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Variability of Syntactic Complexity in Persons With and Without Multiple Sclerosis

Kristin D. Björkman

A thesis submitted to the faculty of  
Brigham Young University  
in partial fulfillment of the requirements for the degree of  
Master of Science

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## ABSTRACT

### Variability of Syntactic Complexity in Persons With and Without Multiple Sclerosis

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Master of Science

Several recent studies have suggested that persons with multiple sclerosis (MS) have diminished syntactic complexity. A greater variability in responses to a variety of tasks has also been noted for persons with MS. However, naturalistic data on syntactic complexity and the complexity's variability in persons with MS have not been examined. In the present study, 8 volunteers with MS (age 18-70 years) and 10 adults without MS participated in both a 15-minute conversational language sample and a sentence completion task in two different sessions. No significant differences were found between groups on any measure, and variability within the groups was similar. This may have been because volunteers were people with mild cases of MS or those in a state of remission and may not be representative of persons who were at a more advanced stage of the disease or in a state of exacerbation.

Keywords: Multiple Sclerosis, language, syntax

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## Introduction

Multiple sclerosis (MS) is a progressive neurological disease that attacks the myelin nerve sheaths throughout the central nervous system (CNS), including the subcortical white matter pathways, which have been found to be involved in normal language processing (Alexander, Naeser, & Palumbo, 1987). Because of this damage, it is likely that complex linguistic functioning in those with MS may be impaired, though differing opinions exist on this matter. It had previously been reported that impaired language was not a major concern in those with MS (Anzola et al., 1990; Herderschee, Stam, & Derix, 1987; Jennekens-Schinkel, Lanser, van der Velde, & Sanders, 1990; Rao, Leo, Bernardin, & Unverzagt, 1991). Several other studies have, in contrast, provided evidence that language impairment in some patients may be a result of MS (Lethlean & Murdoch, 1993; Lethlean & Murdoch, 1997; Wallace & Holmes, 1993). Lethlean and Murdoch (1997) suggested that language impairment may not have been noted as an impairment due to those with MS performing within normal limits on gross measures of language, despite neuropsychologist reports of slight cognitive deficits in patients with MS (Rao, 1986). Lethlean and Murdoch suggested that individuals with MS may have reduced language abilities for complex structures. Therefore, individuals may test within normal limits on gross measures of language, but not on those which measure higher level language functions such as understanding ambiguous sentences and metaphoric expressions, making inferences, re-creating sentences, and vocabulary and semantic tasks (Lethlean & Murdoch, 1997).

This performance deficit associated with MS may interact with another known characteristic of MS: variability. Performance on tasks may be prone to vary, and this finding has been shown in such diverse areas as cognitive functioning (Krup & Elkins, 2000), gait (Crenshaw, Royer, Richards, & Hudson, 2006), heart rate (Mahovic & Lakusic, 2007; Monge-Argiles, Palacios-Ortega, Vila-Sobrino, & Matias-Guiu, 1998), visual threshold, (Patterson,

Foster, & Heron, 1980), speech (Hartelius, Runmarker, Anderson, & Nord, 2000), cortically evoked motor responses (Britton, Meyer, & Benecke, 1991), and stress and fatigue (Kasser, McCubbin, & Hooker, 2003).

Thus the linguistic performance of people with MS may differ from that of people without MS, and this linguistic performance, like other characteristics, may be more variable in persons with MS. The following study examines the nature and variability of aspects of linguistic performance in a group of participants with MS as compared to neurologically healthy, age-matched controls.

### Review of Literature

The following is a discussion of the epidemiology, signs and symptoms, diagnostic characteristics, and courses of MS. The speech characteristics will be reviewed along with the linguistic features of those with MS. Next, the variability in multiple areas of functioning of those with MS will be discussed. Finally, the methods used in the measurement of adult linguistic complexity will be reviewed.

#### *Characteristics of Multiple Sclerosis*

The characteristics of MS will be discussed in the following sections. The etiology of the disease, along with the signs and symptoms, diagnosis, courses, and speech and language characteristics will all be reviewed as they pertain to individuals with multiple sclerosis.

*Etiology.* Multiple sclerosis is a progressive, demyelinating, neurological disease affecting various parts of the white matter of the CNS including the cerebellum, cerebrum, spinal cord, brainstem, and optic nerves (Warren & Warren, 2001). In the healthy nervous system, the myelin sheath provides a high-resistance insulation for the axon; it is divided into discrete units along each axon, which are separated by unmyelinated nodes of Ranvier. These myelinated axons conduct nerve impulses from node to node in a hopping fashion known as salutatory

conduction. This form of transmission is faster than the graded conduction in unmyelinated axons. In a person with MS, there are lesions scattered throughout the white matter. Within these lesions occurs the destruction of the oligodendrocytes, that produce the myelin in the CNS. Therefore, whenever demyelination of the axon occurs, as it does with people with MS, significant abnormalities in conduction naturally follow, impacting both sensory and motor functions. When this conduction failure occurs, the action potential is not transmitted from one end of the fiber to the other, and the information is lost, thus producing clinical deficits (Joy & Johnston, 2001).

*Epidemiology.* The onset of symptoms in MS is frequently seen between 30 and 40 years of age, affecting twice as many women as men (Kantarci & Wingerchuck, 2006; Murdoch & Theodoros, 2000; Warren & Warren, 2001). Peak prevalence rates have been found in countries further from the equator, and are most common in Caucasian populations (Murdoch & Theodoros, 2000; Sadovnick, Dymant, & Ebers, 1997; Warren & Warren, 2001). Genetics, in conjunction with environmental factors, are thought to play a role in the development of the disease (Kantarci & Wingerchuk, 2006). Several studies have shown that first degree relatives of those with MS are 20 to 40 times more likely to develop the disease than the general population (Kantarci & Wingerchuck, 2006; Sadovnick et al., 1997). If genetics alone were the cause of MS, then one would expect a familial connection in 100 percent of the cases. Because this does not occur, both genetics and environmental factors are thought to be contributing factors in the disease. Recent studies have shown an increased prevalence rate of MS associated with smoking and in those with vitamin D deficiency, suggesting the involvement of environmental factors (Kantarci & Wingerchuk, 2006).

*Signs and symptoms.* Scattered throughout the white matter in a person with MS are many focal or multifocal lesions called plaques, where the demyelination of an axon has occurred. Because these lesions are so scattered throughout the white matter, they cause mixed signs and symptoms of disordered motor and sensory function (Warren & Warren, 2001). Some of these symptoms include motor deficits such as impaired coordination, imbalance, weakness, spasticity, intention tremor, ataxia, and eye movement abnormalities. Sensory deficits may include visual abnormalities, numbness, tingling in the hands or feet, dizziness, and a cold or burning sensation accompanied with pain (Joy & Johnston, 2001; Warren & Warren, 2001).

Fatigue is also a common and well-known symptom in those with MS (Schwid, Covington, Segal, & Goodman, 2002). In one study (Yorkston, Klasner, & Swanson, 2001) six out of the seven participants reported fatigue as being a symptom of MS. Individuals stated that fatigue had an effect on communicative abilities including both opportunity to communicate as well as the quality of communication. Others in the study stated fatigue had an effect on their cognitive functioning. In another study (Stuifbergen & Rogers, 1997) 13 individuals with MS were interviewed and asked to describe their experience living with fatigue. Individuals with MS described their fatigue as being an ever-present, ongoing experience which contributed to the exacerbation of their symptoms.

*Diagnosis.* Multiple sclerosis is diagnosed using imaging techniques, laboratory testing, and clinically by a neurologist based on the patient's medical history and neurological examination (Joy & Johnston, 2001; Paty, Noseworthy, & Ebers, 1998). Current thought is that neuroimaging provides the best assessment of disease activity in MS. Neuroimaging techniques such as magnetic resonance imaging (MRI) are used both to detect initial signs of the disease as well as to measure relapses of different lesions throughout the brain. In addition, functional

magnetic resonance imaging is used for determining changes in brain activity in particular regions. Cerebrospinal fluid has also been extracted and used to determine the presence of substances active in the CNS and those that may be involved in MS pathology, although this approach is not used routinely due to the invasive technique and uncertainty about the value of the information gained from the procedure (Joy & Johnston, 2001).

MRI is one of the most helpful diagnostic tools, and has been reported to reveal neural damage in 70 to 95 percent of people with MS. It is important that neuroimaging be used in conjunction with clinical data, because other diseases have lesions that appear similar to those in MS. Therefore, there are specific criteria concerning the size, number, and location of the lesions in MS compared to other diseases (Joy & Johnston, 2001). The neurologist must be careful to obtain the dates of onset, the rate of progression, any reduction in intensity of symptoms, the presence and disappearance of symptoms, and the duration, if any, of remission. In addition, because the symptoms of MS have been found to overlap with those of other diseases, specific questions should be geared towards symptoms that may be specific to MS. One such symptom is Lhermitte's symptom, which is a violent shock that runs through the back and legs upon neck flexion. Although useless hand syndrome, where the hand is functionally impaired due to sensory loss, does not occur in all cases of the disease, when it does occur it is so unique that it is highly suggestive of MS. In addition, optic neuritis is closely connected with MS, and is the first symptom in as many as 16 percent of patients (Paty et al., 1998). A combination of many other fluctuating motor and sensory impairments, ataxia, bladder disturbances, and vision problems are all symptoms that may accompany the disease. Neurological assessments, careful examination of the patient's medical history, and neuroimaging techniques are all key aspects in determining the presence of multiple sclerosis.

*Courses of the disease.* Just as the signs and symptoms of MS are mixed and varied from person to person, so is the course of the disease. There are four basic categories of MS, including a benign course, relapsing-remitting course, remitting-progressive course, and a chronic progressive course. The benign course is characterized by one or more attacks in addition to complete or near complete remission. The relapsing-remitting course involves several longer episodes of deterioration, which are then followed by near-complete recovery. Deficits must persist for a period of at least 24 hours in order for them to be considered a true relapse caused by a new lesion within the CNS, rather than simply a consequence of previously damaged nerve conduction (Joy & Johnston, 2001; Kesselring, 1997; Paty et al., 1998). The signs and symptoms of the disease, persisting from only a few minutes to a few hours, are thought to be the result of old lesions, rather than the formulation of a new lesion. However, attacks characterized by a tingling sensation radiating down the arms, neck, or back, and neurological deficits occurring multiple times a day and lasting less than a minute, are also considered to be true relapses if this pattern persists for several weeks (Joy & Johnston, 2001). This cycle of episodes followed by recovery is a pattern that may persist for several years. Still others with MS have a remitting-progressive course, where there is a slow accumulation of deficits over time. Lastly, the chronic progressive course is characterized by a sudden, dangerous onset, followed by a slow progression of the disease without remission. Although stabilization can occur in the chronic progressive course, typically a patient will develop a slow, relentless progression of neurological impairment (Paty & Ebers, 1998).

*Speech characteristics.* Dysarthria is a neurological motor speech disorder resulting in abnormalities in the strength, speed, range, steadiness, tone, or accuracy of movements required for speech production, and has been reported to occur in as many as 45 percent of people with

MS (Darley, Brown, & Goldstein, 1972; Duffy, 2005). Specific characteristics of dysarthria noted in those with MS include breath support deficits, hypernasality, harshness, breathiness, glottal fry, hoarseness, a strained-strangled vocal quality, and sudden, irregular articulatory breakdowns. In addition, dysprosody is commonly noted, and may be due to impairments in the stress and intonation, pitch, loudness level, control, and fluency of speech (Theodoros, Murdoch, & Ward, 2000). The incidence of dysarthria in those with MS may vary depending on the severity, duration, and stage of the disease progression in each individual (Theodoros et al., 2000). Although any combination, of dysarthria subtypes may be present, a spastic-ataxic dysarthria is the most commonly seen type in individuals with MS. This diagnosis is based on the presence of a harsh vocal quality typically seen in those with spastic dysarthria, and the abnormal stress patterns and impaired pitch variation seen in ataxic dysarthria (Duffy, 2005; Theodoros et al., 2000). Several studies have shown speech differences in individuals with MS when compared to typical controls (Hartelius, Nord, & Buder, 1995; Hartelius et al., 2000).

*Language abilities.* Lethlean & Murdoch (1993) conducted a study to determine if there are difficulties with high level language abilities in people with MS. The study consisted of 17 individuals diagnosed with MS and 17 control participants matched for age and sex. Each participant was administered a battery of five different language tests designed to measure different aspects of language function. Results of the study indicated that individuals with MS scored significantly lower than typical controls in areas of high level language functioning. Areas of deficit that were noted in the study included naming, the comprehension of concepts requiring logico-grammatical operations, repetition of sentences and digits, word fluency, and subtests requiring verbal explanation, verbal reasoning, reconstruction of sentences, definitions of words, and interpretation of absurdities, ambiguities, and metaphors.

Lethlean and Murdoch (1997) extended their previous study to examine a larger sample of individuals with MS. In this study, the authors compared 60 individuals with MS to age matched controls to evaluate high level language abilities using two test batteries. Results revealed that individuals with MS presented with difficulties understanding ambiguous sentences and metaphoric expressions, making inferences, and re-creating sentences. In addition, individuals with MS demonstrated difficulty with vocabulary and semantic tasks compared to the control groups.

In another study, Wallace and Holmes (1993) administered the Arizona Battery for Communication Disorders (ABCD) to determine whether it was a sensitive enough measure to detect differences in cognitive, linguistic, and memory deficits in those with MS. Four individuals with MS were included in the study and compared to four matched controls. Results indicated that the mean overall performance on the ABCD was lower for individuals with MS. On five of the 15 subtests, individuals with MS performed significantly lower than control participants. These subtests included object description, generative naming, concept definition, generative writing, and picture description. Overall, those with MS demonstrated difficulties with word finding, written and spoken language formulation as well as discourse.

#### *Variability in Aspects of Multiple Sclerosis*

*Cognitive.* Krup and Elkins (2000) studied the pattern of cognitive changes within a single testing session in participants with MS compared to healthy controls. All participants completed a four hour session of cognitive testing involving a baseline neuropsychological battery followed by a continuous effortful cognitive task consisting of mental arithmetic problems. After this cognitive task, the neuropsychological battery was again given to all participants. Although the control individuals actually showed improvement on measures of verbal memory and conceptual planning, the participants with MS demonstrated decline. Despite



finding no significant differences at baseline testing of cognitive functioning between the two groups, the participants with MS performed worse than the control group on tests of visual memory, verbal memory, and verbal fluency that were repeated with the neuropsychological battery following the continuous effortful cognitive task. Unlike the control counterparts, the participants with MS failed to show improvement with practice on specific measures of cognitive functioning, but instead showed decline, therefore suggesting cognitive fatigue (Krup & Elkins, 2000).

*Gait.* One study examined the within-day and between-day changes in gait variability for subjects with MS in both fresh and fatigued conditions (Crenshaw et al., 2006). In this study, individuals were tested in the morning and afternoon within the same day, and again one week later. Although there were no significant differences of joint angle variability for participants between days, researchers reported not only significantly higher self report fatigue from the participants with MS, but also significantly greater joint angle variability than the control group at the hip, knee, and ankle likely due to a slower walking pace.

*Heart rate.* In addition to gait variability in MS, autonomic functions have been found to be impaired and variable in individuals with the disease. Several studies have indicated variability in heart rate functions in those with MS when compared to typical controls (Monge-Argiles et al., 1998; Mahovic & Lakusic, 2007).

*Visual threshold.* Because it is known that the visual pathway is frequently impaired in those with MS, it is not surprising then, that the visual thresholds are also sometimes elevated in those with the disease. Visual thresholds refer to the minimum luminous intensity of light stimulus that is necessary for its perception. Patterson et al. (1980) found that the threshold of retinal sites in those with MS showed increased variability, with the highest variability occurring

when the patients were examined at high background luminance levels. Likewise, Snelgar, Foster, Heron, Jones, and Mason (1985) found that participants with MS with reported visual problems had not only significant impairment for luminance threshold, but significant variability of luminance threshold and of two-flash resolution. Two-flash resolution refers to the successive presentation of two flashes of light which, if presented temporally to the same retinal locus at just below the two-flash threshold, are seen as only one pulse of light (Purcell & Stewart, 1971). Interestingly, significant variability in these participants was still found, despite the MS disease in these participants being in a relatively mild stage (Snelgar et al., 1985).

*Speech.* A study was conducted that examined several speech characteristics and speech variability in individuals with MS (Hartelius et al., 2000). The study involved fourteen individuals with MS, who also demonstrated ataxic dysarthria, which is commonly seen in those with the disease. Temporal dysregulation also seemed to be a factor in the ataxic dysarthria of those with MS, and thus was the focus of the study. The individuals were compared with a control group in order to measure syllable durations and durations of inter-stress intervals in five different sentences, each repeated three times. When studying inter-stress intervals, one studies whether each stress beat within the words occur with the same regular temporal interval. Although the participants with MS demonstrated decreased intra-utterance variability, at the inter-utterance level they actually showed an increase in variability as compared to the control group. At the inter-stress interval level, the MS group showed significantly increased durations when compared to the control group, in addition to significantly increased variability. These results indicate that those with MS may have instability in temporal control of speech functions (Hartelius et al., 2000).

*Cortically evoked motor response.* The purpose of a study by Britton et al. (1991) was to determine whether inter-trial variability of motor evoked potential (MEP) onset latency following magnetic motor cortex stimulation is increased in those with MS. MEP onset latency refers to the time it takes between the motor cortical stimulation and the onset of an evoked potential in the targeted muscle. Each individual was asked to make a slight sustained voluntary contraction of the first dorsal interosseous (FDI) muscles by gently squeezing the thumb and index finger together during magnetic stimulation of the cortex. For each FDI muscle, at least ten electromyographic responses to the motor cortex stimulation were obtained, and when assessing the variability of the onset latencies, values that were more than three standard deviations beyond the mean found in normal controls were then considered to be abnormal. Results indicated that the responses in the majority of individuals with MS showed significantly greater trial-to-trial variability in onset times as compared to the neurologically healthy participants. The slowing of impulse conduction over demyelinated segments, the inability to conduct rapid trains of impulses, and/or a conduction block could all contribute to an increase in MEP onset latency variability, due to the demyelination of the cortico-motoneuronal pathways in those with MS (Britton et al., 1991).

*Stress and fatigue.* Kasser et al. (2003) studied intra-individual variability of individuals with MS compared to typical peers in both physical and psychological domains. Areas assessed included leg strength, upright postural control, mood, fatigue, stress, and self-efficacy and how this potential variability affected activities of daily living in those with MS. Although results revealed variability in both physical and psychological areas, there was no strong correlation between the two. Results indicated that the greatest variability occurred in the domains of stress and fatigue. In addition, results demonstrated that variability in isolated tasks was larger than the

variability in the individual's ability to perform the activities of daily living tasks. Therefore, the authors suggested that this information may be useful in developing strategies to decrease a person's perception of fatigue and stress in conjunction with designing mood-enhancing techniques to positively impact quality of life (Kasser et al., 2003).

### *Measures of Syntactic Complexity*

*Production of complex structures.* Subordination is generally recognized as a more difficult syntactical structure, allowing speakers to communicate more complex thoughts than is usually possible with simple independent clauses (Loban, 1976). The use of embedded clauses has been shown to be a critical index of later syntactic development (Loban, 1976; Nippold, Mansfield, & Billow, 2008). Nippold et al. (2008) studied the use of nominal, adverbial, and relative clauses and found them to be helpful in describing syntactic complexity in adolescents. Whereas Nippold et al. (2008) focused on the use of these clauses in expository samples, the present study focused on the use of these embedded finite clauses within natural discourse. Specifically, noun clauses (e.g., *I wish that I had five tacos*), adverbial clauses (e.g., *I am going to be late because it snowed*), and relative clauses (e.g., *I saw the girl who had brown hair*) were measured in each language sample of the current study. Nippold et al. only studied finite clauses, because prior research had shown that nonfinite verb use was not a particularly sensitive indicator of syntactic development during adolescence. Researchers found that nonfinite verb use did not significantly distinguish between speakers with high, lower, or average levels of language proficiency (Loban, 1976; Nippold et al., 2008). Thus, nonfinite clauses were not considered in the current study.

*MLU.* The use of quantitative measures has often been used to quantify language differences in speakers. For developmental language measurement, MLU is considered the

quantitative measurement of choice (Gavin & Giles, 1996; Rice, Redmond, & Hoffman, 2006; Ukrainetz & Blomquist, 2002). MLU attempts to quantify language complexity based on the number of morphemes per utterance. MLU is calculated by dividing the total number of morphemes by the total number of utterances present in a language sample. This final number then gives the clinician the speaker's average utterance length in morphemes.

*DSS.* Developmental Sentence Scoring (DSS; Lee, 1974) has also been widely used in the quantitative measurement of language samples. In several studies (Kemper, Herman, & Lian, 2003; Kemper, Herman, & Liu, 2004) the use of Developmental Sentence Scoring has been effective in distinguishing differences in syntactic complexity between older and younger adults. DSS categorizes and scores eight different grammatical forms in each sentence: indefinite pronouns, personal pronouns, main verbs, secondary (embedded) verbs, conjunctions, negatives, interrogative reversals, and *wh*-questions. Different points are given for the different types of grammatical forms in each category in order to reflect the developmental order of appearance in children's speech. DSS is calculated by adding the total number of points per category. An additional point is then awarded for fully grammatical sentences.

*Completion of sentence stems.* Right-branching sentence stems are those in which the embedded clause occurs to the right of the main clause (*The girl asked that I leave*). Left-branching stems are those in which the embedded clause occurs to the left of the main clause (*Who I loved was very beautiful*). It is assumed that left-branching stems, in which the embedded clause precedes or interrupts the main clause, usually require greater processing demands than right-branching stems because they require the speaker to anticipate and plan for the main clause while producing the embedded clause (Kemper, Thompson, & Marquis, 2001; Kemper et al., 2004). Kemper et al., (2004) used sentence completion tasks involving right and left-branching

stems to study language complexity between younger and older adults. Researchers found that young adults produced longer responses, and DSS scores were higher, for right-branching stems than for left-branching stems. Results also indicated that older adults produced less complex sentences than did younger adults.

Persons with milder MS have been shown not to differ from matched controls in naturalistic language tasks when language performance is quantified (King, 2009). However, performance on aspects of syntactic complexity may be more variable in persons with MS than matched typical controls. The present study evaluates the consistency between language samples taken within 24 hours of those with and without MS in terms of both length and complexity. The current study also examines the variability in the frequency of complex structures, namely noun, relative, and adverbial clauses, produced by those with and without MS. Comparing the variability of length and syntactic complexity of these populations will give further insight into the functional linguistic consistency of those with MS compared to those without the disease.

#### Method

The current study is part of a larger study involving research on the effects of fatigue on the speech characteristics of individuals with MS. Data from previously collected speech tasks were not included in this study because fatigue of speech was not a main focus in the present study. The language samples were collected by a speech-language pathology graduate student at Brigham Young University (BYU), who transcribed 20 of the samples, leaving the remaining 20 samples for analysis in the current study. Syntactic complexity was quantified using MLU and DSS. In addition, the number of finite noun, adverbial, and postmodifying relative clauses in each sample was examined.

### *Participants*

A total of 20 adults participated in the present study. Ten adults, seven females and three males, had been diagnosed with MS by a neurologist. These adults ranged from 26 to 61 years of age. The participants with MS were initially contacted by a local neurologist's office to comply with privacy rights, and those expressing interest and giving consent to participate in the study were then individually telephoned by the researchers for a preliminary screening. These participants had no other known co-existing neurological disease and were receiving treatment within the last six months. One of the participants with MS had mild dysarthria and another had moderate dysarthria, both of the spastic-ataxic type. The language sample from the individual with moderate dysarthria was too unintelligible to transcribe, and his data was not used in the study. All other participants in the study had speech that was observed to be within normal limits.

The remaining 10 participants were matched with the participants with MS for age and sex and had no known neurological impairment. All but two participants passed a hearing screening at 20 dB HL bilaterally at frequencies of 500, 1000, 2000, and 4000 Hz. These two participants were able to pass a hearing screening at 30 dB HL and were therefore included in the present study. There were originally 11 adults with MS and 11 control participants. However, one individual with MS was too unintelligible for the sample to be transcribed and analyzed. Therefore, data provided by this individual and his or her age-matched control were only used in a study of the effect of fatigue on speech and were not used in the present study. A malfunction of the recording equipment led to the dismissal of another sample from an individual with MS. Finally, only a single sample was collected from another participant with MS, leaving a total of 8 participants with MS and 10 control participants for the present study.

### *Language Sample*

Two types of language sample data were collected, within 24 hours, with the first sample being a sentence completion task. The participants completed a sentence “stem,” which was presented both orally and in written form in large (24 point) black font on a white index card and was adapted from procedures used by Kemper et al. (2004). However, the task in the present study used manual rather than electronic presentation of sentence stems and involved no prior examination of participants’ memory abilities. Just as in the Kemper et al. (2004) study, some sentence stems were main clauses ending in *that*, *what*, or *who* and participants were asked to complete the embedded clause. As shown in Table 1, the remaining stems were *that*, *what*, or *whom* clauses and participants then produced a main clause.

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...

The second type of language data involved a 15 minute spontaneous sample collected while the participant was in conversation with a speech-language pathology graduate student.

Two language samples were recorded for each participant, collected within 24 hours. If needed,



conversational prompts were given throughout the sample including vacations, holidays, family, etc.

The language samples were recorded using an Olympus VN-960PC digital voice recorder in a quiet room with no distractions. Language data were then transcribed into Systematic Analysis of Language Transcripts (SALT) format (Miller & Chapman, 2004) for further analysis, although the SALT coding of inflectional morphemes was not necessary for data analysis with the software used. Automatic analysis in addition to manual coding was then performed to code complex structures.

### *Reliability*

To establish a measure of reliability in manually identifying the number of complex structures in each sample, a second observer independently coded 20% of the samples. Interrater agreement was found to be 94%.

## Results

As described earlier, the two groups (persons with MS and persons without MS) were sampled twice as each person participated in two tasks, conversation and sentence completion. Two quantitative measures (MLU and DSS) were obtained for each task, and the use of three finite embedded forms (noun, relative, and adverbial clauses) was tabulated in the conversational samples.

### *Conversational Samples*

The MLU and DSS were calculated to compare group performance in conversation. The means and standard deviations for each group on MLU are shown in Table 2.

Table 2

*Conversation Task: MLU for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	9.73	1.61	9.93	1.80
Persons without MS	9.37	0.67	9.24	0.97

A two-way mixed ANOVA revealed that differences between groups were not significant,  $F(1, 16) = 0.918$ ;  $p = .352$ . Differences between samples,  $F(1, 16) = 0.018$ ;  $p = .894$ , and interaction effects,  $F(1, 16) = 0.341$ ;  $p = .567$ , were also not significant.

The means and standard deviations for each group on the DSS measure are shown in Table 3. A two-way mixed ANOVA revealed that differences between groups were not significant,  $F(1, 16) = 0.240$ ;  $p = .631$ . Differences between samples,  $F(1, 16) = 0.016$ ;  $p = .900$ , and interaction effects,  $F(1, 16) = 0.110$ ;  $p = .744$ , were not significant.

Table 3

*Conversation Task: DSS for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	16.37	3.10	16.49	1.65
Persons without MS	16.16	2.14	15.89	1.37

Data on the three types of finite embedded clauses and for all forms of embedding combined are presented in Tables 4 through 7.

Table 4

*Conversation Task: Noun Clauses for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	20.00	9.75	16.38	8.02
Persons without MS	24.10	10.80	19.80	10.71

Table 5

*Conversation Task: Adverbial Clauses for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	19.62	10.81	17.62	12.85
Persons without MS	25.50	9.12	23.70	5.44

Table 6

*Conversation Task: Relative Clauses for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	8.12	4.82	9.25	3.92
Persons without MS	16.40	7.63	12.90	6.57

Table 7

*Conversation Task: All Finite Clauses for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	47.75	19.94	43.25	21.61
Persons without MS	66.00	22.56	56.40	19.64

It may be noted that participants with longer samples would have the opportunity to produce a higher frequency of finite embedded clauses, and persons without MS tended to have longer samples. Thus, prior to statistical analysis, each participant's number of each type of finite embedded clause was standardized for comparison by dividing the frequency by the number of utterances in the sample.

Statistical analysis revealed that differences between groups and separate samples as well as interaction effects were not significant. For noun clauses, differences between groups,  $F(1, 16) = 0.313, p = .584$ , between samples,  $F(1, 16) = 0.090, p = .769$ , and interaction effects,  $F(1, 16) = 0.069, p = .797$  were not significant. For adverbial clauses, differences between groups,  $F(1, 16) = 2.549, p = .130$ , between samples,  $F(1, 16) = 0.225, p = .642$ , and interaction effects,  $F(1, 16) = 0.574, p = .460$  were not significant. For relative clauses, differences between groups,  $F(1, 16) = 3.626, p = .075$ , between samples,  $F(1, 16) = 0.076, p = .786$ , and interaction effects,  $F(1, 16) = 0.851, p = .370$  were not significant. For all finite embedded clauses combined, differences between groups,  $F(1, 16) = 2.594, p = .127$ , between samples,  $F(1, 16) = 0.008, p = .931$ , and interaction effects,  $F(1, 16) = 0.023, p = .882$  were not significant.

Consistency of measures was examined by correlating the measures from the two samples. These data are presented in Table 8. Persons with MS had higher correlations between

samples than persons without MS on six measures and the number of utterances in each sample; persons without MS had higher correlations on the other four measures.

Table 8

*Conversation Task: Correlations of Measures for Both Groups*

	Persons with MS	Persons without MS
Number of utterances	.555	.749
Frequency		
Noun clauses	.623	.044
Adverb clauses	.906	.326
Relative clauses	.172	.216
All clause types	.887	.255
Frequency/Number of utterances		
Noun clauses	.048	.056
Adverb clauses	.366	.056
Relative clauses	.525	.343
All clause types	.183	.209
Quantitative measures		
MLU	.794	.077
DSS	.570	.170

*Sentence Completion Task*

The means and standard deviations of MLU for each group on the sentence completion task are shown in Table 9.

Table 9

*Sentence Completion Task: MLU for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	10.08	1.25	10.03	0.49
Persons without MS	11.14	1.75	10.47	1.40

A two-way mixed ANOVA revealed that differences between groups were not significant,  $F(1, 16) = 2.142$ ;  $p = .163$ . Differences between samples,  $F(1, 16) = 0.865$ ;  $p = .366$ , and interaction effects,  $F(1, 16) = 0.675$ ;  $p = .423$ , were not significant.

The means and standard deviations for each group on DSS of the sentence completion task are shown in Table 10. A two-way mixed ANOVA revealed that differences between groups were not significant,  $F(1, 16) = 0.846$ ;  $p = .371$ . Differences between samples,  $F(1, 16) = 0.896$ ;  $p = .358$ , and interaction effects,  $F(1, 16) = 0.754$ ;  $p = .398$ , were not significant.

Table 10

*Sentence Completion Task: DSS for Both Samples of Both Groups*

	Sample 1		Sample 2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Persons with MS	14.41	1.70	13.41	1.69
Persons without MS	14.63	2.67	14.59	1.48

Consistency of sentence completion measures was examined by correlating the measures from the two samples. Persons without MS had higher correlations between samples for both MLU ( $r = .327$ ) and DSS ( $r = .366$ ) than did persons with MS (MLU  $r = .250$ ; DSS  $r = .296$ ). However, none of these correlations were statistically significant.

### Discussion

The current study examined possible language differences in persons with MS compared to age- and gender-matched control participants. Two language conversational samples as well as two sentence completion tasks were collected from each participant on different occasions and analyzed to determine group differences and test-retest consistency. Quantitative measures (MLU and DSS) were studied in addition to tabulating the use of three finite embedded forms

(noun, relative, and adverbial clauses) in each sample. Results from the conversational samples indicated that while participants with MS performed slightly higher in terms of quantitative measures (Table 2 and Table 3), control participants used a slightly higher number in each index of complex structures (Tables 4 through 7). Participants with MS had higher correlations between samples on slightly more than half of the measures used. However, all of these differences between groups were not statistically significant. There was so much variability between subjects of either group that the group mean differences could not be considered to be reliable indicators. Results from the sentence completion task showed that typical controls also performed slightly higher in quantitative measures of MLU and DSS (Table 9 and Table 10), although these findings were also not statistically significant.

The findings as to a lack of significant group differences are consistent with those found in a similar, recent study (King, 2009). King found that in mild cases of MS, little difference exists in terms of quantitative measures (MLU and DSS) between participants with or without MS. In contrast, the present study's findings differ from those reported by Lethlean and Murdoch (1993; 1997) and by Wallace & Holmes (1993). Lethlean and Murdoch (1993; 1997) found that when using a comprehensive battery of specific linguistic tests, individuals with MS scored significantly lower than the control participants on tests of higher level language abilities. Similarly, Wallace & Holmes (1993) found that the ABCD was sensitive enough to detect impairments in word finding, written and spoken language formulation, and discourse in those with MS. The difference between these authors' findings and those in the current study may have occurred for a variety of reasons, including severity levels, the sample sizes, and the complexity measures used.

### *Possible Explanations of Current Findings*

The severity level of the participants, the sample size used in the current study, and the linguistic complexity measures used may have led to findings which differ from those reported by Lethlean and Murdoch (1993; 1997) and by Wallace & Holmes (1993).

*Severity level of participants.* One reason why the participants with and without MS did not differ significantly might be the mild severity level of the participants with MS who participated in the present study. Participants were contacted via a local neurology clinic and asked to volunteer, and this self-selection process may have limited the type of individuals who participated to those persons who were presently in a state of remission. Only two of the eleven participants reported that they were in a state of exacerbation at the time of testing, and of these two participants, one was too unintelligible for his language to be accurately transcribed. During the conversational samples, several individuals with MS stated that during periods of exacerbation, they have difficulty with word recall and thought formulation. It is possible that language differences and variability occur more during periods of exacerbation, and those persons experiencing a state of exacerbation were unwilling or unable to travel or participate in the present study. The sample of individuals who took part in this study may be reflective of the language abilities of those who are in a state of remission but may not be a true representation of the overall language abilities of persons with MS. Perhaps the same complexity measures used in the present study would have detected significant differences in more severely affected persons or persons in a state of exacerbation.

*Sample size.* In addition to the mild severity levels of the participants, the small sample size used in the current study may have played a role. Although eleven participants with MS originally volunteered for the study, language samples from only eight participants could be used in the current study. As mentioned above, one participant's samples could not be accurately



transcribed, and a second sample from two other participants was not available. The small sample size may be related to the severity level of participants, whereas those more severely affected and in a state of exacerbation were unable to participate for the collection of both samples, but the exact reasons are unknown. Lethlean and Murdoch (1997) had a much larger sample size of 60 individuals. However, Wallace and Holmes (1993) had a smaller sample size than the present study, suggesting that differences in language may still be found despite a small number of participants.

*Complexity measures used.* The current study evaluated the complexity of participants' language based on quantitative measures (MLU and DSS) and participants' use of noun, adverbial, and relative clauses. The use of the quantitative measures MLU and DSS to examine adult conversational language was based on the work of Kemper et al. (2001) and Kemper et al. (2003). The use of a sentence completion task to evaluate sentence complexity in adults was based on the work of Kemper et al. (2004). Nippold et al. (2008) used the production of noun, adverbial, and relative clauses to examine language abilities in adolescents. Thus, the measures used in the present study could plausibly isolate differences in language production. Although Lethlean and Murdoch (1993) suggest that there are language impairments in individuals with MS, results from the current study indicate that these differences and variability may not be apparent in the conversational use of the three finite embedded structures used by participants in the present study. In other words, differences in the language of persons with and without MS may exist, but these particular measures might not be sensitive to this difference.

#### *Future Research*

Several factors may be of interest in future studies of linguistic complexity in MS. First, future research into the linguistic effects of MS should examine a more severely affected population of individuals with MS. It may be of benefit to visit the homes of those in states of

exacerbation, if illness is preventing them from traveling to a research facility. Second, the area of linguistic inquiry might be expanded. Several individuals with MS in the present study reported difficulties finding words or formulating thoughts and sentences, though the existing measures did not detect differences. For example, Wallace and Holmes (1993) reported that individuals with MS produced fewer utterances per minute, had a lower percent of complete and grammatically correct utterances per minute, and had a smaller mean number of information units per utterance than did the control subjects. It may be of interest to study whether these factors, in comparison with linguistic complexity as operationalized in the present study, differ in individuals with MS. Third and finally, conversational language samples were used to determine the presence of complex structures in the present study. Nippold et al. (2008) suggested that expository discourse tasks are generally more effective than conversational or narrative tasks in eliciting complex syntax in typically developing children, adolescents, and adults. Perhaps obtaining expository rather than conversational samples from individuals with MS would reveal greater difference or variability in their use of complex language.

### *Conclusion*

The current study revealed that in with mild cases of the disease, or during periods of remission, individuals with MS were able to retain their ability to consistently use complex structures and language during natural discourse. If complex language structures are variable in persons with MS, it was not apparent in the conversational language samples taken from the participants in the present study. Research attention might thus be profitably focused elsewhere, specifically on examination of language abilities of persons with more severe levels of MS.

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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 Stems

**Right Branching:**

Emily asked that...

David Cut what...

Bonnie took what...

Richard saw who...

Kate knew that...

Ashley wanted what...

Mindy wondered who...

Liz offered that...

Andrew asked that...

Anna said what...

Adam knew when...

Lisa smiled if...

Susan wondered how...

Jon slept while...

Ashley waited for...

Bill read when...

Ben spoke if...

Rachel dressed how...

Mary shopped while...

Lisa looked for...

**Left Branching:**

That Shawn cooked...

What Sandy found...

That Bob stole...

What Mary assumed...

Who Ron saw...

What Tom kept...

Who Beth told...

That Amy sang...

What Harold said...

Who Guy loved...

When Roger found...

If April smiled...

How Karen left...

While Michelle waited...

Why Martha ate...

When Kate spoke...

If Ida knew...

How Frank found...

While Josh played...

Why Fran sighed...