) showed that there is increased activation of Broca's, Wernicke's and right hemisphere homologues with additive activation of superior and inferior parietal lobes for verb processing. Thompson and colleagues also showed that as the number of arguments of verbs increase there is more activation of Wernicke's area, bilaterally. However, the activation patterns for nouns were more widespread with less activity in the Perisylvian region. Shapiro et al. (2001) used repetitive transcranial magnetic stimulation (rTMS) to demonstrate that grammatical categories have a neuroanatomical basis by showing that grammatical operations involving verbs can be selectively impaired. rTMS was applied to the anterior portion of the left midfrontal gyrus of 8 right-handed native English speakers. Following stimulation, the response latency (RT) decreased markedly from baseline for verbs (third-person plural and singular forms). The same findings also were seen for pseudowords (phonologically and orthographically

plausible one-syllable nouns and verbs, for example "wug", "cheen", and "flonk"). Shapiro et al concluded that left prefrontal cortex is involved in verb retrieval but is not critical for noun retrieval. They also stated that with respect to at least the one dimension of grammatical category, nouns and verbs have distinct neuroanatomical underpinnings, and can be dissociated by targeted suppression of the left prefrontal cortex.

Neuroimaging studies also have been conducted to investigate whether the distinctions between regular and irregular verb forms are reflected in the pattern of brain activity (Keilar, 2008). Keilar found significant activation in the left inferior temporal lobe, including the middle occipital lobe and extending into the fusiform gyrus (BA 37/19) for combined regulars (e.g., walk-walked), suffixed-irregulars (e.g., sleep-slept) and vowel-change irregular verbs (run-ran). However, an fMRI priming task did not reveal a double dissociation in processing irregular versus regular forms indicating that there were no two brain regions showing opposite activation patterns, nor a single brain region showing priming to regulars or irregulars. Kielar's investigations indicated that different brain regions work simultaneously to process the different forms and that both regular and irregular forms are processed by the same integrated system that involves various interactive brain networks specializing in processing different types of information.

Although mounting evidence shows that verb impairment is increasingly related to frontal lesions (Bak & Hodges, 1997), only a few studies have

examined the same pattern in individuals with ALS. Bak and Hodges (1997) studied verb and noun naming in three individuals with ALS. They found that in all of the three individuals, verbs were significantly more impaired than nouns. The same authors also studied ranges in performance in seven individuals with ALS with dementia. They administered tests to examine noun and verb naming including the noun-verb comprehension test (Berndt, Mitchum & Wayland, 1997) and the Kissing and Dancing test (Bak & Hodges, 2003). Bak and Hodges (1997) found that all participants suffered more problems in both production and comprehension for verbs vs. nouns. They concluded that the principles of selectivity leads to predominant dysfunction of the motor and relative sparing of sensory systems in ALS and also is responsible for the verb deficits more so than for the noun deficits.

Neuropsychological investigations also have shown the above distinctions between cortical regional processing of verbs vs. nouns. High resolution EEG and event-related brain potentials demonstrated an association between verb processing and motor function (Pulvermuller, Harle, & Hummel, 2000; Pulvermuller, Lutzenberger, & Preiss, 1999).

In a more recent study Grossman and colleagues (2008) used MRI to study the performance of 34 individuals with ALS on word-description matching and associativity judgments with actions and objects. They found that individuals with ALS were significantly more impaired on measures requiring knowledge of actions than measures requiring knowledge of objects.

*Statement of the Problem*

It is well documented in the literature that individuals with aphasia (both with fluent and with agrammatism) and Alzheimer's disease exhibit greater difficulty producing verbs vs. nouns both on single word confrontation naming tasks as well as narrative discourse. The number of syntactic arguments associated with the verb and corresponding thematic roles influences the production of verbs (Kim, 2004; Thompson et al., 1997, 2003, 2004). Verb production deficits both on confrontation naming and on narrative discourse are also reported in certain subtypes of FTD such as the non-fluent primary progressive aphasia (NFPA) (Hillis et al., 2004; Thompson et al., 1997). It also has been reported that there exists an anatomic continuum between NFPA and ALS both reflecting dysfunction of the left posterior, inferior frontal lobe and /or left premotor cortex, and insula (Hillis et al., 2004). As these areas have been reported to be important for verb processing (Damasio & Tranel, 1993; Shapiro et al., 2001; Lu et al., 2002) and also with the high prevalence of FTD in ALS (Strong et al., 2008), it can be expected that individuals with ALS may exhibit verb deficits.

To date only two studies have examined verb naming using single word confrontation naming tasks in individuals with ALS (Bak & Hodges, 1997, 2003). No study to date has examined the nature of verb deficits on narrative discourse samples in individuals with ALS. Hence, exploring the verb deficit patterns in individuals with ALS will provide a better understanding about underlying

grammatical and semantic representation. Correlation of verb place arguments with neuroimaging and detailed psycholinguistic studies may provide for an in-depth understanding of verb processing and its neural representation. Verb performance of individuals with ALS on discourse tasks such as a topic directed interview (TDI) and a picture description task has yet to be explored.

*Purpose and Research Questions*

The purpose of this proposed study is two-fold. The first is to examine verb use in participants with ALS (bulbar and non-bulbar) on a picture description task and also on a topic directed interview task. The second purpose is to determine whether there are differences in verb use in the picture description task vs. the TDI task.

*Research Questions*

There are two research questions posed for the study. They are:

1) Do participants with ALS display verb impairments on a picture description task and a topic directed interview (TDI) vs. control participants?

2) Do participants with ALS display verb impairments on picture description task vs. TDI task?

## *Method*

*Participants*

All participants were given a clinical diagnosis of ALS (El Escorial criteria)

(World Federation of Neurology Research Group on Neuromuscular Disease, 1994). The participants in this study were part of a larger, longitudinal study on cognition, language, motor control, and vascular neuroimaging. The participants for the longitudinal study were selected such that the duration of the disease was less than one year from the time of onset of clinical symptoms. The participants were recruited as a convenience sample from the Motor Neuron Diseases (MND) Clinic at London Health Sciences Center, University Campus. The participants were selected by the director of the MND clinic, Dr. M. J. Strong. None of the participants included in the study had a history of other medical conditions such as hypoparathyroidism, pernicious anemia, alcoholism, hypothyroidism, AIDS or AIDS-related complex, exposure to heavy metals (e.g., lead, aluminum, mercury), history of head trauma with periods of unconsciousness greater than five minutes, history of other neurological disease or psychiatric illness. Data were collected from all the participants at 6-month intervals. A total of sixteen ALS (n=16) and twelve control (n=12) participants were recruited at the beginning of the longitudinal study. The controls included in the study were spouses or relatives of the participants with ALS.

*ALS participants.* Fourteen participants with classical sporadic ALS and two participants with familial ALS participated in the study at baseline. Five participants presented with bulbar signs and symptoms at disease onset. The remaining eleven participants presented with either upper limb (n=6) or lower limb (n=3) signs and symptoms at disease onset. There were 10 men and 6

women. Their age at onset ranged from 34 to 68 years (*M*=52.8 ± 9.15). They were all native speakers of English and their education ranged from 10 to 22 years (*M*= 14.9 ± 3.22). One participant was excluded from the calculation of the mean number of years of education because the data were not obtained. See Table 1 for a summary of the demographic characteristics of the ALS participants.

*Control participants.* Seven men and five women participated as controls at baseline. None of the control participants had a history of neurological disease, including ALS, psychiatric illness or other medical conditions (as mentioned above). All the participants were native speakers of English and their ages ranged from 34 to 63 years (*M*=53.3 ± 8.03). Their education ranged from 10 to 19 years (*M*=13.4 ± 2.60). See Table 1 for a summary of the demographic characteristics of control participants. Data obtained from the control participants were used as baseline measures to compare performance of ALS participants on language and discourse tasks. It is advantageous to use spouses and family members as control participants because they help control for socio-economic status, years of education, job experiences and other potentially influencing factors on language performance.

*Procedure*

All of the participants with ALS underwent neuropsychological testing, language and discourse testing, perfusion computerized transaxial tomography (CT Perfusion) and pulmonary, neuromotor and physiotherapy testing at London

Health Sciences Centre and St. Joseph's Health Care - St. Joseph's Hospital at London Canada in a single day. Participants were tested at 6-month intervals using the same protocol. The language and discourse data for this study are derived from the initial baseline testing.

*Language and discourse assessment.* Language tests comprising a comprehensive set of standardized and non-standardized measures were administered. Non-standardized discourse tasks and non-standardized scales of pragmatics also were administered. The language and discourse testing sessions were completed in 1 to 1.5 hours and were video recorded in a quiet room in the ALS clinic on the seventh floor at the London Health Sciences Centre, University Hospital, London Canada. All language and discourse testing was administered by the same individual and performed in the same order across all time periods with very few changes in the order of test administration. The language and the discourse tests were administered earlier in the day and all the participants were provided with rest breaks throughout the testing to minimize fatigue. However, all the ALS participants were administered the language tests after a 2-hour standardized battery of neuropsychological tests as per the testing protocol. Tests were chosen to minimize the requirements of speech production and manual motor movement. Participants were asked to respond verbally for the language and discourse assessment. If they were unable to give a verbal response as a result of severe dysarthria or anarthria, written

responses were accepted. All of the discourse data used in the current study are from verbal responses provided by all ALS and control participants.

Standardized language tests included *The Peabody Picture Vocabulary test –III (PPVT-III)* (Dunn & Dunn, 1997) which was administered to measure comprehension of single word vocabulary. Participants responded either by providing a verbal response or pointing to one of four pictures that best matched the target item. Selected subtests from *Arizona Battery for Communication Disorders (ABCD)* (Bayles & Tomoeda, 1991) were administered. Non-standardized measures included *The Action Naming* test (Obler & Martin, 1986) which does not have published psychometric properties.

Discourse samples were obtained from each ALS and control participant in a face-to-face topic-directed interview (TDI) with Dr. JB Orange, School of Communication Sciences and Disorders, and using the Cookie Theft Picture description task from the *Boston Diagnostic Aphasia Examination (BDAE)* (Goodglass & Kaplan, 1983). The spouse or the family member of the participants with ALS who acted as controls completed two non-standardized scales of pragmatics including the *RICE 2nd Edition –Pragmatic Communication Skills: Rating Scale (PCSRS)* (Rehabilitation Institute of Chicago, 1996) and the *Perception of Pragmatic Communication Skills (PPCS)* (Ehrlich& Sipesk, 1985).

The Geriatric Depression Scale (GDS) (Yesavage, J.A. et al., 1982) was administered to all the ALS participants. None of the ALS participants were depressed as measured by the GDS.

The TDIs were initiated by the examiner using the starter phrase "Tell me about _____" and included the following five topics: 1) your family, 2) where you were born and raised, 3) your health right now, 4) the jobs you had or the work you did, and 5) what do you do each day.

The picture description task from the *Boston Diagnostic Aphasia Examination (BDAE)* (Goodglass & Kaplan, 1983) was administered to obtain a measure of discourse content. Participants were shown the Cookie Theft picture and prompted by Dr. Orange with the open-ended request: "Tell me everything that is going on in this picture". The participants described the picture or wrote their answers. For the purpose of the proposed study only the procedures and analyses of verb naming in the discourse tasks are discussed below in detail because they constitute the primary focus of the study.

The outcome measures for analysis of spoken language for verb usage in both the picture description task and the TDI include the following (1) the proportion of verbs and nouns, (2) noun: verb ratios, (3) type of irregular vs. regular verbs in both the discourse elicitation tasks, (4) number of one place vs. two-or three-place verb argument structures per utterances. These analyses are based on the study by Kim and Thompson (2000, 2004) conducted on individuals with agrammatism, fluent aphasia, AD and NFPA.

*Agreement Study*

An inter-rater agreement study was completed on total number of words transcribed and on utterance segmentation from a randomly selected sample of

data. Fifteen percent of the transcripts from both the discourse tasks (i.e., TDI and picture description task) were randomly selected using software (Random Sequence Generator).

Inter-rater agreement was performed by the author (AMN) and a trained rater who was an under-graduate student in health sciences. The rater underwent training by the author and his research supervisor (Dr. JB Orange) prior to transcription of the video sample and utterance segmentation. The rater was trained for word transcriptions before being trained on utterance segmentation. Training involved randomly chosen transcripts and video recordings from each discourse task from the current data set excluding the 15% of the transcripts and video recordings used for the agreement study. A criterion level of at least 80% point-by-point agreement was achieved during the training sessions before the rater completed the inter-rater agreement study.

The rater was provided with the video recordings, which were to be transcribed. The total number of words transcribed by the rater was counted. After completion of the word transcriptions, the rater then segmented the transcripts into utterances.

Percent agreement was calculated for word transcription and utterance segmentation by dividing the total number of agreements by the total number of agreements plus disagreements, and multiplying by 100. Percent agreement for total number of words transcribed ranged from 80.2% to 100% (*M = 96.16, SD = 6.57*). Percent agreement for utterance segmentation ranged from 70% to 92.7%

(*M = 78.96, SD = 9.022*) which was lower than criterion level of 80%. The lower percent of agreement was attributed to the inter-rater discrepancy in segmenting compound utterances into individual utterances. Hence, disagreements were discussed and resolved by both author and rater by re-listening to the video recorded samples. The percent of agreement for utterance segmentation after consensus agreement ranged from 83.3% to 100% (*M = 92.35, SD = 5.24*).

*Speech Intelligibility and Rate*

Cooper (2008) calculated speech intelligibility and rate scores of individuals with ALS in the longitudinal database used in this current study to ensure that any deficits found on her language analyses of noun use were attributable to language changes and not to motor speech difficulties as a result of their mixed dysarthria. A visual analogue scale (VAS) comprising a 100 mm line with anchors of "Completely Intelligible" to "Completely Unintelligible" was used to measure the participants' intelligibility at each time period. Additionally, a VAS comprising a 100 mm line with anchors of "Very Slow" to "Very Fast" with normal as the centre (i.e., 50 mm) was used measure the participants' rate at each time period.

Speech intelligibility and rate scores were determined by a group of three untrained listeners (i.e., graduate students in speech-language pathology) for each participant at each of her four time periods. The three raters were blinded to the objectives of the study and to the participants' diagnostic category (i.e., ALS vs. control). The three listeners rated the participants' speech intelligibility and

speech rate using the visual analogue scales as described above. They listened to a digitized audio sample of each participant's speech taken from the Topic Directed Interview task video recorded at each of the time periods. There were 60 samples in total. Samples were not evaluated for ALS participant 13 because he did not complete the TDI task. Ninety-three percent of the samples were 30 seconds long, 5% were less than 30 seconds and 2% were over 30 seconds long. The speech samples were presented to the three raters in a randomized order (i.e., ALS vs. controls). It took the listeners between one hour 6 minutes and one hour 24 minutes to complete the rating task.

Inter-rater reliability was strong for both intelligibility (.875) and rate (.972). Intelligibility and rate scores were determined for each participant by calculating the mean scores given by the three listeners. Group comparisons were made to determine if there were differences in rate and intelligibility scores between the ALS participants and controls.

Correlational analysis by Cooper (2008) indicated that there was no significant correlation between intelligibility and total number of items generated for participants with ALS and controls. The same result was found for rate measure. Although the influence of intelligibility and rate cannot be completely eliminated, the above analysis was designed to minimize the effects of dysarthria on the specific language deficits exhibited by individuals with ALS.

*Data Analyses*

The words produced for both picture description and TDI task were

transcribed orthographically by the investigator (AMN) from the video recordings for each participant. The raw scores for the total number of words, total number of nouns and verbs, noun/verb ratio, number of correct and incorrect regular and irregular verbs and number of correct and incorrect obligatory 1, 2, 3 and optional 2, 3 place verb arguments were recorded for each participant during both the tasks. See Appendices C and E for raw scores showing the correct discourse measures for individual participants with ALS. See Appendices D and F for the raw scores showing the number of correct discourse measures for individual control participants.

*Research question 1.* Research question 1 addressed whether individuals with ALS have verb impairments on the picture description task and the TDI in comparison to the control participants. A chi-square test was conducted to determine whether there were significant differences between groups (ALS vs. Control) for the total number of verbs, and regular and irregular verb production during both picture description and TDI tasks. A Kruskal-Wallis One Way Analysis of variance was conducted with the group (ALS vs. Control) as the between participant variable and place of verb arguments (obligatory 1 place vs. Obligatory 2 place vs. Obligatory 3 place vs. Optional 2 place vs. Optional 3 place) as the within participant variable for both the task *Research question 2.* Research question 2 addressed whether there are significant differences in the use of verbs in the picture description task vs. the TDI task in individuals with ALS. A chi-square test was conducted within group (ALS-picture description task

vs. ALS-TDI task) for total number of verbs, regular and irregular verb production. A Friedman one- way ANOVA was conducted with the group (ALS-picture description task vs. ALS-TDI) as the between participant variable and place of verb arguments (obligatory 1 place vs. Obligatory 2 place vs. Obligatory 3 place vs. Optional 2 place vs. Optional 3 place) as the within participant variable for both the tasks.

*Significance level.* This is an exploratory study of individuals with ALS; therefore, for all repeated measures ANOVAs the alpha level was set at 0.05 to indicate statistical significance. Values between 0.05 and 0.10 were regarded as approaching significance.

## *Results*

### *Research Question 1*

Research question 1 addressed whether individuals with ALS have statistically different verb impairments on the picture description task and TDI task vs. control participants. Chi-square analysis was conducted to determine whether there were any significant between group (ALS vs. control) differences in the total number of verbs, regular verbs and irregular verbs produced during the picture description task (i.e., Cookie Theft) and the TDI. There was no significant group by verb number and type difference for both picture description task ($\chi^2$ = 4.1349, *df* = 2, $p > 0.05$) and TDI task ($\chi^2$= 0.0615, *df* = 2, $p > 0.05$). Figures 1 and 2 shows that both groups produced almost equal proportions of regular and irregular verbs on the picture description task and the TDI task.

Table 1

*Summary of Demographic Information for ALS and Control Participants*

| | Participants | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measures | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | *M* | *SD* |
| | | | | | | | | *ALS* | | | | | | | | | | |
| Sex | F | M | F | M | M | M | F | M | F | F | M | F | M | F | M | M | | |
| Age (yrs) | 40 | 51 | 59 | 47 | 42 | 53 | 56 | 34 | 61 | 58 | 60 | 48 | 56 | 63 | 48 | 68 | 52.8 | 9.15 |
| Ed (yrs) | 17 | 15 | 12 | 15 | 14 | 22 | 16 | 12 | 16 | 18 | 10 | 17 | 13 | - | 17 | 10 | 14.9 | 3.22 |
| Site at Onset | B | LL | LL | UL | UL | B | LL | UL | UL | UL | B | B | B | UL | LL | UL | | |
| Familial (F)/ Sporadic (S) | S | S | F | S | S | F | S | S | S | S | S | S | S | S | S | S | | |
| Control | | | | | | | | *Control* | | | | | | | | | | |
| Sex | M | F | M | F | M | M | M | M | F | M | F | F | | | | | | |
| Age (yrs) | 34 | 53 | 58 | 45 | 63 | 54 | 59 | 57 | 54 | 53 | 62 | 48 | | | | | 53.3 | 8.03 |
| Ed (yrs) | 16 | 10 | 10 | 14 | 14 | 13 | 14 | 16 | 14 | 11.5 | 18 | 10 | | | | | 13.8 | 2.67 |

Note. Dashes indicate the data were not obtained for the participant. B = Bulbar. LL = Lower Limb. UL = Upper Limb

A $\chi^2$ analysis also was conducted to determine whether there were any significant between group differences in the place of verb arguments (i.e., Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place) produced during the picture description and TDI tasks. There was a significant group by place verb argument difference for the picture description task ($\chi^2$= 10.9563, *df* = 4, $p < 0.05$). Figure 3 shows that the ALS group produced significantly more obligatory 1 and 2 place arguments (i.e., absolute value, rather than proportion) than the control group and that the control group produced more obligatory 3 place, optional 2 place and optional 3 place arguments than the ALS group. There was no significant group by place of verb argument difference for the TDI task ($\chi^2$= 5.1279, *df* = 4, $p > 0.05$).

Kruskal-Wallis One Way ANOVA was conducted for the picture description and TDI tasks to determine whether there were any between group differences in the number of Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments produced. Group (ALS vs. Control) was the between participant variable and the place of verb arguments within a task (picture description task vs. TDI) was the within participant variable. The means, standard deviations, minimum and maximum values for the picture description and TDI task are outlined in Tables 2 and 3, respectively. There was no significant group by place of verb argument interaction for the picture description task Obligatory 1 place ($\chi^2$= 0.620, *df* = 1, $p > 0.05$), Obligatory 2 place ($\chi^2$= 0.267, *df* = 1, $p > 0.05$), Optional 2 place ($\chi^2$= 1.583, *df* = 1, $p > 0.05$) and Optional 3 place ($\chi^2$= 1.895, *df* = 1, $p > 0.05$).

However, there was a difference that approached significance for Obligatory 3 place ($\chi^2 = 3.386$, $df = 1$, $p = 0.066$). The control group produced more Obligatory 3 place verb arguments than the ALS group.

For the TDI there was no significant group by place of verb argument interaction for Obligatory 1 place ($\chi^2 = 0.326$, $df = 1$, $p > 0.05$), Obligatory 2 place ($\chi^2 = 0.002$, $df = 1$, $p > 0.05$), Obligatory 3 place ($\chi^2 = 0.00$, $df = 1$, $p > 0.05$), Optional 2 place ($\chi^2 = 0.311$, $df = 1$, $p > 0.05$) and Optional 3 place ($\chi^2 = .194$, $df = 1$, $p > 0.05$).

*Research Question 2*

Research question 2 addressed whether there are significant differences in the use of verbs in the picture description task vs. the TDI task in participants with ALS. A $\chi^2$ analysis was conducted to determine whether there were any significant differences in the total number of verbs, regular verbs and irregular verbs produced during the picture description task versus the TDI tasks. There was no significant task by verb number and type difference ($\chi^2 = 1.6228$, $df = 2$, $p > 0.05$).

The Friedman One-Way ANOVA for repeated measures was conducted between picture description and TDI tasks for the ALS group to determine whether there was any between task differences in the number of Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments produced. Group (ALS-picture description task vs. ALS-TDI) was the between participant variable and the place of verb arguments within a task (picture description task vs. TDI) was the within participant variable. There

was a significant group by place of verb argument interaction ($\chi^2$= 76.931, *df* = 4, $p < 0.05$). Figure 4 shows that the ALS participants produced more Obligatory 2 place and Optional 3 place verb arguments in the TDI task than in the picture description task.

*Additional Findings*

Some interesting findings were observed, although they are not directly related to the research questions posed for this study. It was observed that there was an obvious difference between ALS vs. control group in the usage of parenthetical remarks and ellipsis. However, parametric statistics were not completed for group differences. A descriptive comparison of transcripts between both groups revealed that the ALS participants produced more parenthetical remarks vs. control group on a combined performance for the picture description and TDI tasks (ALS = 152, control = 69). In addition, control participants produced more Obligatory 1 and 2 place, and Optional 3 place ellipsis vs. ALS participants for both of the tasks (control total number of ellipsis = 143 and ALS total number of ellipsis = 115 ). It also was noted that subject omission occurred more predominantly for ellipsis in both of the groups. Moreover, the ALS participants showed differences between tasks for both parenthetical remarks and ellipsis. ALS participants produced more parenthetical remarks in the TDI task vs. the picture description task (total number = 138 vs. 14 for TDI vs. picture description task, respectively). The same pattern was observed for ellipsis produced by the ALS participants wherein they produced more Obligatory 1 (2 vs. 0) and 2 place (95 vs. 1) and Optional 3 place ellipsis (16 vs. 1) in the TDI

task vs. picture description task respectively. A notable difference was observed among the ALS group for the production of Obligatory 2 place ellipsis between the tasks (total number of Obligatory 2 place ellipsis = 95 vs. 1 for the TDI and the picture description task).

*Discussion*

The purpose of this proposed study was two-fold. The first was to examine verb use in participants with ALS (bulbar and non-bulbar) on a picture description task and also on a topic directed interview task. The second purpose was to determine whether there are differences in verb use in the picture description task vs. the TDI task.

*Research Question 1.*

Research question 1 addressed whether individuals with ALS have verb impairments on the picture description task and TDI tasks vs. control participants. The total number of verbs, regular verbs, irregular verbs, Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments were obtained from participants with ALS and controls. See Table 2 and 3 for summary of results. Based on the data obtained from the study participants, the total number of verbs and the total number of regular and irregular verbs produced by the ALS participants were not statistically different from control participants for the both picture description and TDI tasks. See Figure 1 and 2 for results.

This finding is inconsistent with previous literature which shows that individuals with ALS have significant verb naming deficits (Bak & Hodges, 1997).

One possible explanation for this discrepancy is the nature of the data collection task (i.e., confrontation naming vs. discourse). Difficulties with confrontation naming of verbs among participants with ALS, as observed by others in previous studies, may be the result of issues around lexical access due to frontal and temporal site of lesions and linguistic constraint rather than to deficits in the integrity of the semantic system itself (Snowden et al., 1996). Discourse tasks vs. confrontation naming task provide more opportunities for participants to use verbs. In addition, discourse tasks (e.g., Cookie Theft picture description task) provide visual cues which can help in verb retrieval. Moreover, discourse tasks provide opportunities for participants with ALS to use high frequency of occurrence verbs to compensate for low frequency of occurrence and complex verb use.

The ALS participants did not show any significant differences in the use of regular vs. irregular verbs vs. the control participants. An error analysis did not show any pattern of regular/irregular verb dominance between ALS vs. control groups. However, further examination of regular and irregular verb patterns is warranted in future studies.

The ALS participants did differ significantly from the controls on the number of places of verb arguments that they used. The ALS participants produced more Obligatory 1 and 2 place arguments vs. the controls. The control participants produced more Obligatory 3 place, Optional 2 place and Optional 3 place arguments than did the ALS participants. See Figure 3 for results. This significant difference between ALS vs. controls could be due to the increasing

complexity of verb processing with the increase in the number of places of argument (Shapiro et al., 1991; 1987). All possible argument structures associated with a verb are momentarily and exhaustively activated when the verb is accessed (Thompson et al., 1995). Thompson et al., (1995) reported that Optional 2 and 3 place verb arguments are computationally more complex than Obligatory 1, 2 and 3 place verb argument structures. As a consequence, the linguistic processing load increases with access to verbs that have multiple obligatory/optional places of argument and also with participant's preference of usage of obligatory vs. optional place verb argument.

A second possible explanation for this difference could be attributed to the nature of the picture description task which constrains the use of a verb repertoire and provides fewer opportunities for optional place verb usage. It can be argued that in dysarthria, motor economy and fatigue could affect verb production in individuals with ALS as the production of Obligatory 3 place and Optional 2 and 3 place arguments require increased motor effort. However, in the current study there was no correlation between intelligibility, rate and total number of words generated by individuals with ALS.

*Research Question 2*

Research question 2 addressed whether there were significant differences in the use of verbs in the picture description task vs. the TDI task in the participants with ALS. The total number of verbs, regular verbs, irregular verbs, Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments produced by individuals with ALS during picture

description and TDI tasks were compared. See Table 2 and 3 for summary of results. There was no significant difference between tasks for the total number of verbs, regular and irregular verbs produced. The ALS participants produced significantly more verbs in the TDI task vs. the picture description task. This difference can be explained on the basis of the nature of the tasks. The TDI is comprised of open-ended questions compared to the picture description task and hence provides more linguistic opportunities for verb use and verb variability. This thus provides opportunities to increase the number and type of verbs produced.

The ALS participants did differ on the picture description task vs. the TDI task for the place of verb arguments. The ALS participants produced fewer Obligatory 2 place and Optional 3 place verb arguments in the picture description task than in the TDI task. The ALS participants produced an equal number of Obligatory 1 and 3 place and Optional 2 place verb arguments in both tasks. See Figure 4 for the results. The discrepancy for the Obligatory 2 place and Optional 3 place verb arguments can be attributed to the difference in the nature of the tasks. The picture description requires formal organization and focused use of verbal responses while simultaneously providing a constant and unvarying visual stimulus (Cherney et al., 1998). Yorkston and Beukelman, (1980, p. 30), described Content Unit (CU) as "a grouping of information that was always expressed as a unit by normal speakers". The authors identified norms for content units for normal adult group aged 19 to 49 years (mean CU= 18, SD = 4.7) and normal geriatric group aged 58 to 93 years (mean CU= 14.7, SD = 3.6).

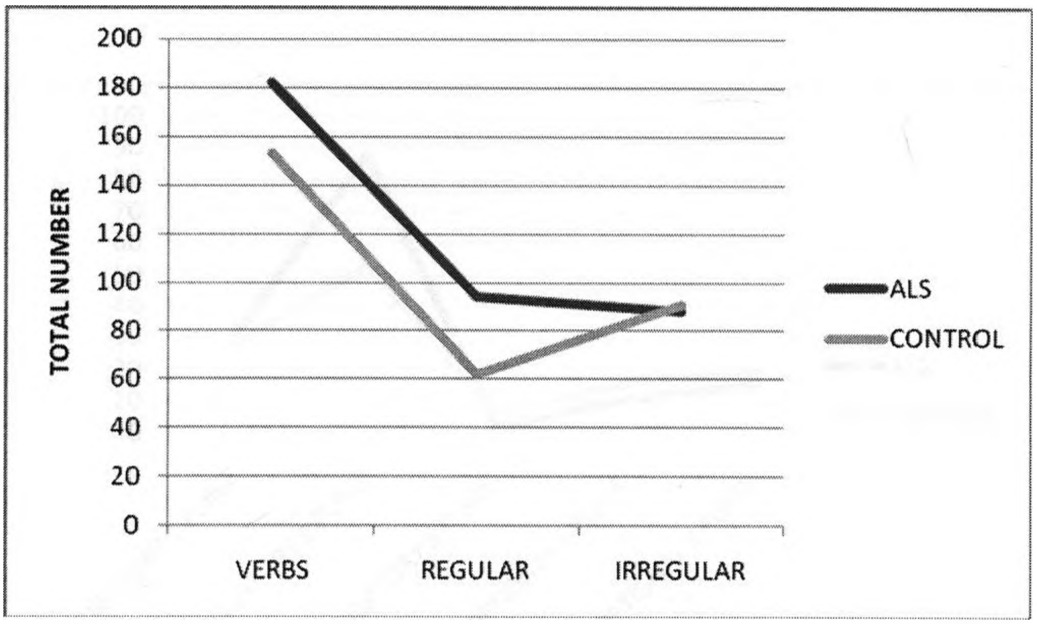


*Figure 1.* Cookie Theft Picture Description. Number of Verbs, number of regular verbs, and number of irregular verbs produced by the ALS and Control participants.

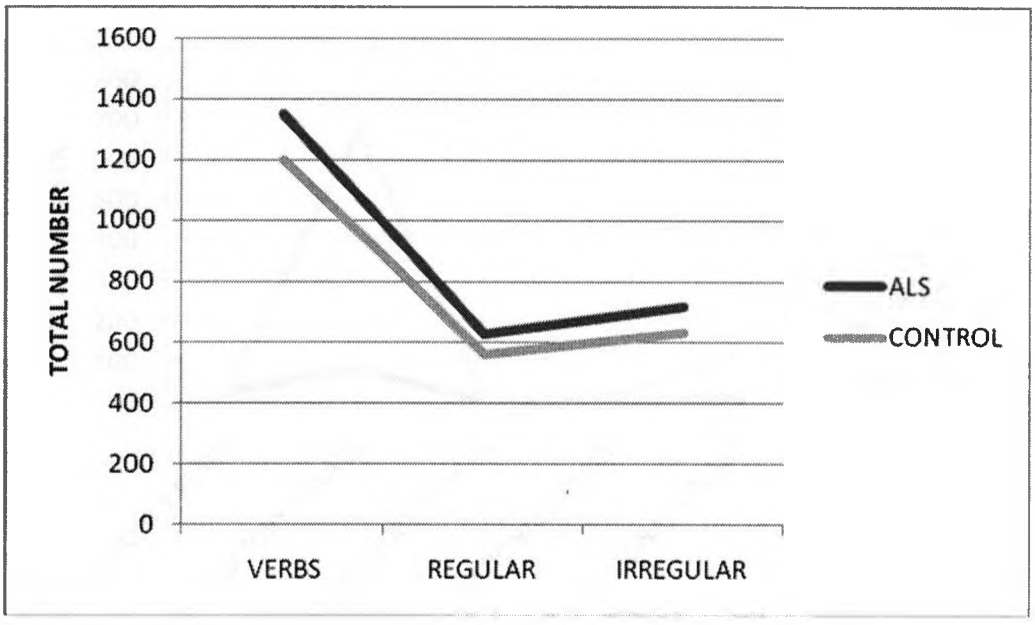


*Figure 2.* Topic Directed Interview (TDI). Number of Verbs, number of regular verbs, and number of irregular verbs produced by the ALS and Control participants.

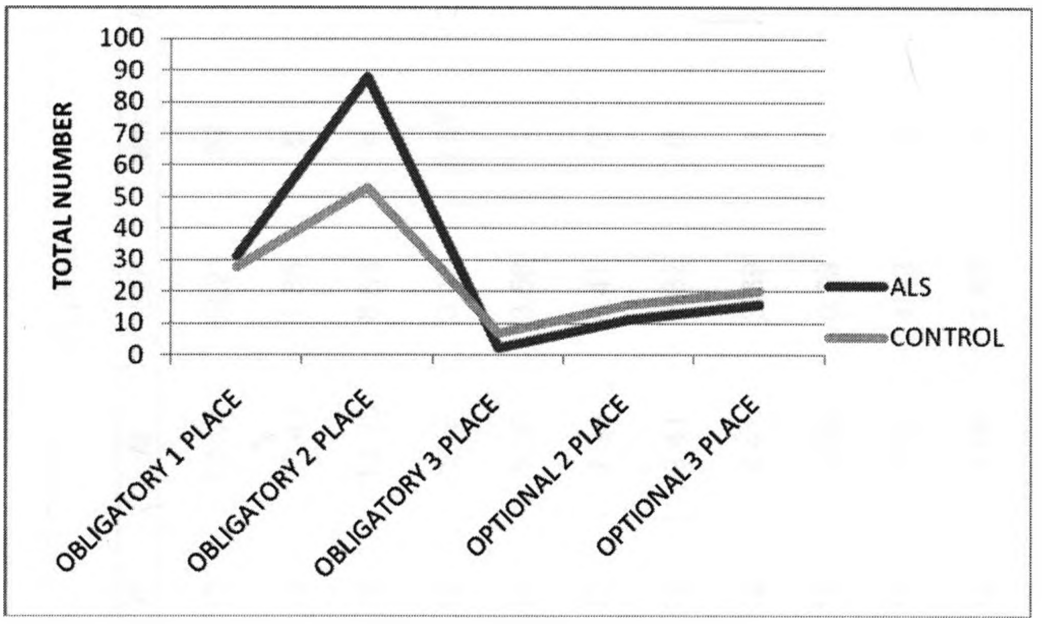


*Figure 3.* Cookie Theft Picture Description. Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments produced by the ALS and Control participants.

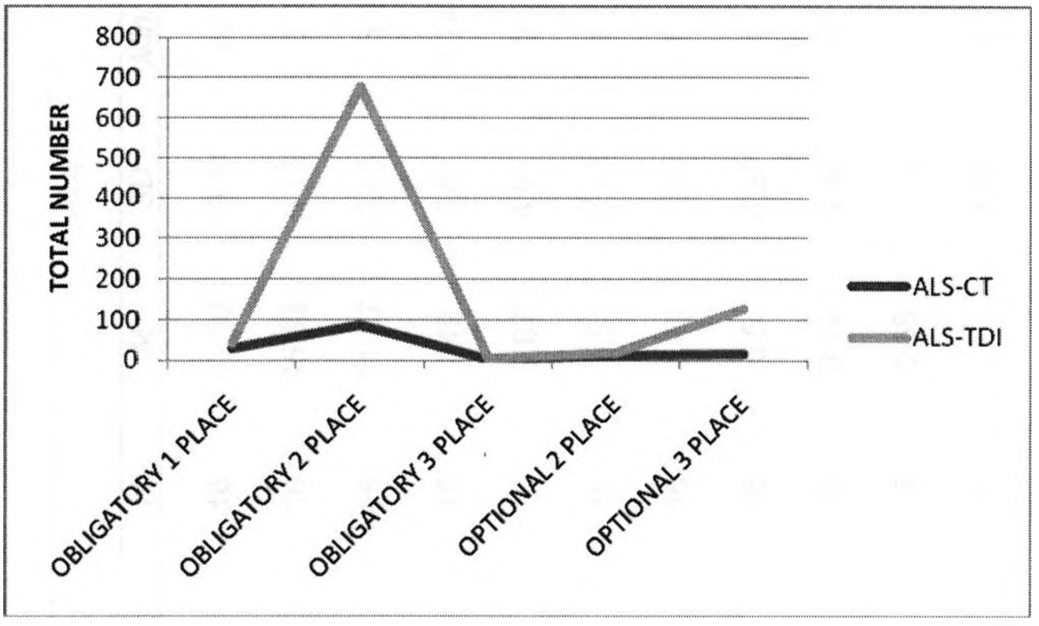


*Figure 4.* ALS- Cookie Theft Picture Description and Topic Directed Interview (TDI). Obligatory 1 place, Obligatory 2 place, Obligatory 3 place, Optional 2 place and Optional 3 place verb arguments produced by the ALS participants.

Table 2

*Picture Description Task scores for ALS and Control Participants*

| | *ALS* | | | | | *Controls* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | *N* | *M* | *SD* | *Min.* | *Max.* | *n* | *M* | *SD* | *Min.* | *Max.* |
| Total words | 16 | 91.00 | 49.51 | 25 | 204 | 12 | 90.41 | 66.21 | 27 | 227 |
| Total nouns | 16 | 15.93 | 9.13 | 5 | 37 | 12 | 15.41 | 7.85 | 6 | 37 |
| Total verbs | 16 | 11.37 | 5.65 | 3 | 23 | 12 | 12.75 | 8.63 | 4 | 33 |
| Noun: Verb Ratio | 16 | 1.49 | 0.63 | 0.74 | 2.84 | 12 | 1.38 | 0.43 | 0.57 | 2.16 |
| Regular verbs | 16 | 5.87 | 4.01 | 0 | 13 | 12 | 5.16 | 3.56 | 1 | 12 |
| Irregular Verbs | 16 | 5.5 | 2.78 | 1 | 12 | 12 | 7.58 | 6.47 | 3 | 25 |
| Obligatory 1 place | 16 | 1.93 | 1.23 | 0 | 4 | 12 | 2.41 | 1.62 | 0 | 5 |
| Obligatory 2 place | 16 | 5.5 | 4.22 | 1 | 14 | 12 | 4.41 | 3.39 | 1 | 12 |
| Obligatory 3 place | 16 | 0.12 | 0.34 | 0 | 1 | 12 | 0.58 | 0.79 | 0 | 2 |
| Optional 2 place | 16 | 0.68 | 0.70 | 0 | 1 | 12 | 1.33 | 1.43 | 0 | 5 |
| Optional 3 place | 16 | 1 | 1.21 | 3 | 1 | 12 | 1.66 | 1.43 | 0 | 5 |

Table 3

*Topic Directed Interview (TDI) scores for ALS and Control Participants*

| | *ALS* | | | | | *Controls* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | *N* | *M* | *SD* | *Min.* | *Max.* | *n* | *M* | *SD* | *Min.* | *Max.* |
| Total words | 15 | 932.86 | 497.15 | 277 | 1875 | 12 | 1010.33 | 610.01 | 313 | 2577 |
| Total nouns | 15 | 152.93 | 73.42 | 44 | 287 | 12 | 157.16 | 86.62 | 62 | 366 |
| Total verbs | 15 | 90 | 56.59 | 17 | 223 | 12 | 99.75 | 55.81 | 29 | 238 |
| Noun : Verb Ratio | 15 | 1.89 | 0.53 | 1.121 | 2.595 | 12 | 1.61 | 0.32 | 1.415 | 2.166 |
| Regular verbs | 15 | 41.93 | 25.14 | 10 | 83 | 12 | 47 | 24.60 | 14 | 104 |
| Irregular Verbs | 15 | 48 | 34.86 | 7 | 144 | 12 | 52.75 | 32.07 | 15 | 134 |
| Obligatory 1 place | 15 | 2.93 | 3.19 | 0 | 13 | 12 | 2.08 | 1.62 | 0 | 5 |
| Obligatory 2 place | 15 | 45.13 | 28.18 | 8 | 89 | 12 | 48.08 | 28.97 | 12 | 116 |
| Obligatory 3 place | 15 | 0.46 | 0.83 | 0 | 1 | 12 | 0.33 | 0.49 | 0 | 1 |
| Optional 2 place | 15 | 1.26 | 1.38 | 0 | 4 | 12 | 2.08 | 2.84 | 0 | 10 |
| Optional 3 place | 15 | 8.53 | 4.35 | 3 | 17 | 12 | 9.16 | 5.33 | 0 | 17 |

The verbs identified in the content units were predominantly 1 and 2 place Obligatory arguments. Hence, there is more linguistic constraint and fewer opportunities to use verbs with more places of argument.

*Additional Findings*

It was noted that the ALS participants produced more parenthetical remarks vs. control participants on both the picture description and the TDI tasks. Parenthetical remarks generally are considered non-propositional language structures adding limited semantic content to the primary information being conveyed. Increased use of parenthetical remarks denotes possible lexical access and linguistic difficulties. The high use of parenthetical remarks also could indicate underlying word-finding and memory difficulties which get masked through the use of parenthetical remarks. Parenthetical remarks can be culturally and cohort dependent.

It was noted that the control participants produced more ellipsis vs. ALS participants on both tasks. One possible explanation for this difference could be the increasing linguistic sophistication and processing associated with ellipsis. That is, the controls used ellipsis to substitute for the place of argument while simultaneously preserving the overall content of the topic.

The second explanation could be due to lack of topic cohesion and coherence described in individuals with ALS which could possibly indicate early frontal lobe dysfunction (i.e., attention, organization) (Aere, 1998). This explanation is supported further by informal transcript analysis where one ALS

participant (# 6) failed to describe the essential components of "Cookie Theft" picture description task. The participant's output consisted mainly of irrelevant and inaccurate information which could possibly indicate an early cognitive impairment involving language, as illustrated in the following example:

| | |
|---|---|
| Examiner: | Now I'm just gonna show you a picture and I want you to tell me everything you see going on in this picture. |
| Participant 6: | well Jane # has got Dick to climb up on the stool # and get the cookies. |
| Participant 6: | but foolishly Dick has XXX and is about to falling in his little ass. |
| Participant 6: | mom # who should be uh # paying ah # closer attention # has taken an overdose of tranquilizers which explains why she is ignoring both Dick and Jane. |
| Participant 6: | and there is a pending accident. |
| Participant 6: | the overflowing sink. |
| Participant 6: | and the fire that's consuming the grass outside. |
| Participant 6: | is that enough? |
| Examiner: | uhm # you let me know when it's enough or if you +... do you see anything else? |
| Participant 6: | well # I see # this oddly XX cups but I think that's probably because they are just XX is minimally talented. |
| Participant 6: | and they need to get proper proportions. |
| Participant 6: | If you look at mom and Dick you will notice that their faces are too small for their bodies. |
| Participant 6: | uhm # If you look at your face and mine you will see # that's too small # for the body. |
| Participant 6: | Especially with kids who have a larger head proportional to their bodies. |
| Participant 6: | uhm # so that's enough. |
| Examiner: | Okay. |

(Note: # denotes 1-2 second pause between words, XX denotes 2 unintelligible words, XXX denotes multiple unintelligible words, +... denotes trailing off )

It also was noted that the ALS participants produced more parenthetical remarks and ellipsis on the TDI task vs. picture description task. One possible explanation for this difference could be the nature of task. The TDI is an open-

ended task in which participant's processing load on the use of sophisticated language is limited. The increased use of parenthetical remarks by ALS participants in the TDI task could possibly indicate the use of less sophisticated and non-propositional language adding limited content to the information. On the contrary, the picture description task vs. the TDI task is a close-ended task which affords a limited set of formal responses and hence requires increased attention and organization for ellipsis production. The increased use of ellipsis in the TDI task could not only indicate sophisticated language use but also memory problems contributing to the overall topic cohesion and coherence problems. Hence, further analysis of ellipsis is warranted in future studies in participants with ALS.

*Limitations of the Study*

The current study yielded several unique patterns in verb argument production among the ALS participants. However, these results should be carefully interpreted considering the following limitations. The investigator examined verb production on discourse tasks based on a small sample of ALS participants which makes it difficult to generalize the results to a larger population.

A cross-sectional study design chosen in the current study was appropriate to answer the research questions. However, with the progress of cognitive and dementia in the ALS participants, the use of a longitudinal design would be beneficial to understand changes in verb use in discourse over time.

Finally, the control participants did not differ from the ALS participants in the total number of verbs, regular and irregular verbs. These results however support the null hypothesis. Hence, further exploration using a larger sample of both ALS participants and controls to understand the verb pattern and processing is warranted.

*Future Directions*

This is the first study to examine in detail the nature of verb deficits in discourse tasks among individuals with ALS. Further investigation of verb impairments is warranted due to the limited significant findings.

The first recommendation for future research is to perform a study with larger sample of participants with ALS and controls which may help to distinguish small significant differences between the two groups.

The second recommendation is to conduct a longitudinal study to examine the change in verb use in discourse among individuals with ALS over time.

The findings of the current study indicate that discourse tasks like the picture description and TDI tasks can be used to detect verb impairments in individuals with early stages of ALS. Hence, the third recommendation for future research is to explore replicating the findings in the current study and to explore in detail the nature of task differences between picture description and TDI tasks.

The fourth recommendation is to use a comprehensive method of analysis of verb structure analysis. In depth analysis of copulas, parenthetical remarks

and ellipsis structure is warranted to provide better insight into verb usage in discourse.

The fifth recommendation is to perform correlation analyses between mean length of utterance and speech rate and between intelligibility and place of verb argument in individuals with ALS to understand the effect of motor speech component on language processing. A correlation analysis between language findings and neuro-psychological measures also is warranted to understand the role of cognition on verb processing.

The sixth recommendation is to perform correlation analyses between regular and irregular verb processing, place of verb argument production and the CT perfusion results which have been collected as a part of the larger multi-disciplinary study. These analyses will provide better understanding of the neuro-anatomical correlates of the brain involved in verb processing and also help support or refute current neurolinguistic theories of verb processing.

The results of the current study indicate no subgroups at baseline. However, Cooper, (2008), found subgroups and differences on performance between bulbar and non-bulbar groups on category naming in a longitudinal study in ALS. Hence the seventh and final recommendation is to explore for possible subgroups (e.g., bulbar vs. non-bulbar) in verb use in discourse over time.

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*Appendix A*

*Individual scores on Intelligibility and rate measures for ALS and Control Participants*

| | Participants | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measures | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | | | | | | | | *ALS* | | | | | | | | |
| Intelligibility | 14.67 | 4.67 | 26.33 | 1.33 | 2.67 | 38.33 | 3.00 | 15.33 | 11.67 | 3.33 | 61.33 | 18.33 | - | 26.00 | 35.00 | 71.67 |
| Rate | 26.67 | 40.67 | 41.33 | 42.33 | 45.00 | 28.00 | 48.67 | 35.00 | 31.67 | 34.00 | 16.00 | 39.33 | - | 33.67 | 26.33 | 27.33 |
| | | | | | | | | *Control* | | | | | | | | |
| Intelligibility | 2.67 | 2.00 | 5.00 | 0.67 | 6.67 | 1.33 | 4.67 | 0.67 | 0.33 | 1.00 | 6.33 | 0.33 | | | | |
| Rate | 46.00 | 40.67 | 35.67 | 52.00 | 41.67 | 49.67 | 35.33 | 51.33 | 51.33 | 45.00 | 47.33 | 49.00 | | | | |

Note. Dashes indicate the data were not obtained for the participant.

*Appendix B*

*Intelligibility and Rate Measures for ALS and Control Participants*

| | ALS | | | | | Control | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Measure | *n* | *M* | *SD* | *Min.* | *Max.* | *n* | *M* | *SD* | *Min.* | *Max.* |
| | | | | | | *Time 1* | | | | |
| Intelligibility | 15 | 22.24 | 21.47 | 1.33 | 71.67 | 12 | 2.64 | 2.39 | 0.33 | 6.67 |
| Rate | 15 | 34.40 | 8.67 | 16.00 | 48.67 | 12 | 45.42 | 5.89 | 35.33 | 52.00 |

Note. For intelligibility the anchor score 0 means "Completely Intelligible" while the anchor score 100 means "Completely Unintelligible". For rate the anchor score 0 means "Very Slow" while the anchor score 100 means "Very Fast".

*Appendix C*

*Cookie Theft Picture Description Task scores for ALS Participants*

| | ALS Participants | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Total no. of words | 59 | 107 | 152 | 106 | 143 | 51 | 150 | 51 | 74 | 53 | 65 | 85 | 40 | 91 | 204 | 25 |
| Total no. of Nouns | 8 | 17 | 18 | 12 | 33 | 24 | 21 | 11 | 16 | 5 | 12 | 9 | 10 | 16 | 37 | 6 |
| Total no. of Verbs | 9 | 16 | 23 | 13 | 17 | 16 | 19 | 10 | 6 | 7 | 8 | 5 | 6 | 11 | 13 | 3 |
| Noun : Verb ratio | 0.88 | 1.06 | 0.78 | 0.92 | 1.94 | 1.5 | 1.10 | 1.10 | 2.66 | 0.71 | 1.5 | 1.8 | 1.66 | 1.45 | 2.84 | 2.00 |
| Regular Verbs | 6 | 4 | 13 | 6 | 10 | 10 | 13 | 3 | 2 | 3 | 2 | 4 | 3 | 6 | 9 | 0 |
| Irregular Verbs | 3 | 12 | 10 | 7 | 7 | 6 | 6 | 7 | 4 | 4 | 6 | 1 | 3 | 5 | 4 | 3 |
| Obligatory 1 place | 1 | 0 | 2 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 3 | 2 | 4 | 4 | 1 |
| Obligatory 2 place | 3 | 8 | 14 | 8 | 5 | 12 | 12 | 3 | 1 | 3 | 4 | 2 | 1 | 4 | 7 | 1 |
| Obligatory 3 place | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| Optional 2 place | 1 | 2 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| Optional 3 place | 2 | 0 | 2 | 1 | 3 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

*Appendix D*

*Cookie Theft Picture Description Task scores for Control Participants*

| | *Control Participants* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Total no. of words | 216 | 101 | 27 | 53 | 55 | 45 | 61 | 60 | 121 | 72 | 227 | 47 |
| Total no. of Nouns | 37 | 16 | 6 | 13 | 12 | 11 | 19 | 13 | 18 | 11 | 19 | 10 |
| Total no. of Verbs | 25 | 16 | 4 | 6 | 9 | 9 | 15 | 6 | 14 | 9 | 33 | 7 |
| Noun : Verb ratio | 1.48 | 1.00 | 1.5 | 2.16 | 1.33 | 1.22 | 1.26 | 2.16 | 1.28 | 1.22 | 0.57 | 1.42 |
| Regular Verbs | 12 | 6 | 1 | 3 | 5 | 4 | 5 | 3 | 11 | 1 | 8 | 3 |
| Irregular Verbs | 13 | 10 | 3 | 3 | 4 | 5 | 10 | 3 | 3 | 8 | 25 | 4 |
| Obligatory 1 place | 5 | 0 | 0 | 1 | 5 | 2 | 3 | 3 | 2 | 2 | 3 | 3 |
| Obligatory 2 place | 8 | 8 | 2 | 1 | 3 | 4 | 4 | 1 | 4 | 5 | 12 | 1 |
| Obligatory 3 place | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 |
| Optional 2 place | 2 | 2 | 2 | 1 | 0 | 1 | 5 | 0 | 2 | 0 | 1 | 0 |
| Optional 3 place | 5 | 2 | 0 | 1 | 0 | 1 | 3 | 1 | 3 | 2 | 1 | 1 |

*Appendix E*

*Topic Directed Interview (TDI) Task scores for ALS Participants*

| | ALS Participants | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 14 | 15 | 16 |
| Total no. of words | 313 | 787 | 1574 | 1875 | 1283 | 653 | 637 | 277 | 722 | 1337 | 987 | 1464 | 1162 | 614 | 308 |
| Total no. of Nouns | 62 | 156 | 287 | 250 | 161 | 122 | 121 | 44 | 120 | 195 | 155 | 246 | 212 | 100 | 63 |
| Total no. of Verbs | 52 | 69 | 160 | 223 | 132 | 47 | 47 | 17 | 66 | 99 | 124 | 144 | 85 | 55 | 30 |
| Noun : Verb ratio | 1.19 | 2.26 | 1.79 | 1.12 | 1.21 | 2.59 | 2.57 | 2.58 | 1.81 | 1.96 | 1.25 | 1.70 | 2.49 | 1.81 | 2.1 |
| Regular Verbs | 20 | 39 | 83 | 79 | 74 | 30 | 25 | 10 | 28 | 40 | 41 | 81 | 39 | 28 | 12 |
| Irregular Verbs | 32 | 30 | 76 | 144 | 58 | 17 | 22 | 7 | 38 | 59 | 83 | 63 | 46 | 27 | 18 |
| Obligatory 1 place | 3 | 4 | 13 | 3 | 2 | 4 | 0 | 0 | 1 | 1 | 3 | 5 | 2 | 3 | 0 |
| Obligatory 2 place | 15 | 26 | 70 | 89 | 73 | 30 | 18 | 9 | 38 | 70 | 69 | 80 | 55 | 27 | 8 |
| Obligatory 3 place | 0 | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Optional 2 place | 0 | 3 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 | 3 | 4 |
| Optional 3 place | 4 | 7 | 16 | 13 | 7 | 8 | 11 | 3 | 8 | 5 | 9 | 17 | 11 | 6 | 3 |

Note. Participant 13 did not provide a TDI sample.

*Appendix F*

*Topic Directed Interview (TDI) Task scores for Control Participants*

| | Control Participants | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Total no. of words | 552 | 857 | 481 | 313 | 834 | 1384 | 1448 | 1190 | 1066 | 887 | 2577 | 535 |
| Total no. of Nouns | 107 | 126 | 71 | 62 | 143 | 235 | 181 | 234 | 148 | 129 | 366 | 84 |
| Total no. of Verbs | 59 | 89 | 55 | 29 | 78 | 148 | 145 | 108 | 102 | 76 | 238 | 70 |
| Noun : Verb ratio | 1.81 | 1.41 | 1.29 | 2.13 | 1.83 | 1.58 | 1.24 | 2.16 | 1.45 | 1.69 | 1.53 | 1.2 |
| Regular Verbs | 30 | 38 | 25 | 14 | 44 | 67 | 65 | 58 | 57 | 31 | 104 | 31 |
| Irregular Verbs | 29 | 51 | 30 | 15 | 34 | 81 | 80 | 50 | 45 | 45 | 134 | 39 |
| Obligatory 1 place | 2 | 2 | 5 | 1 | 3 | 3 | 1 | 0 | 1 | 1 | 5 | 1 |
| Obligatory 2 place | 25 | 50 | 33 | 12 | 25 | 63 | 75 | 55 | 59 | 46 | 116 | 18 |
| Obligatory 3 place | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| Optional 2 place | 4 | 0 | 1 | 0 | 0 | 3 | 0 | 3 | 2 | 1 | 10 | 1 |
| Optional 3 place | 4 | 10 | 7 | 2 | 9 | 17 | 0 | 14 | 13 | 12 | 15 | 7 |

*Appendix G*

Definitions for Discourse Measures

**Word**

Words are identified according to Nicholas and Brookshire's (1993) definitions and guidelines. According to their definition, words are "intelligible in context to someone who knows the topic being discussed". They "do not have to be accurate, relevant, or informative relative to the topic being discussed" (p.348). The following rules apply:

- Interjections (e.g., oh, wow, golly, gosh, gee, aha, ahh, shhh) are counted.
- Informal terms (e.g., uh-huh [affirmative], un-uh [negative], nope, yep, yeah, mhmm) are counted.
- Common contractions and simplifications (e.g., "gonna" for "going to", "em" for "them", 'n' or an' for "and") are counted.
- Standard contractions (e.g., don't, he's) and colloquial contractions (e.g., gonna, sorta) are counted as two words.
- Each word in hyphenated forms is counted as one word (e.g., jack-in-the-box = 4 words).
- Each word in numbers is counted as one word (e.g., one hundred thirty-four = 4 words).
- Compound words (e.g., pancake, cowboy) are counted as one word.
- If a pause occurs in the middle of a compound word, it is still counted as only one word (e.g., shuffle [pause] board = 1 word).
- If a filler placed in the middle of the compound word, then it is counted as two words (e.g., sun uh room = 2 words).
- If a revision or repetition occurs within a compound word, it is still counted as one word (e.g., sunr-room = 1 word).
- Each word in proper names is counted as one word (e.g., Mary Smith = 2 words).
- Acronyms (e.g., TWA, GM) are counted as one word.
- Initials (e.g., K.G.) are counted as one word.
- Words in revisions and repetitions are counted as separate words.
- Single letters are **not** counted (e.g., N6H = 1 word ['six']).
- Non-word fillers (e.g., um, er, uh, hmm, mmm) are **not** counted.
- Paraphasic errors that result in non-words (e.g., crolesterol) are **not** counted.

**Utterance**

Utterances are defined according to Shewan (1988). According to her definition, an utterance is a "complete thought, usually expressed in a connected grouping

of words, which is separated from other utterances on the basis of content, intonation contour, and/or pausing" (p.124). The following guidelines apply:

- A change in content signals the beginning of a new utterance.
- Falling or rising intonation contours signal the end of an utterance.
- Pauses are interpreted in conjunction with content and intonation contours to signal the end of an utterance. Pauses longer than 2.0 seconds, in conjunction with a falling or rising contour and change in content localizes the end of an utterance.
- Tag questions or tag sentences are not segmented as separate utterances (e.g., It's cold in here, isn't it? = 1 utterance).
- Parenthetical remarks that are complete thoughts are segmented as separate utterances (e.g., I think that's right. = 1 utterance).
- Sentence starters and enders (e.g., okay, you know) are not segmented as separate utterances unless the sentence starter or ender is accompanied by a falling or rising intonation contour and a distinct pause marking it as a separate utterance.
- Quotations are segmented as separate utterances (e.g., The father said [1 utterance]: Let's go children. [1 utterance]).
- Utterances that are completely unintelligible are not counted.
- Utterances that contain unintelligible components, but do have intelligible content are counted.
- For the purposes of this study, when an address is provided, the house/apartment number plus street name and then the city plus postal code are counted as separate utterances (e.g., 123 Rose Avenue [1 utterance] London N6H 4Y8 [1 utterance]).

**Incomplete Utterance and Complete Utterance**

Incomplete utterances are defined following the definitions and guidelines of the CHILDES Project (MacWhinney, 1995). According to this definition, utterances are "incomplete but not interrupted" utterances in which the participant "trails off" without completing the thought (p.43).

e.g., Utterance #1: *The doctor here was in touch with him and told him...*
Utterance #2: Oh the B-12 shot was something that I got for a long time.

Utterances that do not "trail off" and contain a complete thought are counted as complete utterances.

Utterances that are interrupted by the examiner are counted as neither complete nor incomplete. They are not included in analysis of complete and incomplete utterances.

**Noun**

Nouns include people, places, objects, and ideas. For the purposes of this study, the following guidelines apply:

- Each word in a proper name is counted as a noun (e.g., Highway Market = 2 nouns).
- Numerals are counted as nouns only if they do not modify another noun (e.g., "I have *two* cats." [two = adjective]; but "I have *two*." [two = noun] )
- Nouns occurring in revisions are counted.
- Only the first occurrence of nouns in repetitions is counted.

**Verb**

The following guidelines apply:

- Participles (e.g., present: verb + ing; past: verb + ed) are counted, except when they are used as adjectives (e.g., The movie was entertaining - "entertaining" = adjective; He was entertaining the audience - "entertaining" = verb).
- Infinitives (i.e., to + verb) are counted.
- Gerunds (i.e., verb form ending in -ing used as nouns, such as "I quit *smoking.*") are counted.
- Verbs acting as auxiliaries (e.g., *be*, *have*, *do*) are not counted.
- *Going to*, *have to, got to* are not counted when used as auxiliary verbs as substitutes for *will* and *must.*
- Modals (e.g., *can*, *could*, *may*, *would*, *shall*, *should*, *will*, *must*, *used to*) are not counted.
- Verbs occurring in revisions are counted.
- Only the first occurrence of verbs in repetitions is counted.

**Proportion of Nouns to Verbs**

The proportion of nouns to verbs is calculated by dividing each participant's proportion of nouns (number of nouns/ total number of words) by his/her proportion of verbs (number of verbs/ total number of words).

**Transitive Verb**

A verb that has a receiver of its action (e.g., the shore was *battered* by the storm-driven waves) (Quirk & Greenbaum, 1973).

**Intransitive Verb**

A verb that does not have a receiver of its action or that expresses a state of being (e.g., if he *comes*, he will be welcome) (Quirk & Greenbaum, 1973).

**Regular verb**

A verb that forms its past tense and past participle by adding ed, d, or t to the present stem (e.g., talk, *talked*; dive, *dived*; burn, *burnt*) (Quirk & Greenbaum, 1973).

**Irregular Verb**

A verb that forms its past tense and past participle in any other way than by adding ed, d, or t to the present stem (e.g., drive, drove, *driven*; think, thought, *thought*) (Quirk & Greenbaum, 1973).

**Verb Argument**

The number of participants that go into the 'action' described by the verb are called arguments of the verb. Arguments are typically Noun Phrases (though they can also be sentential clauses, prepositional clauses, or adjectival phrases) that fill argument positions (typically, subject, object, and indirect object positions). Each argument is assigned a thematic role (e.g., agent, theme, and goal) (Chapey, 2001).

**Verb type**

**Obligatory one-place (Ob1)**

Verbs that take only an external argument: Agent/Experiencer.
E.g., Control 13: um my # parents are both *deceased.*
Other examples: smiles, skates, skis, laughs, pray (Thompson, et al., 1997).

**Obligatory two-place (Ob2)**

Verbs that require both arguments: Agent/Experiencer and Theme.
E.g., Control 4: The woman is *washing* the dishes.
Other examples: catches, hugs, opens, kisses, closes (Thompson, et al., 1997).

**Obligatory three-place (Ob3)**

Verbs that require three arguments: Agent/Experiencer, Theme and Goal/Location.
E.g., Control10: and <she> [/] she really wanted me to go back to school
Control10: or I wanted to go back to school
Control10: but she said # she would *put* me # through school
Other examples: leans, gives, nails (Thompson, et al., 1997).

**Optional two-place (Op2)**

Verbs that require one external argument: Agent/Experiencer. The second argument (Theme) is optional.
E.g., Participant 9: his mother is doing the dishes and the water is *overflowing* in the sink.
Other examples: feeds, studies, sings, cleans, shaves (Thompson, et al., 1997).

**Optional three-place (Op3)**

Verbs that require an Agent/Experiencer and a Theme, but the third argument (Goal/Location) is optional.
E.g., Control 13: I *went* to teacher's college for one year in Windsor
Other examples: mails, reads, teaches, throws, writes (Thompson, et al., 1997)

**Ellipsis**

The omission of a word or a phrase necessary for the completion of a syntactical construction but not necessary for understanding (Fowler, et al., 2005).

Obligatory 1 place Ellipsis
E.g., Examiner: can you tell me <more> [/] more about what you do each day?
Participant 5: um # well it's a matter of # well going to the call.
Participant 5: and # hopefully fixing the machine.
Participant 5: <going> [//] *calling* up and seeing if there's any new calls in that area before I go on.

Obligatory 2 place Ellipsis
E.g., Participant 12: I lived on a farm.
Participant 12: and then I lived there (un)til I was nineteen.
Participant 12: *went* off to university.

Optional 3 place Ellipsis
E.g., Control 4: children are behind her
Control 4: shes' not viewing them
Control 4: *getting* cookies out of the cookie jar

**Parenthetical Remarks**

A parenthetical remark is a word or clause within an utterance that has been added by the speaker into something written or spoken, as an explanation or comment (Collins, 2003).
E.g., Participant 4: but uh generally *you know* the family is coping quite well