SYNTACTIC COMPLEXITY IN PERSONS WITH MULTIPLE SCLEROSIS

by

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A thesis submitted to the faculty of

Brigham Young University

in partial fulfillment of the requirements for the degree of

Master of Science

Department of Communication Disorders

Brigham Young University

August 2009

BRIGHAM YOUNG UNIVERSITY

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ABSTRACT

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Several studies using standardized tests have provided evidence for the presence of language disorders in persons with Multiple Sclerosis (MS) and have suggested that persons with MS may have language that is less complex. One aspect not thoroughly studied is that of syntactic complexity in naturalistic, conversational settings. The present study collected language samples from 10 adults with MS and 10 age-matched controls and compared scores on five quantitative measures derived from those samples. No significant differences were found between groups on any measure. This finding suggests that in mild cases of MS or during periods of remission, individuals may retain their ability to use complex language structures in naturalistic discourse.

ACKNOWLEDGMENTS

Many sources contributed to the completion of this thesis. This work was part of a larger study carried out by my fellow researcher Kristi Hollis. Kristi, you have been a pleasure to work with. I've appreciated your wisdom and experience, humor and down to earth character. Thank you so much to my outstanding thesis committee. Dr. Channell, you have made a daunting task accomplishable through your accessibility, patience, guidance, and encouragement. Thanks you for your tirelessness in answering questions, responding to emails, and editing drafts. I couldn't have asked for a better mentor. Dr. Nissen, thank you for your flexibility and support. You have increased my appreciation for the importance of collaboration. Dr. Dromey, you have increased my appetite for knowledge and learning. You have instilled in me the importance of a rationale.

I would like to thank countless friends and family, who willingly participated in this study in one form or another. I thank my colleagues. What an amazing group of women I have been enlightened and inspired by. Women I have laughed with, cried with, and eaten chocolate with. These are friends for life.

Lastly, I would like to thank my family for their tireless inquisitions regarding when I would complete this thesis. I especially thank my mother, for picking up the phone in the middle of the night time and again to help me get through tears and fears as I submitted draft after draft. She has been a great support to me and has given countless time and prayers to this cause.

Table of Contents

List of Tables

Table Page

List of Appendixes

Appendix Page

Introduction

While speech characteristics in persons with multiple sclerosis (MS) have been and continue to be the focus of research in communication disorders, the study of language impairments in MS has received much less attention. With rare exception, language in MS was assumed not to be impaired (Anzola et al., 1990; Jennekens-Schinkel, Lanser, Van der Velde, & Saunders, 1990; Rao, Leo, Bernardin, & Unverzagt, 1991). However, several studies have provided evidence for the presence of language disorders (Blackwood, La Pointe, Holtzapple, Pohlman, & Graham, 1991; Day, Fisher, & Mastaglia, 1987; Fitz Gerald, Murdoch, & Chenery, 1987; Friedman, Brem, & Mayeux, 1983; Lethlean & Murdoch, 1993; Olmos-Lau, Ginsberg, & Geller, 1977) and have suggested that persons with MS may indeed have language that is less complex (Lethlean & Murdoch, 1997; Wallace & Holmes, 1993). Determining the presence of language deficits in persons with MS might be important for rehabilitation because language disorders typically have a negative impact on the individual’s functional communication and quality of life.

Standardized, norm-referenced tests have produced ambiguous findings relative to language problems in this population; however, part of the problem might be the tests themselves (Anzola et al., 1990; Blackwood et al., 1991; Day et al., 1987; Fitz Gerald et al., 1987; Friedman et al., 1983; Jennekens-Schinkel et al., 1990; Lethlean & Murdoch, 1993; Olmos-Lau et al., 1977; Rao et al., 1991). Primarily, studies have utilized language subtests from neuropsychological assessments rather than tests designed specifically for measuring linguistic abilities. Neuropsychological tests are designed to assess only basic, functional language abilities and are not sufficiently sensitive assessments for measuring higher language function. These tests may have failed to identify more complex language processes, resulting in conflicting reports regarding this population. Multiple studies have reported word-finding difficulties among this population (Beatty, Goodkin, Hertsgaard, & Monson, 1990; Caine, Bamford, Schiffer, Shoulson, & Levy, 1986; Jambor, 1969). Other studies have reported intact naming (Pozzilli et al., 1991; Ron, Callanan, & Warrington, 1991). In addition, reduced speed of lexical access is another inconsistently reported linguistic deficit (Anzola et al., 1990; Fitz Gerald et al., 1987; Heaton, Nelson, Thompson, Burks, & Franklin, 1985). Furthermore, the majority of studies have reported competent reading, writing, and spelling skills as well as relatively intact comprehension abilities in persons with MS. Inconsistent findings among researchers make it difficult to draw concrete conclusions about language abilities in the MS population.

Language assessments designed to test individuals with aphasia have also been commonly used by researchers studying the MS population in an effort to provide more valid testing measures (Fitz Gerald et al., 1987; Franklin, Heaton, Nelson, Filley, & Seibert, 1988; Heaton et al., 1985; Wallace & Holmes, 1993). Results have differed due to methodology, but most have found evidence of semantic or lexical impairments.

Two studies have focused closely on the description of language in persons with MS. Lethlean and Murdoch (1993) used a comprehensive battery of specific linguistic tests to research the presence of linguistic impairment in persons with MS. Using tests specifically designed for the purpose of assessing high level language abilities, Lethlean and Murdoch were able to more fully describe language impairment in persons with MS in the most extensive study to date utilizing this methodology. Since the original report in 1993, Lethlean and Murdoch (1997) have extended their study to include 43 additional individuals with MS, for a total of 60 participants. As a group, the MS participants performed significantly below the control group on the test battery given.

A second study focusing on the language characteristics of persons with MS was conducted by Wallace and Holmes (1993), who assessed cognition, language, and memory in persons with MS using the Arizona Battery for Communication Disorders (ABCD). Although the ABCD was not particularly sensitive to cognitive areas expected to be affected by MS, the ABCD subtests offered a sensitive assessment of subtle linguistic impairments in the MS population, including impairments in written and spoken language formulation and discourse. Although further research must be conducted with a larger sampling of individuals to allow for generalization, Wallace and Holmes provided evidence for the presence of higher language impairment in the MS population.

However, these studies have only initiated the investigation of language problems in persons with MS. Standardized testing has provided evidence for and against the argument that language complexity is diminished in the population with MS. Discrepancies among findings suggest that there is a need for further assessment of high level language performance to more fully describe the presence and nature of language impairment in this population. One aspect not thoroughly studied is that of syntactic complexity in naturalistic, conversational settings, and it may be the case that differences in higher language function may be measurable using commonly used, well-tested clinical measures of syntactic complexity.

Naturalistic language sampling has long been used to gather data to analyze and quantify the production of syntactic structure. Research has mainly focused on studying the language produced by children. Recently, measures used in analysis of children's syntactic complexity have been successfully applied in studies of adult language (Cheung & Kemper, 1992; Kemper, Herman, & Lian, 2003; Kemper, Herman, & Liu, 2004; Kemper, Thompson, & Marquis, 2001). Studies of syntactic complexity in the adult population have been made using common measures derived from language samples, such as the mean length of utterances in morphemes (MLUm; Brown, 1973), the mean number of clauses per utterance (MCU; Kemper, Kynette, Rash, Sprout, & O'Brien, 1989), Developmental Sentence Scoring (DSS; Lee, 1974), or the Language Assessment Remediation and Screening Procedure (LARSP; Crystal, Fletcher, & Garman, 1989).

Using these tested, common clinical measures to examine syntactic complexity in persons with MS might help to better characterize the language produced by this population and offer insight regarding the often contradictory findings produced by standardized testing. The present study compares the syntactic complexity of persons with and without MS on syntactic measures derived from naturalistic language samples.

Review of Literature

The following review gives a basic description of the disease, signs, and symptoms associated with MS. Next, the speech and language problems in this population will be reviewed. Finally, clinically used measures of syntactic complexity will be discussed.

MS: An Overview

MS is a demyelinating disease of the central nervous system (CNS). Myelin, or white matter, is produced by oligodendricytes in the CNS and acts as a high resistance insulator for the axon. Myelin covers axons in segmented units separated by nodes of Ranvier. Nodes allow axons to conduct nerve impulses in a hopping manner along the axon, increasing the speed of transmission. Unsurprisingly, the demyelination results in conduction deficits. Scar tissue or *sclerotic plaque* forms as a result of the demyelination process and can occur anywhere in the CNS. Anatomical site of lesion is varied across individuals, may occur in multiple regions throughout the CNS, and may vary in size and shape. However, in the early stages of disease, the majority of persons with MS have lesions within a relatively limited distribution throughout the CNS (Darley, Brown, & Goldstein, 1972; National Multiple Sclerosis Society, 2006).

Epidemiology. MS occurs post-pubescently with onset of symptoms occurring between the ages of 20-40 years and is slightly more common in females (Hartelius, Nord, & Buder, 1995). Higher incidence is associated in countries further away from the equator with peak prevalence at latitudes between 40°to 60°. In the United States, a higher incidence occurs in the northern half of the country (Darley et al., 1972).

Disease course. The general course of MS is variable; however, it generally follows one of four courses: relapsing-remitting, primary-progressive, secondary-progressive, and progressive-relapsing. The majority of the MS population initially experiences the relapsing-remitting form, in which periods of exacerbation are followed by periods of complete recovery. Many persons with the relapsing-remitting form develop a secondary-progressive disease course in which neurological function steadily decreases with or without remission. A primary-progressive course affects 10% of the MS population and is characterized by slowly worsening neurological function without remission of symptoms. The fourth course, progressive-relapsing, is a rare form which involves a steady worsening of neurological function with clear attacks throughout the progression of the disease. These individuals may or may not experience some recovery of symptoms.

Disease Symptoms. As previously discussed, the most common symptoms associated with MS include monocular visual loss, diplopia, gait difficulty, paresis or incoordination of an upper extremity, fatigue, and urinary difficulties. Other symptoms such as dysarthria, dysphagia, nystagmus, auditory dysfunction, weakness, ataxia, intention tremor, spasticity, and emotional lability are reportedly more common in individuals with advanced MS. Fatigue has been noted in some studies as among the most common symptoms and one that exacerbates other symptoms (Morris, Cantwell, Vowels, & Dodd, 2002; Stuifbergen & Rogers, 1997).

Speech and Language Problems in MS

Dysarthria. Dysarthria is a motor speech impairment characterized as slow, weak, imprecise and/or uncoordinated movements of the speech mechanism. Dysarthria subtypes are classified according to their unique perceptual features. Although dysarthria is considered to occur more commonly in individuals with the advanced form of the disease, Darley et al. (1972) found presence of dysarthria in 40% of individuals with MS. Furthermore, Hartelius, Runmarker, and Anderson (2000) reported a 51% incidence of dysarthria in their study. Perceptual features of dysarthria subtypes are dependent on site of lesion. Dysarthria in MS is attributable to damage in cerebellar, brain stem, cerebral, and spinal function. Consequently, ataxic, spastic, and mixed dysarthrias are associated with MS. Severity of accompanying dysarthria is related to the degree of neurologic involvement and speech deviations become more prominent with increased motor system involvement (Darley et al., 1972).

In 1877, Charcot described abnormal speech in persons with MS as slow, drawling, ‘scanning’ speech and this description was commonly accepted as characteristic in persons with MS. However, Darley et al. (1972) found its incidence to be surpassed by nine other speech deviations, such as pitch and loudness control, appropriateness of pitch level, voice quality deviations, articulation, hypernasality, and overall adequacy of emphasis. In their study the most frequent speech deviation was that of impaired loudness control (Darley et al., 1972). Fitz Gerald et al. (1987) also found the most prominent speech deviations to be impaired respiratory support, pitch variation and steadiness, abnormal prolongation of intervals during speech, and harsh voice quality. Hartelius, Theodoros, Cahill, and Lillvik (2003) found similar perceptual dimensions. These included imprecise consonants, harshness and glottal fry, reduced speech rate, reduced pitch level, and reduced loudness.

Prosody. Acoustic analysis is useful in describing key features of disordered speech in MS, providing quantitative measures of severity and documenting disease progression. Temporal dysregulation occurs frequently in dysarthric persons with MS and has been associated with equalization of syllable duration, although Hartelius, Runmarker, Andersen, and Nord (2000) suggest the interstress interval (the time between the main stressed syllables) could also contribute to perceived dysprosody. Individuals with MS exhibit significant differences from normal speakers in phonatory instability in measures of intensity and fundamental frequency (Hartelius, Buder, & Strand, 1997). Thus, a definite laryngeal component is associated with this dysarthric population.

Cognition. Jennekens-Schinkel et al. (1990) examined cognition in a group of 39 patients with MS using tests requiring language usage and figure copying. Participants were matched for socioeconomic status to a group of 24 controls. The authors found linguistic and cognitive-constructional problems to be no more severe or frequent than in control subjects. Decreased speed in copying and reading aloud was attributed to impaired control of the phonatory apparatus, oculomotor problems, or weakness of color vision rather than being of cognitive origin.

Rao et al. (1991) analyzed cognition in a group of 100 community-based patients with MS and 100 demographically matched healthy controls. The authors asserted that estimates of cognitive dysfunction in MS resulted from studying clinical populations and expected to find decreased incidence of cognitive impairment than had been previously estimated. On a comprehensive neuropsychological test battery, patients with MS were more frequently impaired on measures of recent memory, sustained attention, verbal fluency, conceptual reasoning, and visuospatial perception, and less frequently impaired on measures of language and immediate and remote memory. Of the 48 patients with MS and five controls showing impairment on given testing measures, patterns of cognitive decline were not uniform. Cognitive impairment was not significantly associated with illness duration, depression, disease course, or medication usage; however, it was weakly correlated with physical disability. The percentage of persons with MS exhibiting cognitive decline was 43%, which was lower than previous estimates, which had ranged from 54 to 65 percent. The authors concluded that the incidence of cognitive decline in MS may not be as prevalent as previously thought.

Language. Standardized testing has provided evidence for and against the argument that language complexity is diminished in the population with MS. Discrepancies among findings suggest that there is a need for further assessment of high level language performance to more fully describe the presence and nature of language impairment in this population. However, several studies have provided evidence that persons with MS may indeed have language that is less complex.

Documentation of language impairments in the MS population has consisted primarily of case studies providing evidence for the presence of language disorders. Documented cases have reported an array of language problems in this population, reflecting the diversity of the disease itself. Reported language disorders have included incidences of motor aphasia (Olmos-Lau et al., 1977), global aphasia (Friedman et al., 1983), and a fluent language disorder with alexia and agraphia (Day et al., 1987).

Olmos-Lau et al. (1977) reported a case in which a 17-year-old woman developed motor aphasia characterized by absent spontaneous speech, paraphasias in naming and repetition, intact auditory comprehension, preservation of written language, and orofacial apraxia. Friedman et al. (1983) documented a case of global aphasia in a 32-year-old woman with MS. She presented with non-fluent language production, severely impaired repetition, naming, reading, and writing, and poor comprehension of simple commands. Another study by Day et al. (1987) described a case of fluent aphasia paired with alexia with agraphia in a 34-year-old woman. Her symptoms eventually resolved to mild language deficits. However, dysnomia and mildly impaired comprehension and repetition persisted along with alexia and agraphia. Additionally, Achiron et al. (1992) presented a case of two subjects with a relapsing-remitting disease course of MS who experienced an acute onset of severe non-fluent aphasia. Magnetic resonance imaging (MRI) located plaques in the left frontal region and the left centrum semiovale which were sufficiently large enough to disrupt commissural, association, and projection fibres in the dominant fronto-temporal region, thus causing motor aphasia.

A larger case study by Wallace and Holmes (1993) consisted of four individuals with a chronic progressive disease course. The authors documented cognitive and linguistic deficits on the ABCD. When compared to a control group, lower scores were found on the linguistic subtests assessing object description, generative naming, concept definition, generative writing, and picture description abilities. Although the ABCD was not particularly sensitive to cognitive areas expected to be affected by MS, the ABCD subtests offered a sensitive assessment of subtle linguistic impairments in the patients with MS, including impairments in written and spoken language formulation and discourse. Although research must be conducted with a larger sampling of individuals to allow for generalization, Wallace and Holmes provided further evidence for the presence of higher language impairment in the MS population.

Research of language abilities in groups of persons with MS has been primarily limited to investigations of performance on neuropsychological assessments. Language subtests utilized in neuropsychological test batteries assess only basic functional language abilities such as naming, verbal fluency, spelling, reading, and writing. Although word-finding difficulties have been documented on naming tasks such as the Boston Naming Test (BNT), the abbreviated BNT, and the Graded Naming Test as well as other unspecified tests of naming (Beatty et al., 1990; Caine et al., 1986; Jambor, 1969), other studies have reported intact naming abilities in MS (Pozzilli et al., 1991; Ron et al., 1991). Reduced speed of lexical access is another deficit that has been inconsistently reported (Anzola et al., 1990; Fitz Gerald et al., 1987; Heaton et al., 1985) among studies utilizing neuropsychological test batteries.

In an effort to more accurately identify language abilities in the MS population, studies were developed employing the use of aphasia test batteries (Fitz Gerald et al., 1987; Franklin et al., 1988; Heaton et al., 1985; Wallace & Holmes, 1993). Heaton et al. (1985) used the Aphasia Screening Test to compare 57 relapsing-remitting and 43 chronically progressive subjects with MS to a control group. The chronically progressive group was found to perform lower than both the relapsing-remitting and control groups, while the relapsing-remitting and control groups performed similarly.

Franklin et al. (1988) also assessed a chronically progressive MS group using the Multilingual Aphasia Examination and the subtest of commands with auditory sequencing from the Western Aphasia Battery. Interestingly, the subjects with MS demonstrated receptive and expressive language skills that were not significantly different from the control group.

Similarly, Fitz Gerald et al. (1987) used subtests from the Neurosensory Centre Comprehensive Examination for Aphasia and the Wiig-Semel Test of Linguistic Concepts to assess a group of 20 persons with MS. More than half of these persons performed at a lower than normal level of functioning on subtests of tactile naming, word fluency, sentence construction, writing to dictation, and articulation; however, no typical aphasic syndrome was identified in this group.

In another study utilizing aphasia test batteries, Blackwood et al. (1991) compared participants having both aphasia and MS to participants with MS only using the BNT. As a group the participants with MS performed similarly to the control group. However, differences were found in naming abilities among the participants with aphasia and MS and a small subset of the participants with MS only that could not be explained by differences in age, education, or length of illness.

As mentioned previously, a comprehensive battery of specific linguistic tests was employed by Lethlean and Murdoch (1993) to research the presence of linguistic impairment in persons with MS. Using tests specifically designed for the purpose of assessing high level language abilities, Lethlean and Murdoch were able to more fully describe language impairment in persons with MS. Since the original report in 1993, Lethlean and Murdoch (1997) have extended their study to include 43 additional individuals with MS, for a total of 60 participants. As a group, the participants with MS performed significantly below the control group on the test battery given.

Clinical Measures of Syntactic Complexity

Several measures of linguistic complexity shown to differentiate between groups of adults (Cheung & Kemper, 1992; Kemper et al., 2003; Kemper et al., 2004, Kemper et al., 2001) or having the potential to do so were used in the present study. These measures were Mean Length of Utterance in morphemes (MLUm; Brown, 1973), Mean Clauses per Utterance (MCU; Kemper et al., 1989), Developmental Sentence Scoring (DSS; Lee, 1974), and two methods which quantify the information obtained in a Language Assessment, Remediation and Screening Procedure analysis (LARSP; Crystal et al., 1989): the Syntactic Complexity Score (SCS; Blake, Quartaro, & Onorati, 1993) and the Picture-elicited Scoring procedure for LARSP (PSL; Ward & Fisher; 1990).

MLU. MLU is perhaps the most popular informal method of language sample analysis (Brown, 1973; Hux, Morris-Friehe, & Sanger, 1993; Kemp & Klee, 1997). Since its introduction in the early 1970s, MLU has been widely used by clinicians. MLU attempts to quantify language complexity based on the average number of morphemes present in each utterance. To calculate MLU, a clinician must divide the language sample into separate utterances, find the total number of morphemes in the sample, and then divide the total number of morphemes by the total number of utterances. This gives the child's average utterance length in morphemes.

The reliability and validity of MLU has been the focus of much study. For example, Miller and Chapman (1981) studied the correlation between age and MLU in younger children. Samples from 123 pre-school and early school-age children in Madison, Wisconsin were collected during an unstructured free-play session with the children and their mothers. MLU correlated significantly with age, $r = .88$. Miller and Chapman concluded that age and MLU could reliably predict each other in children with normal language development.

Although MLU does correlate with chronological age (Miller & Chapman, 1981; Rondal, 1987), some researchers have questioned the measure's ability to accurately quantify syntactic complexity. Studies have correlated MLU with the order of grammatical morpheme acquisition (de Villiers & de Villiers, 1973; Klee & Fitzgerald, 1985). A recent study documented a correlation between MLU and other formal and informal measures of complexity (Rice, Redmond, & Hoffman, 2006). However, the relationship between the overall complexity of a language sample and the MLU score remains controversial.

MLU was used in studies of adult syntactic complexity (Cheung & Kemper, 1992; Kemper et al., 2003; Kemper et al., 2004; Kemper et al., 2001) and has been found to reflect differences between the syntactic complexity of younger and older adults.

MCU. One indication of syntactic complexity is the number of conjoined and embedded clauses in an utterance. Syntactic development is marked by increases in the number and types of embedding (Miller & Chapman, 1981; Scott, 1988). Thus a calculation of the average number of clauses per utterance in a sample reflects the overall level of syntactic complexity. Kemper and colleagues (Cheung & Kemper, 1992; Kemper et al., 2003; Kemper et al., 2004; Kemper et al., 2001; Kemper et al., 1989) have found MCU to be a useful index of syntactic complexity in adults.

DSS. Lee (1974) developed DSS to assess children's grammatical development. Using a naturalistic language sample of at least 50 complete (subject + predicate), consecutive, intelligible sentences, scores are given using eight different categories of grammatical forms: (a) indefinite pronouns, (b) personal pronouns, (c) main verbs, (d) secondary (embedded) verbs, (e) conjunctions, (f) negatives, (g) interrogative reversals, and (h) *wh*-questions. Scores are calculated within each of the eight categories to reflect the developmental sequence found is children's speech. Total points for each sentence are calculated using the points from each category. An additional point is given to fully grammatical sentences.

Researchers have evaluated the effectiveness of this method and discovered both the strengths and limitations of DSS. Its strengths include its utility in quantitative verification of a language problem (Bloom & Lahey, 1978), its help in the description of development and its usefulness in organizing efforts in asking and answering clinical questions (Hughes, Fey, & Long, 1992), its widespread familiarity (Hux et al., 1993; Kemp & Klee, 1997), the availability of tutorial software (Hughes, Fey, Kertoy, & Nelson, 1994) and effectiveness in teaching the analysis (Lively, 1984), its low materials cost and public-domain status, and the comparatively thorough documentation of its coding rules.

DSS has several documented limitations. These limitations include the time and complexity of the analysis (Fristoe, 1979), the questionable validity of its developmental sequencing (Klee & Sahlie, 1986), the nonhierarchical nature of the analysis (Klee, 1985), the fact that a single score might represent quite different grammatical profiles (Hughes et al., 1992), the omission of many grammatical form types and (Bloom & Lahey, 1978), the scoring of certain structures (e.g. *like* as a preposition meriting 8 points). Other issues include the limited size and diversity of the standardization group (Fristoe, 1979; Vaughn-Cook, 1983), the sampling variability inherent in a nonstandardized setting (Fristoe, 1979), the tenuous nature of quantifying verbal behavior (Muma, 1998), and the questionable reliability of using only 50 sentences in its computation (Johnson & Tomblin, 1975).

Knowledge of the strengths and weaknesses of DSS allows clinicians to use this method as “a valuable tool for assessing grammatical development, assisting in making diagnostic judgments, aiding in treatment planning, and evaluating treatment gains” (Hughes et al., 1992, p. 9). Recent research has focused on the development of automated DSS using the Computerized Profiling software (CP; Long, Fey, & Channell, 2008). Long and Channell (2001) and Channell (2003) found the CP software to produce DSS scores that were highly correlated with those produced by human coders. DSS has also been used to study syntactic complexity in adults (Cheung & Kemper, 1992; Kemper et al., 2003; Kemper et al., 2004; Kemper et al., 2001).

LARSP. LARSP (Crystal et al., 1989) is a technique for profiling the syntactic complexity manifest in a naturalistic language sample. LARSP describes grammatical ability on the clause, subordinate clause, phrase, and word levels as well as offering a developmentally sequenced way to inventory the syntactic constructions in a language sample. LARSP has been used to profile samples from children and adults (Crystal, 1979), but does not yield a score or index. Two methods, the SCS and the PSL, have been developed by other authors to quantify the information in a LARSP analysis.

SCS. Originally developed by Blake & Quartarto (1990), the SCS counts the number of grammatical categories within an utterance. These categories are the subject, verb, object, and complement. The number of constituents is summed and the average across all multiword utterances is calculated and called the SCS. The SCS is calculated only for multiword utterances because single-word utterances do not involve syntax since syntax is the relationship among morphemes. Blake et al. (1993) found evidence to support the use of SCS as a useful measure for indexing syntactic complexity. No studies have investigated the SCS in adult language samples.

PSL. Ward and Fisher (1990) developed the PSL in an effort to improve the ease of scoring the Renfrew Action Picture Test (RAPT), and their procedure was originally referred to as the Picture-Elicited Scoring Procedure. The RAPT is a screening task designed to elicit language which is then scored for grammatical structures using LARSP. The PSL treats the LARSP grammatical items as an inventory and gives one point for each item, multiplied by the LARSP stage level for that item. For example, structures occurring in LARSP Stage IV would each score four points while structures occurring in Stage II would each score two points. Each grammatical structure is only counted a single time. The PSL score is the sum of the points awarded. PSL scores thus indicate a certain level of grammatical complexity (Ward & Fisher, 1990). No studies using PSL with adults have yet been published.

Summary

Research has suggested that persons with MS differ not only in speech but in language characteristics from other adults (Lethlean & Murdoch, 1997; Wallace & Holmes, 1993). A variety of procedures for quantifying the syntactic complexity shown in a naturalistic language sample exist; several of these have been applied to the naturalistic language of adults. No study has yet applied these measures to the language samples of adults with MS; this task is the focus of the present study.

Method

The present research was conducted in conjunction with a larger study to understand the effects of fatigue on the communication of individuals with MS. Following language data collection, the volunteers participated in a series of speech tasks for acoustical analysis. Speech tasks were repeated later within the same day to study the effects of fatigue in this population. Fatigue is not a focus of the present study, and data from the speech tasks will not be included in this report. All forms, questionnaires and protocols used in this study are included in Appendixes A through E.

Participants

A total of 20 adults participated in this study. Ten persons diagnosed with MS by a neurologist and receiving treatment within the last 6 months were recruited though a local neurology clinic. These participants had no other co-existing neurological disease and included seven females and three males, ages 26 to 61 (M = 44 years). Among the participants there occurred various severities of dysarthria. One was moderately dysarthric, one was mildly dysarthric, and all others had perceptually normal speech. Individuals with MS were initially contacted by a local neurologist's office in order to protect patient privacy rights. Those who expressed an interest in participating and who gave their consent to be contacted were telephoned by the researchers for a preliminary screening.

The other 10 participants were non-neurologically impaired individuals matched for age and sex (*M* = 45 years). All but two participants passed a hearing screening at 20 dB HL at frequencies of 500, 1000, 2000, and 4000 Hz. These two participants were able to pass at 30 dB HL therefore, they were included in this study. There were originally 11 adults with MS and 11 control participants. However, one individual with MS was severely dysarthric, and the language sample collected was too unintelligible to be transcribed and analyzed. Data provided by this individual and their age-matched control were only used to study the effect of fatigue on the communication of individuals with MS and is not reported in this study.

Language Sample

Two types of naturalistic language sample data were collected. The first was a sentence completion task, wherein participants completed a sentence *stem* presented both orally and in written form in large (24 point) black font on a white index card. This task was adapted from procedures used by Kemper et al. (2004); the current task was presented on a printed note card by the experimenter rather than electronic presentation of sentence stems. This task involved no examination of memory abilities. As in Kemper et al.'s study, right-branching sentence stems were main clauses ending in *that*, *what*, or *who* and participants completed the embedded clause. In this case, embedding occurred at the right of the sentence (e.g. *Emily asked that I take her home*). Left-branching stems began with *that*, *what*, or *who* clauses and participants then produced a main clause, causing embedding to occur at the left of the sentence (e.g. *That Shawn cooked surprised us all*). Examples of sentence stems can be found in Table 1.

The second type of language data collected was a 10-15 minute spontaneous sample collected while the participant was in conversation with the experimenter. If necessary, conversational prompts were used during the language sampling. These included vacations, holidays, fond memories, family, etc.

Table 1

Examples of right and left-branching sentence stems.

Right-branching	Left-branching
Emily asked that…	That Shawn cooked…
David cut what…	What Sandy found…
Bonnie took what…	That Bob stole…
Richard saw who…	What Mary assumed…
Kate knew that	That Ron saw

Language samples were recorded using an Olympus VN-960PC digital voice recorder in a quiet room. Language data were transcribed into Systematic Analysis of Language Transcripts (SALT) format (Miller & Chapman, 2004) for subsequent analysis, except that the SALT coding of inflectional morphemes was not necessary for data analysis with the software used.

Linguistic Complexity Analysis

Several measures of linguistic complexity shown to differentiate between groups of adults (Cheung & Kemper, 1992) were used in the present study. These measures were MLU (Brown, 1973), MCU (Kemper et al., 1989), and DSS (Lee, 1974). Two measures which quantified LARSP (Crystal et al., 1989), the PSL (Ward & Fisher, 1990) and the SCS (Blake et al., 1993), were also used. The CP software (Long et al., 2008) was used to tabulate all complexity measures.

MLU. The MLU is calculated by dividing the total number of morphemes by the total number of utterances produced by the participant.

MCU. The MCU is calculated by counting the main clause and each embedded or subordinate clause in the utterance and then dividing this per-utterance total by the total number of utterances within the sample.

DSS. In DSS, each utterance is awarded a number of points based on the presence of certain grammatical structures; some of these structures appear later in development and receive more points. An additional point is given to fully grammatical sentences. The number of points is summed and divided by the number of utterances scored, yielding the DSS score.

SCS. The SCS counts the number of grammatical constituents within the LARSP parse of an utterance. These categories are Subject, Verb, Object, Complement, and Adverbials. The SCS is the average number of these constituents per utterance across the multi-word utterances of the sample.

PSL. The PSL score is the total number of items manifest at least once on the LARSP profile of morphosyntactic categories multiplied by the LARSP stage level of each item. Unlike the other measures used in this study, it is calculated on a per-sample basis rather than being an average of per-utterance scores.

Interrater Reliability

Two clinicians independently coded 10% of the language samples using the measures listed above. Agreement between coders was found to be 97%.

Results

Conversational Samples

The data for individual participants' scores on each measure on the conversational task are presented in Table 2 and the two groups' means, standard deviations, and results of *t*-tests are presented in Table 3. It can be seen in Table 3 that on every conversational measure the control participants scored slightly higher than the participants with MS. However, none of these differences were statistically significant.

Sentence Completion Task

Descriptive data on the sentence completion task are shown individually for all participants in Table 4 and the means, standard deviations, and results of *t*-tests are presented in Table 5. It can be seen in Table 5 that on every measure except the PSL the participants with MS scored slightly higher on the sentence completion measures than did the control group. However, these differences were not statistically significant.

Table 2

Conversational Data for Participants With MS and for Controls

	N Utts	MLU	MCL	DSS	SCS	PSL
MS						
1	81	10.07	4.59	11.58	5.20	188
2	203	10.15	4.64	14.68	5.27	215
3	74	10.04	4.15	11.98	5.03	173
4	112	7.30	3.33	11.21	4.44	160
5	120	10.27	4.37	14.76	5.06	198
6	116	9.55	4.23	11.33	4.86	188
7	129	12.68	5.03	15.60	5.99	193
8	161	11.11	4.33	16.26	5.55	188
9	204	10.63	4.45	15.90	5.56	203
10	123	10.30	4.45	14.05	5.27	189
Control						
1	117	9.92	4.92	14.30	5.08	191
2	236	9.82	4.45	13.25	5.22	217
3	98	11.70	4.44	17.04	5.86	176
4	128	10.66	4.77	13.44	5.43	190
5	154	11.84	4.69	16.17	5.76	206
6	199	13.89	5.60	15.94	6.24	214
7	103	9.98	4.41	12.55	5.13	206
8	146	11.16	4.83	15.09	5.30	194
9	132	10.67	4.41	13.97	5.54	204
10	119	10.08	4.55	16.22	5.23	190

Note: *N* Utts = number of utterances produced

Table 3

Conversation Task: Statistics Describing Both Groups

	Persons with MS		Persons without MS		*t*-value
	M	*SD*	*M*	*SD*	
N Utts	132.30	44.62	143.20	43.64	-.55
MLU	10.21	1.34	10.97	1.26	-1.31
MCU	4.36	.44	4.71	.37	-1.94
DSS	13.74	2.01	14.80	1.51	-1.33
SCS	5.22	.42	5.48	.37	-1.43
PSL	189.50	15.15	198.80	12.70	-1.49

Note: *N* Utts = number of utterances produced; *df* = 18 for all comparisons

Table 4

Sentence Completion Data for Participants with MS and for Controls

	MLU	MCL	DSS	SCS	PSL
MS					
1	8.65	3.79	14.05	5.30	59
2	9.80	4.67	16.55	5.56	106
3	12.45	5.13	21.60	6.20	125
4	8.20	3.70	14.05	5.05	79
5	19.85	7.56	23.48	7.92	141
6	9.10	3.89	13.40	5.00	82
7	9.25	4.05	15.30	5.50	83
8	8.85	3.95	14.70	5.40	105
9	8.75	3.85	16.05	5.20	79
10	12.00	4.78	20.55	6.40	106
Control					
1	9.65	4.10	14.70	5.35	102
2	9.20	4.25	15.35	5.50	96
3	8.55	4.26	14.35	5.35	85
4	9.80	3.80	15.95	5.45	99
5	10.20	4.30	17.85	5.95	108
6	8.75	4.35	13.30	5.30	97
7	8.85	4.10	15.35	5.25	82
8	9.25	4.24	15.85	5.55	94
9	10.55	4.70	20.40	5.90	113
10	8.85	3.85	18.45	5.85	82

Table 5

Sentence Completion Task: Statistics Describing Both Groups

	Persons with MS		Persons without MS		*t*-value
	M	*SD*	*M*	*SD*	
MLU	10.70	3.52	9.37	.67	1.17
MCU	4.54	1.17	4.20	.26	.90
DSS	16.97	3.58	16.16	2.14	.62
SCS	5.75	.89	5.55	.26	.71
PSL	96.50	24.62	95.80	10.52	.08

Note: *df* = 18 for all comparisons

Discussion

In this study, language samples were collected and later transcribed using two tasks from adults with MS and age and gender matched control participants ranging in age from 29 to 61. Language data collection tasks included the elicitation of a conversational sample and a sentence completion task. Language samples were analyzed for syntactic complexity using five measures: MLU, MCU, DSS, SCS, and PSL, and the MS and control groups were compared statistically on these measures. Results from the conversational sample revealed the control participants to be slightly higher on every measure than the participants with MS. However, none of these differences were significant. On the sentence completion task, the participants with MS scored higher on average than the control participants on all measures except for PSL, although these differences were also not significant.

These findings differ from those reported by Lethlean and Murdoch (1993) and by Wallace and Holmes (1993). Lethlean and Murdoch (1993) had used a comprehensive battery of specific linguistic tests to examine the presence of linguistic impairment in persons with MS. Lethlean and Murdoch found participants with MS to score significantly below the control participants on tests of higher level language abilities.

In addition, Wallace and Holmes (1993) found that participants with MS scored significantly lower than control participants in written and spoken language formulation and discourse. The differences between the findings of these authors and those of the present study may have occurred for several reasons: the severity levels of the participants, the language data collection tasks, and the syntactic complexity measures applied to the data.

Severity of Participants with MS

Differences between syntactic complexity levels associated with MS may exist, but only at more severe levels of MS than were represented in the present study. Participants in this study were contacted via mail by a local neurology clinic and asked to volunteer for this study. Self selection of participants in this study may have led to a less severe population being studied. All but two participants with MS reported that they were experiencing a period of remission during the time of testing. Of the two participants with MS who were not in the remission stage, only one was intelligible enough for a language sample to be transcribed. Anecdotally, many participants with MS reported during the conversational sample that they often had difficulty putting words together to form a sentence during an exacerbation of MS symptoms. Perhaps participants were more inclined to volunteer during a period when they experienced mild symptoms, and more severely afflicted potential participants were unable or unwilling to travel or participate. Thus the self-selecting participants with MS may have not represented a true picture of

MS language complexity in general, and the language tasks and measures used in this study might have detected differences in a more severely afflicted population.

Standardized Measures Versus Nonstandardized Measures

The testing measures used in the present study were all naturalistic and nonstandardized, whereas both the Lethlean and Murdoch (1993) and the Wallace and Holmes (1993) studies used a comprehensive battery of standardized tests measuring higher language function. Lethlean and Murdoch (1993) found significant deficits in areas of attention and memory in the MS group they studied. Deficits in attention and memory may have had an effect on participants' ability to perform on standardized tests thereby deflating scores in higher language functioning. However, any existing processing deficits may perhaps have been compensated for in the naturalistic tasks used in the current study. Without the interference of attention and memory deficits and given flexibility in the linguistic responses given, persons with MS may produce language at a similar level of complexity when compared with age-matched controls. Future studies might use both standardized and nonstandardized or naturalistic measures to examine whether the differences on standardized tests observed between participants with and without MS are clinically significant.

Sensitivity of Measures

A third possible explanation for the difference in findings between the present study and those of earlier authors might be that differences in syntactic complexity exist, even in naturalistic situations, but the specific measures used in the present study were not sensitive enough to detect these differences. While most of the measures used in the present study (MLU, DSS, and MCL) have successfully found differences between other adult populations (Cheung & Kemper, 1992; Kemper et al, 2003; Kemper et al., 2004; Kemper et al., 2001), these measures may not be sensitive enough to characterize differences between adults with and without MS. Differences may exist but may require the development and use of more sensitive measures than those of the present study.

Future Research

The study has several other limitations. The small sample size used in this study may have not allowed for an accurate picture of the MS population at large. Lethlean and Murdoch (1993) used a sample size of 60. However, the Wallace and Holmes (1993) study used fewer participants than the current study, which suggests that differences may still be observed even in smaller sample sizes. In addition, all participants came from the same geographic area, and factors such as educational level were not controlled for.

Future research might concentrate on the development of more sensitive testing measures, both formal and informal, and the use of larger sample sizes having a wider range of severity.

Conclusion

Despite limitations, the present study provides evidence suggesting that in mild cases of MS or during periods of remission, individuals may retain their ability to use complex language structures in naturalistic discourse. If complex language structures are impaired in MS, it is not verifiable using those measures of naturalistic language that were used in the present study.

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Appendix A

Telephone Interview Questions

Upon receipt of the response card, each participant was telephoned for an initial screening. The purpose of the screening was to group participants and to ensure that the participants: 1) were at least one year post-diagnosis; 2) considered fatigue as a symptom of their MS; 3) were native English-speakers; 4) considered their vision and hearing normal, and 5) had no history of speech or language problems prior to the onset of MS.

1. When were you diagnosed with MS?
2. What are the primary symptoms that you experience with MS?
3. Is fatigue one of the symptoms that you associate with your diagnosis of MS?
4. If yes, how often do you feel fatigued? Daily, Once a week, Several times a week, Depends
5. If yes, are there any activities that trigger the fatigue?
6. Before being diagnosed with MS, have you ever had any speech or language problems? If so, what?
7. Have you noticed any changes, even subtle changes, in the way that you communicate since you have been diagnosed with MS?
8. Would you consider your hearing to be normal?
9. Do you wear hearing aids?
10. Would you consider your vision to be normal?
11. Do you wear glasses or contacts?
12. Is English your native language?
13. To participate in the study we would ask you to come to BYU campus and have your speech recorded twice on the same day. These recordings would each take about 1 hour and would be approximately 6 hours apart. Would you be able to travel twice to BYU campus for these recordings?
14. What day of the week would be most convenient for you to come to BYU campus?
15. We will contact you to make an appointment and then again as a reminder of your appointment. In the event that you are unavailable to answer your phone, do we have your permission to leave a detailed message, or would you prefer that we just leave a call-back number?
16. What age are you?

Appendix B

Data Collection Protocol

Protocol:

Thanks for participating

We would like to get to know you better and what you have to say. I will ask you some open ended questions to help me do this. Remember that this task is designed to be conversational, so feel free to talk with me the way you would with a friend or family member.

AM Prompts:

Talk about your favorite holiday and why you like it

Tell me about an interesting vacation you've been on or one you'd like to take if money were no object.

Talk about somebody you really admire. Tell Why.

If you could be given another talent or ability, what would you want it to be? How would you use it?

Tell about a favorite hobby and why you enjoy it.

PM Prompts:

Talk about 3 things for which you are thankful

Describe your favorite way to spend an evening

What is something you have never done that you would like to try? Why?

What do you think life will be like in 100 years

Do you prefer being a leader or a follower? Explain

Sentence Completion task:

This next task is for sentence completion. I will present an incomplete sentence and you will read and complete the sentence aloud. Feel free to take your time during this task. Remember to form a complete sentence.

Appendix C

Sentence Completion Task: Sentence Stem

Right Branching:	**Left Branching:**
Emily asked that…	That Shawn cooked…
David cut what…	What Sandy found…
Bonnie took what…	That Bob stole…
Richard saw who…	What Mary assumed…
Kate knew that…	Who Ron saw…
Ashley wanted what…	What Tom kept…
Mindy wondered who…	Who Beth told…
Liz offered that…	That Amy sang…
Andrew asked that…	What Harold said…
Anna said what…	Who Guy loved…
Adam knew when…	When Roger found…
Lisa smiled if…	If April smiled…
Susan wondered how…	How Karen left…
Jon slept while…	While Michelle waited…
Ashley waited for…	Why Martha ate…
Bill read when…	When Kate spoke…
Ben spoke if…	If Ida knew…
Rachel dressed how…	How Frank found…
Mary shopped while…	While Josh played…
Liza looked for…	Why Fran sighed…

Appendix D

Initial Letter

Dear (Name of Patient),

Two graduate students and their supervising faculty at Brigham Young University (BYU) are conducting a study to examine the effects of fatigue on the speech and language of individuals with MS. They would like to meet with people whose communication has been affected, and who experience fatigue as a symptom of MS. Participation would involve volunteering 2 hours of time during the month of November for an analysis of speech and language characteristics. If you decide to take part in this study, you will need to go to the BYU Speech and Language Clinic, receive a free hearing evaluation, read some simple passages of text into a microphone, and have a short interview with the researchers.

As you know, MS affects every person differently. The purpose of this study is to better understand how both MS and fatigue affect communication. If you would be willing to participate in this study, please complete the enclosed response card and return it in the stamped, pre-addressed envelope or call one of the following numbers:

Kristi Hollis: (801) 123-4567 Kate King: (208) 357-6342

In the event that no one is available to take your call, please leave a message including your full name and contact information. Because your medical information is confidential, the BYU researchers do not have your name or contact information. If you choose not to send in the response card or call them, your privacy will be maintained, and nobody will call you in connection with this study.

Thank you,
Dr. Pamela Vincent and Staff

Appendix E

Informed Consent

Introduction

You have been invited to participate in a research study about the effect fatigue has on the speech and language of persons with MS. This study is being conducted by Kristi Hollis and Kate King, graduate students at Brigham Young University, under the direction of Dr. Christopher Dromey and Dr. Ron Channell, who are members of the faculty in the Communication Disorders Department. You have been invited to participate because you have MS, and have no history of a previous speech or language disorder.

Procedures

You will be asked to attend two recording sessions lasting approximately one hour each; one during the morning and one in the late afternoon of the same day. Before the recording you will receive a complimentary hearing evaluation, and be asked to fill out a short questionnaire that will be used to develop a demographic profile of the participants of this study. You will then be asked to rate your current level of fatigue.

Next you will participate in a short interview with one of the researchers. This interview will be recorded and used as data for the research study. Then, while sitting in a sound booth in 106 TLRB, you be asked to read a number of sentences and paragraphs. You will then be asked to repeat these samples while wearing a device that measures tongue position in the mouth. The device includes a small magnet that is attached to your tongue with a drop of removable adhesive. You will wear a headset that tracks the position of the magnet within your mouth. You will be asked to return later the same day to repeat the recordings. These recordings will be analyzed with a computer program.

Risks/Discomforts

There are no known risks associated with participation in this study. The equipment used in this study has been used previously here and elsewhere with no adverse effects.

Benefits

Aside from a complimentary hearing evaluation, you will receive no direct benefits from participating in this study. However, the results of this study are expected to provide valuable information about how fatigue affects communication in persons with MS.

Confidentiality

An anonymous identification number will be used in storing and analyzing the recordings of each speaker. Your name and other identifying information will not be used in print or electronic records of this study. Only summary data without reference to names will be reported when the study is complete.

Participation

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely without any impact on your medical treatment or your relationship with BYU.

Questions about the Research

If you have any questions about this study, you may contact Dr. Christopher Dromey at (801) 422-6461.

Questions about Your Rights as a Research Participant

If you have questions you do not feel comfortable asking the researcher, you may contact Sandee Muñoz, IRB Administrator, at (801) 422-1461.

Signatures

I understand what is involved in participating in this research study. My questions have been answered and I have been offered a copy of this form for my records. I understand that I may withdraw from participating at any time. I agree to participate in this study.

______________________________ ______________

Signature Date

____

Printed Name