ABSTRACT

Title of thesis: EXAMINING NARRATIVE LANGUAGE IN EARLY STAGE PARKINSON'S DISEASE AND INTERMEDIATE FARSI-ENGLISH BILINGUAL SPEAKERS

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This study aimed to examine procedural aspects of language (grammaticality, syntactic complexity, regular past tense verb production), verb use, and the association between motor-speech, language abilities, and intelligibility in Early Stage Parkinson's Disease (PD) and Intermediate Farsi-English Bilingual Speakers (L2). Ullman's Declarative-Procedural Model (2001) provided this study with a dual-mechanism model that justified a theoretical comparison between these two populations. Twenty-four neurologically healthy native speakers of English, twenty-three Parkinson's Disease participants, and thirteen bilingual Farsi-English speakers completed three narrative picture description tasks and read the first three sentences of the Rainbow Passage. Language samples were transcribed and analyzed to derive measures of morphosyntax and verb use, including grammatical accuracy, grammatical complexity, and proportions of regular past tense, action verbs and light verbs. The results did not show any evidence of morphosyntactic or action verb deficit in PD. Neither was there any evidence of a trade-off between morphosyntactic performance and severity of speech motor impairment in PD.

L2 speakers had lower scores on grammatical accuracy and a measure of morphosyntactic complexity, but did not differ from monolingual speakers on measures of verb use. Overall, these results show that language abilities (morphosyntax and verb use) are preserved in early stage PD. This study replicates the well-documented finding that morphosyntax is particularly challenging for late bilingual speakers. The results did not support Ullman's Declarative-Procedural (2001) hypothesis of language production in Parkinson's Disease or L2 speakers.

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by

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Introduction

Parkinson's disease (PD) is a neurodegenerative disorder characterized by loss of voluntary control over movement caused primarily by a deficiency in dopamine and subsequent functional impairment of the basal ganglia. Research focusing on language patterns in Parkinson's disease (PD) has been growing in past years, complementing advances in neurological and motor impairments that clinically define the progressive neurodegenerative disease (Bastiaanse & Leenders, 2009; Troche & Altmann, 2012). Research on language production in PD has specifically focused on morphosyntax and verbs. The interest in morphosyntactic patterns of language for persons with PD stems from the role of the basal ganglia in implicit rule-based memories (Clark & Lum, 2017). Verbs, particularly production of action verbs, has also generated interest in PD (Bocanegra et al., 2017). This is due to the idea that language is grounded in sensory-motor representations, which is also referred to as embodied cognition (Barsalou, 1999). Thus, the motor impairment in PD is proposed to have a downstream impact on producing words that refer to actions (i.e., action verbs). A third way in which language could be impacted is through persons with PD producing short and syntactically simple utterances as a strategy to accommodate their motor speech difficulties (Chu et al., 2020; Marquardt, 2016). This thesis proposes to investigate these three aspects of language in PD: morphosyntax, action verbs, and the relationship with severity of speech impairment. To our knowledge, this will be the first study to examine all three in the same group of individuals with PD.

Ullman et al. (1997) used data from individuals with PD to propose that morphosyntactic rules of language are learned and processed by procedural memory, which is compromised in PD. In his declarative-procedural hypothesis, Ullman (2001) also proposed that people learning a 2nd language (L2) under-utilize procedural learning for morphosyntax. Thus, according to the declarative-procedural hypotheses, both PD and L2 speakers show weaknesses in implementing morphosyntax via procedural memory. However, to our knowledge, these two groups have not been directly compared.

This study will analyze and compare narrative language production patterns observed in PD speakers, L2 speakers, and neurologically healthy L1 speakers of English. The goals of this study are to: 1) compare morphosyntactic aspects of narrative language in early stage PD and intermediate proficiency L2 speakers of English, 2) examine patterns of verb production in early stage PD and intermediate proficiency L2 speakers of English, 3) examine the relationship between dysarthria and language production in PD Speakers
and 4) examine the relationship between intelligibility and morphosyntax in L2 speakers.

Literature Review

This study will first review literature related to Ullman's (2001) Declarative-Procedural (DP) model to examine the relationship between procedural aspects of language in PD and L2 speakers of English. Next, verb production patterns in each group will be reviewed. Lastly, literature exploring the impact of speech severity due to oromotor impairment on language production in PD speakers and the association between intelligibility and morphosyntax in L2 speakers will be reviewed.

Approximately 50-80% of persons with PD eventually develop dementia throughout the span of the disease (Aarsland et al., 2005). Parkinson's Disease with Dementia (PDD) is considered to be neuropathologically distinct from PD (Meireles & Massano, 2012). The present thesis focuses on PD without dementia. Additionally, the present thesis focuses on later learners of a L2 and will be defined by exposure to the L2 after late childhood or puberty.

Ullman's Declarative-Procedural Model

Ullman's (2001) Declarative-Procedural Model (DP) of Lexicon and Grammar proposes that language processing involves dual-mechanisms. First, a mental lexicon of memorized words is mediated by declarative memory. Second, a mental grammar of rules used for the construction of lexical forms and sentences is achieved through the procedural memory. The declarative memory specializes in learning arbitrary related information, such as memorization and use of simple words, in temporal lobe structures. This underlies the explicit use of fact-based knowledge, and the acquisition of sounds and meanings of morphologically simple and complex words. This includes words that have not experienced inflectional, derivational, or compounding morphological transformations. These all form the mental lexicon. Procedural learning of syntactic well-formedness and morphological affixation rules occurs implicitly through repeated exposure and is subserved by frontal/basal-ganglia circuits. Alternative theories (Seidenberg & Plaut, 2014) have challenged whether speakers activate semantic, grammatical, and phonological information at once in order to process and determine a subsequent appropriate production. Ullman (2001) suggests that acquisition and use of morphosyntactic rules, such as the past tense, is dominantly controlled by the procedural system.

Ullman's DP model illustrates the dual-mechanisms of language using the example of English past tense. Ullman (2001) expanded on Pinker and Prince's (1988) original dual mechanism proposal to suggest that English regular past tense is derived by implementing a rule from procedural memory. An example includes adding *-ed* affix to the end of a verb. Irregular past tense forms have direct entries in the mental lexicon as part of declarative memory, such as *sang* and *drank*. Ullman (2001) proposed that, unlike native speakers, L2 speakers use declarative memory for morphosyntax because they have not yet had the repeated exposure needed to activate procedural learning. L2 speakers are likely to make errors on non-native morphosyntactic elements because declarative memory systems are not well-equipped for rule-based aspects of morphosyntax. An impaired frontal/basal-ganglia circuit in PD (Illes, 1989) indicates compromised procedural memory and will likely impair morphosyntactic processes. According to Ullman's (2001) model, both PD and L2 speakers experience limitations in the use of rule-based aspects of morphosyntax, such as subject-verb agreement and regular past-tense production.

Ullman's (2001) model has served as a neurocognitive basis for investigating L2 and adult-onset disorders involving the frontal/basal-ganglia structures (Gotseva, 2017). The model claims the possibility of L2 learners ultimately becoming L1-like in terms of proficiency and underlying neurocognitive correlates. This initially challenged the critical period hypothesis, which claims that the ability to acquire language is biologically limited by age (Clark & Lum, 2017). Ullman (2013) discussed adult-onset disorders, such as PD, and suggested that impairment of procedural memory brain structures damage the use of rule-governed complex forms (e.g., "*Yesterday I walk over there*," leaving off the rule-governed -*ed* suffix). Ullman also proposed that weaker patterns are reported in milder hypokinesia irrespective of PD.

Ullman's model provides a foundation for the comparison in narrative language production patterns seen in early stage PD speakers and intermediate L2 speakers of English due to procedural, or rule-based, limitations (see also: Ullman, 2006; Ullman, 2013). The following sections will present findings on specific components of morphosyntactic production in PD and L2 speakers in accordance with Ullman's DP model.

Morphosyntactic Production

The role of basal ganglia neurodegeneration in distinguishing poorer procedural learning (Clark & Lum, 2017) and Ullman's (2001) proposal of procedural memory system functions suggests similar patterns of narrative language in measures of grammaticality, complexity, and past-tense verb production in both PD and L2 speakers.

<u>*Grammatical Accuracy*</u>

Speakers must adhere to many grammatical constraints of the language when producing sentences. In English, this includes word order (typically subject-verb-object), subject-verb agreement for number (*The boy eats* vs. *The boys eat*), phrase structure rules (e.g., determiners before nouns, auxiliaries/modals that match the verb inflection, *is eating* but not *is eats*), and inflectional morphology (e.g., tense and aspectual markings on verbs and plural markings on nouns).

Parkinson's Disease

In the PD literature, less is known regarding the nature of grammatical accuracy for persons with early stage non-demented PD. Yet, studies show errors in verb agreement in oral language tasks when working memory demands increase (Altmann & Troche, 2011). Studies have reported that persons with PD produced similar amounts of utterances when compared to control speakers (Murray, 2000; Troche & Altmann, 2012), but demonstrate increased use of sentence-medial pauses, non-lexical fillers, and more abandoned or ungrammatical utterances. This is especially evident in increasingly complex working memory tasks (Altmann & Kemper, 2006). Early empirical evidence supports that persons with PD learn adaptation strategies, such as simplifying the content of their language production, given the role of primary motor speech deficits of the degenerative disease (Illes, 1989). More recent studies have reported the presence of syntactic simplification and misarticulation of consonant cluster endings due to PD dysarthria.

This resulted in low grammaticality during narrative production (Illes, 1989; Pinto et al., 2017). Authors have reported that measuring the proportion of informative utterances in narrative tasks, like the cookie theft (Goodglass & Kaplan, 1972) and grocery scene pictures (Helm-Estabrooks, 1992), resulted in smaller proportions of grammatical sentences that contained less information defined by correct information units (Murray, 2000). A review conducted by Altmann and Troche (2011) found no examples of aberrant word order in their participants with PD; thus far, yet studies have mainly examined this element of grammaticality through sentence level tasks.

L2 Speakers

In L2 speakers, lower grammatical accuracy during production tasks has been attributed to the relationship between a gap in vocabulary knowledge in the speaker's L2 and greater effort to process rule-based morphosyntax in a later acquired language (Ullman et al., 2005). Some studies have examined L2 speaker's sensitivity to grammatical (i.e. singular vs. plural) or conceptual number *(i.e.* a clear-cut boundary in distinguishing subject-verb agreement*)* when asked to respond to subject-verb agreement tasks (Hoshino et al., 2010) in the presence of greater task demand. Authors expected participants to finish a prompt such as, "The drawing on the posters" by adding something such as, "was colorful" to indicate the ability to process subject-verb agreement (Hoshino et al., 2010). Authors reported that L2 speakers produced greater subject–verb agreement errors for distributive-referent items, where the subject of the sentence could refer to multiple referents (e.g. "The *drawing* on the *posters*"). More preserved production was reported in single-referent items (e.g. "The *authors* of the *novels*"), where the subject could only refer to a single referent. This was especially evident when the head noun *(*i.e. the word that determines the nature of a phrase*; posters)* and the local noun *(drawing)* mismatched in number, as seen by "The drawing on the posters." Other studies have reported that L2 speakers experience greater difficulty in processing and accessing information for conceptual number in their less dominant language when it is often automatically available in their dominant language (Birdsong & Flege, 2001). Intermediate bilingual speakers show sensitivity to both grammatical and conceptual number in their L1; however, they failed to demonstrate sensitivity to conceptual number in their L2 (Hoshino et al., 2010). Therefore, Bird et al. (2003) reported that L2 performance is not expected to demonstrate a specific sensitivity to conceptual numbers in subject-verb agreement tasks in the presence of greater task demand. Plural marking errors in L2 speakers have also been reported within sentence generation tasks, irrespective of their effect on the semantic coherence of the intended production (McDonald & Roussel, 2010).

To summarize, there is weak evidence of inflectional morphology deficits during narrative language tasks (Altmann & Troche, 2011) for persons with PD. There is some support for vulnerability in grammaticality (subject-verb agreement for number, phrase structure rules) in the presence of greater working memory demands and in response to oromotor restrictions (Illes, 1989; Pinto et al., 2017). In L2 speakers, findings on grammatical accuracy are reported during narrative based tasks. Subject-verb agreement, phrase structure rules, and inflectional morphology have been reported as potentially vulnerable in intermediate proficiency speakers of a second language (Hoshino et al., 2010; McDonald & Roussel, 2010).

Overall, there is some evidence that grammaticality is limited in PD and L2 speakers, and Ullman’s (2001) DP model may provide an explanation for demonstrated lower accuracy. The proposed study predicts that PD speakers’ procedural memory limitations (Ullman, 2001) and adaption to diminished oromotor function (Illes, 1989), and L2 speakers’ under-utilization procedural memory to process information (Bird et al., 2003) will result in a lower proportion of grammatical utterances as compared to neurologically healthy, monolingual participants in narrative tasks. Based on Ullman's DP model, grammaticality in narrative language production will be discussed further through the perspective of syntactic complexity.

Syntactic Complexity

Speakers may include various grammatical structures that increase the complexity of their production when talking. One definition of syntactic complexity includes any of the following elements: an embedded clause such as a subject relative (e.g. The woman, *who is very old*, looked very different years ago.) and/or syntactic movement (e.g. passive sentences; *The turkey was eaten by the dog*, wh-questions; *Where are the kids?*, and object relatives; *The man that the woman is pulling pulls the dog*) (Hsu & Thompson, 2018). Studies have reported that object relative clauses are cognitively more demanding than subject relative clauses (King & Just, 1991; King & Kutas, 1995; Traxler et al., 2002). Relative clauses and passives have been found harder to encode in procedural memory or emerge later in language acquisition than other structures (i.e., coordinate and active structures) (Diessel, 2004; Ortega & Byrnes, 2009).

Parkinson's Disease

Several studies have investigated whether syntax is impaired, and if so, the nature of its impairment given the well-documented role of basal ganglia pathology in PD. In an early study, Illes et al. (1988) used the Grandfather passage (Van Riper, 1963) and spontaneous speech production tasks to report that persons with PD produced longer utterances through listing several events within a single sentence. Syntactic complexity was measured by applying a score of complexity per clause. For example, embedded clauses were reflected with a higher degree of planning than nonembedded clauses (Ford, 1978). The production of embedded clauses and center-embedded relative clauses (e.g., *that man who won the race was born in Jamaica*) require simultaneous access to the message and lemmas of intended clauses (Dick et al., 2018). Authors reported that if persons with PD experience limitations in activating both items, they will produce fewer complex embedded sentences and use longer strings of content words (Kemper and Sumner, 2001). Findings from Illes et al. (1988) were not indicative of greater syntactic complexity, but demonstrated a higher proportion of content word phrases (i.e., noun, verb, and adjective phrases) as compared to healthy controls. Only moderately impaired PD speakers produced sentences with lower syntactic complexity.

More recent studies have documented syntactic simplification in speakers with PD, such as use of shorter utterances, a reduced number of clauses, and fewer syntactically complex sentences in brief, non-narrative based samples (Dick et al., 2018; Murray & Lenz, 2001). Limitations in complexity of language production may represent a primary characteristic of PD, even in the absence of cognitive impairment (Altmann & Troche, 2011). Other studies have found no significant differences in spoken language complexity of PD speakers as compared to healthy ageing older adults (Huber et al., 2012). Variable findings across studies could be attributed to numerous factors that include the severity of PD among participants, variations in outcome measures or definitions of syntactic complexity, and differences in experimental tasks.

L2 Speakers

Inadequate encoding and under-utilization of procedural memory, and limited access to lexical knowledge in a second language have been proposed as underlying sources for decreased syntactic complexity in L2 literature (Hartsuiker & Barkhuysen, 2006). Studies have reported lower syntactic complexity in intermediate proficiency L2 speakers, including fewer subordinate structures (Vèronique, 2004), adverbial clauses, and relative clauses (Bartning & Schlyter, 2004), as compared to native speakers in a variety of narrative tasks (Wolfe-Quintero et al., 1998). Other studies have reported long, pragmatically unnatural, yet grammatical utterances in film retelling and phone call tasks. Native speakers produced syntactically simpler and shorter units that were more appropriate to the pragmatic context of the task (Pallotti, 2009). The frequency of syntactic structures within the L2 (Goldschneider & DeKeyser, 2001), as compared to their L1, also contributes to the learning, encoding, or processing difficulty (Bulté & Housen, 2012). Fehringer and Fry (2007) defined L2 speakers' use of complex and pragmatically appropriate syntax through "optionality." Components considered *complex* are focused on syntactically optional information that is not necessary to the basic message, but elaborate on the speaker's message.

Findings of decreased syntactic complexity in both PD and L2 speakers could theoretically be attributed to impairments in the functioning of, or use of, the procedural memory system. Existing evidence is mixed for PD, with some studies showing decreased syntactic complexity (Dick et al., 2018; Murray & Lenz, 2001) while others showing some, albeit non-significant differences (Illes et al., 1988; Terzi et al., 2005). If syntactic simplification does occur in PD, it is not clear if this is due to a lack of cognitive and linguistic resources (Altmann & Troche, 2011), inadequate encoding in procedural memory due to prefrontal dysfunction (Ullman, 2001), both of these reasons, or as an adaptation to oromotor restrictions (Terzi et al., 2005). The latter suggestion arises from the observation that syntactic impairments in PD have largely been reported as unimpaired in early stages of the progressive disease (Illes et al., 1988). Syntactic complexity in the language of L2 speakers is understandably reduced when compared to native speakers of a language (Fehringer & Fry, 2007; Hartsuiker & Barkhuysen, 2006; Wolfe-Quintero et al., 1998).

Based on Ullman's DP Model, we predict that both groups will perform worse on measures of syntactic complexity when compared to neurologically healthy native speakers of

English. We specifically include examination of past-verb production, a frequent topic in the DP model, in the next section.

<u>*Past-Tense Verb Production*</u>

The production of the past tense of regular verbs via rule application should be compromised in English speakers with procedural memory impairments or in L2 speakers of English who do not use procedural memory for all rule-based linguistic processes (Ullman, 2001). In contrast, the past tense of irregular verbs (e.g., *taught*), which must be learned as individual lexical items and retrieved from declarative memory, is likely to be unimpaired.

Parkinson's Disease

Several studies have used sentence completion and elicitation tasks to compare past tense production of regular and irregular verbs in persons with PD (Colman et al., 2009; Longworth et al., 2005; Ullman et al., 1997). Some studies have also included "pseudoverbs" that resemble either regular or irregular verbs to test the applicability of dual mechanisms of past tense production to new situations (Ullman et al., 1997).

Ullman et al. (1997) used data from persons with Alzheimer's Disease (AD) and PD to support his claims of a dual-system model. Both groups generated the past tense of regular verbs, irregular verbs, and pseudo-verbs through the Past Tense Generation task (PTG). Persons with AD demonstrated declarative memory impairments. This resulted in more errors in forming the past tense of irregular than regular verbs and pseudo-verbs. Persons with PD made more errors in the past tense of regular verbs and pseudo-verbs than irregular verbs (Ullman et al., 1997). Studies have also reported persons with PD generate more inaccurate productions of the regular past tense when the present tense is required. Colman et al. (2009) asked participants to generate the inflected form of a verb when presented with picture stimuli and a fill-in-the-blank sentence. Past tenses were elicited with a time biasing adverb such as "yesterday," and present tenses were elicited with no adverbial cue. The authors found that PD speakers produced the wrong inflected form, especially when having to switch between past and present tenses when no adverbial cue appeared in the sentence. Other studies have also reported perseverations when participants were expected to produce the appropriate past tense form in verb production tasks (Longworth et al. 2005). Persons with PD perseverated on the present tense verb stem that was given as a cue. It is not clear if regular past tense formation deficits can be attributed to the greater task demand required to switch between the present and past tense in sentence completion tasks (Colman et al., 2009), or a distinct impairment of regular past tense associated with the procedural memory system (Ullman, 2001). Other studies have found error production on both regular and irregular verbs in sentence completion tasks in speakers with PD as compared to healthy controls (Longworth et al., 2005; Terzi et al., 2005), which would not support the DP model.

An attention-based cognitive control impairment, rather than a language-specific grammatical deficit, has also been reported to potentially explain the difficulty experienced by PD speakers when producing regular past-tense forms (Troche & Altmann, 2012). Studies have examined the relationship between cognition and sentence production, repetition, and generation tasks in PD speakers. PD participants performed significantly worse during sentence generation tasks and continued to perform poorly even once cognitive ability was controlled, showing potential language-specific impairment, regardless of limitations in cognitive resources. The authors suggested that persons with PD have an impaired inhibitory control system that impacts language processing, rather than a defective language system and an impairment of actual linguistic representations (Troche & Altmann, 2012).

L2 Speakers

Ullman (2001) claimed that later learners of a L2 *(*exposed to the L2 after late childhood or puberty*)* process morphologically complex forms (e.g. adding *-ed* to regular past tense verbs; *walked*) through the declarative/lexical memory system as opposed to the procedural system used in L1 acquisition. Thus, it is claimed that L2 speakers process both irregular past and regular past through the same declarative retrieval process.

Pinker & Ullman (2002) reported that L2 speakers often treat unfamiliar past tense words as essentially nonce form. The speaker uses a specific lexeme for a single moment to solve an immediate gap in communication (i.e. *slock* for *stopped)*. Lardiere (2003) explored Ullman's (2001) claims in an L1 (Chinese)-L2 (English) longitudinal case study using speech production tasks, and reported that highly frequent regular past tense verbs, which are encoded by declarative memory, and irregular past tense verbs, were more likely to be incorrectly produced due to the participant's relatively late age of L2 exposure. The absence of practice or exposure to less frequent regular past-tense forms potentially led to inaccurate productions and greater reliance on procedural encoding (Lardiere, 2003).

Some studies have reported that L1 speakers produced more regularized phonological forms *(*i.e. *gooses* for *geese*) than nonce verbs (Murphy, 2004). Grammaticality judgement and verb production tasks have been used to report significantly worse performance in both regular and irregular past production in L2 speakers (McDonald & Roussel, 2010). Authors reported a positive correlation between intact lexical access and accurate irregular verb form production, and a negative correlation between decreased lexical access and less accurate production of overregularized verb forms in L2 speakers (McDonald & Roussel, 2010; Murphy, 2004). However, poor phonological ability was correlated with a greater number of errors in past tense production and unmarked forms of regular verbs, such as producing verbs as present tense. Poor lexical access demonstrated on a picture naming task, was correlated with poor irregular past tense production and over-regularization. While the correlation between picture naming accuracy and irregular past accuracy supports the retrieval of irregulars via declarative memory, the over-regularization of irregulars (e.g., *singed* for *sang*) suggest that L2 speakers have in fact mastered the regular past tense rule. This shows evidence of unimpaired use for past tense generation, incompatible with the DP hypothesis.

Both PD and L2 groups have been reported to have deficits in accurate past-tense verb production, with some in support of Ullman's DP model (Ullman et al., 1997) and others against (McDonald & Roussel, 2010; Ortega & Byrnes, 2009). In PD speakers, the findings are complicated by perseveration errors when another form of the verb is provided as a prompt. For example, participants may produce the previously provided cue "*walk*" for the target "*walked*" form in the past tense verb generation task, (Ullman et al., 1997). It is unknown whether PD speakers have an attention-based cognitive control impairment, a language-specific grammatical deficit (Troche & Altmann, 2012), or a combination of both that result in past-tense verb production errors (Friederici et al., 2003; Terzi et al., 2005).

Similarly, in L2 speakers, Ullman's claims have been challenged by findings of inaccurate production of both regular and irregular past tense verb through tasks assessing lexical access and phonological ability (McDonald & Roussel, 2010). Other studies have explored the role of limited lexical knowledge in an L2 (leading to inadequate declarative encoding), limited exposure to rule-based items (leading to inadequate procedural encoding), as factors leading to failure to produce accurate past tense forms (Lardiere, 2003).

The proposed study predicts that both PD and L2 speakers will perform worse on regular past-tense verb production, as compared to neurologically healthy controls, assessed through the proportion of regular past tense verb over all instances of past tense production in a narrative language sample.

Thus far, Ullman's Declarative-Procedural model has been used to demonstrate known and anticipated similarities when comparing PD and L2 speakers with typical speakers. The following section will examine evidence of differences that have been observed that cannot be attributable to problems using the procedural memory system.

Verb Production

It is important to highlight key nuances between verbs that are known to impact verb use and accuracy. Some verbs represent bodily movements (action verbs such as *running* and *laughing*), events (such as *melt* or *construct*), or abstract concepts (such as *think* or *imagine*). Verbs also differ in the specificity of their meaning, as contrasted by heavy and light verbs, such as *bake* versus *make,* and *travel* versus *go*. In English, light verbs have general and less specific semantic features (*do, make, take, give,* and *get*) (Ninio, 1999).

Clinical and neuroimaging studies have shown that verb processing, retrieval, and production involve the left prefrontal/frontal network, which is dysfunctional in PD (Cappa et al., 2002; Shapiro et al., 2001). Processing of action-related words activates the left inferior frontal cortex and precentral gyrus, indicating involvement of the motor cortex (Hauk et al., 2004; Martin et al., 1996). The left fusiform gyrus, a region near the visual word form area (Dehaene et al., 2002), and the left inferior temporal cortex, activate across all action words and contribute to semantic processing, respectively (Hauk et al., 2004). The left posterior-lateral-temporal cortex (PLTC) appears to be more sensitive in the activation of motion verbs when compared to non-motion verbs (Wallentin et al., 2011). This region is suggested to be innately predisposed to represent the retrieval of visual-motion features of actions. From a cross-linguistic perspective, verbs tend to be more variable in meaning across languages and yield a wider variety of translations by bilingual speakers (Prior et al., 2013). Finally, verbs are considered to be semantically and morphosyntactically more complex than nouns, and children acquire verbs later than nouns (Gentner, 2010). These factors are among many that make verbs more challenging to learn by L2 speakers and more vulnerable to loss in PD.

Verb Use in Parkinson's Disease

An influential theory of word meaning, Embodied Cognition (Barsalou, 1999), provides a model of semantic processing that connects a unique verb problem with PD (Barsalou, 1999; Kemmerer et al., 2013). This theory suggests that semantic representations inherently activate sensorimotor neurons that are relevant to the word's meaning (Hauk et al., 2004). Thus, processing (listening, reading or producing) an action related verb, such as *kicking*, will activate the leg/foot region of the left precentral cortex (Pulvermüller et al., 1999). This modality-specific sensory, action, and emotion system provides experience-based input to temporal and inferior parietal convergence zones, and stores increasingly abstract representations (Atkinson, 2010). In other words, the brain's 'language areas' activate during sensorimotor action (Bonda et al., 1996), while brain motor areas activate during speech (Hauk et al., 2004).

Action verbs are defined by things humans can perform (Bocanegra et al., 2015). Some studies have used object and action naming tasks to examine action verb production and processing in non-demented persons with PD (Bocanegra et al., 2017; Cotelli et al., 2007). Authors have reported that PD speakers generate selectively worse productions when naming high-motion action verbs that are actively manipulated throughout the production task. This suggests a connection between prefrontal dysfunction and action verb production. Studies have also used the action-naming subtest of the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1972) to report deficits in action-verb production and action semantics even in the absence of mild cognitive impairment or additional working memory demands (Bocanegra et al., 2015). Participants were expected to produce associations among action-verb, action-action, and object-object combinations. Similar findings were replicated by Peran et al., (2003) who used noun and verb word generation tasks. The authors required non-demented PD participants to produce a semantically related noun or verb when presented with either a noun or verb cue (noun cue/noun response, noun cue/verb response, verb cue/verb response, etc.). Authors reported significant impairment in both verb/verb and noun/verb generation, with more errors reported in cross-category generations (noun/verb) (Peran et al., 2003). This is potentially indicative of persons with PD experiences difficulty with quickly shifting from different types of verb use when accommodating for impaired action verb use. In a subsequent fMRI study, the authors reported positive correlations between the severity of the motor deficit in PD and in-depth processing of semantic representation of actions required when activating a verb in a word generation task (Peran et al., 2009).

Verb Use in L2 Speakers

The lexical representation of a verb strengthens and enables easier access for subsequent contexts where retrieval of that verb is necessary every time it is activated (Li et al., 2019). Heavy verbs *(kick, blow, speak)*, which have lower frequency of use, are less likely to be strengthened and are often produced in contexts with lower syntactic complexity (Kim & Rah, 2016).

Kim and Rah (2016) reported that lower to intermediate proficient L2 speakers of English rely on light verbs when learning to construct language because of the greater frequency and applicability in varied contexts. The authors included heavy and light verb conditions in sentence sorting tasks. Participants were expected to sort four lexical options (*throw*, *slice*, *get*, and *take*) with four sentence constructions (e.g., transitive ditransitive, caused-motion, and resultative) into groups based on their overall meaning. They reported greater reliance on light verbs as compared to advanced learners and native speakers. As proficiency increases, L2 speakers are understandably better able to integrate any type of verb, regardless of its frequency within the language, into the intended structure of their production (Kim & Rah, 2016). Other studies have found a high frequency of light verbs that are irregular (Ullman, 2001) , and that factors impacting verb production patterns in L2 narrative speech may not be restricted to verb frequency; easier/faster lexical access is also expected for verbs with earlier ages of acquisition (Dent et al., 2008; Hilton, 2008; Morrison et al., 1992).

In summary, several studies have found greater vulnerability in action verb retrieval in persons with non-demented PD (Bocanegra et al., 2015, 2017; Péran et al., 2003). This suggests that action verb naming may be impacted by the isolated dysfunction to the prefrontal network in PD. The processing of light verbs, their less specific semantic features, and greater frequency in varied contexts, are anticipated to contribute to a higher frequency of light verb production in L2 narrative production (Kim & Rah, 2016). The proposed study predicts that PD speakers will produce proportionally fewer action verbs in narrative language compared to neurologically healthy controls (Bocanegra et al., 2017), and that L2 speakers will produce more light verbs compared to neurologically healthy native speakers of English (Kim & Rah, 2016).

The previous sections discussed some common linguistic patterns in both PD and L2 groups. The next two sections discuss an aspect that is unique to each group. First and foremost, in PD, there are speech motor difficulties. This may interact with the formulation of linguistically long and complex utterances. In L2 speakers, the phonetic inventory of their L1 has a strong impact on their L2 speech production. The discussion of these two topics in the next sections lay the groundwork for the third research question of this thesis.

Interaction between Language and Speech Motor Abilities in PD

PD is accompanied by hypokinetic dysarthric speech, which is defined by imprecise consonant production, rigidity in oromotor mechanisms, short bursts of speech, reduced pitch variation, and reduced loudness (Duffy et al., 2014; Smith & Goffman, 2004). Traditionally, speech motor planning and language formulation have been investigated independently. However, a few authors have examined the inter-relationship between language production and speech-motor control in neurologically healthy individuals (Schulz et al., 2009), and PD (Darley et al., 1969; Pinto et al., 2017). There are a number of possible mechanisms for this relationship. First, if excessive cognitive resources are utilized to linguistically plan a long or syntactically complex utterance (Dromey & Benson, 2003), then there may be insufficient cognitive resources for fine-grained articulatory motor planning (Kegl et al., 1999; Pieruccini-Faria et al., 2014). Second, individuals with speech motor deficits may strategically produce shorter and syntactically simple utterances to devote more cognitive resources for speech-motor control. Speakers may then abandon utterances more frequently because of inadequate breath support or muscular difficulties (Marquardt, 2016). This would result in a higher proportion of ungrammatical utterances, as well as fewer words and clauses per utterance.

If greater cognitive resources are required for articulatory motor planning, fewer resources are then available for the other cognitive, motor, and language processes required for accurate language production. For instance, authors have reported that when more attentional resources are allocated to increasingly complex motoric activity, language complexity significantly decreases (Ho et al., 2002; Marquardt, 2016). In varying simultaneous gait and speech tasks (*standing vs. walking vs. walking over obstacles)* (Marquardt, 2016), visual tracking and speech tasks (Ho et al., 2002), and sentence repetition tasks with distractor activities, authors have reported a range of language processes with decreased complexity. These include decreased noun clauses, relative clauses, adverbial clauses, speech rate, volume, and intensity. Authors have reported that dual task demand resulted in greater variability in labial articulatory placement and led to more errors in articulatory precision. Some research has suggested that, if a speaker has more severe dysarthria, greater motoric restrictions will adversely impact articulator placement during language production tasks (Altmann & Troche, 2011; Illes et al., 1988). Studies have reported a relationship between increased syntactic complexity and greater variability/demand on the lip, tongue, and jaw articulators during sentence repetition tasks (Berg et al., 2003). For example, increased syntactic complexity could include targets embedded within a longer sentence, which would require greater cognitive resources while concurrently performing a complex linguistic task (Maner et al., 2000). An increase in breath pauses at non-syntactic boundaries have been found as an accommodation for insufficient cognitive resources allotted to articulatory motor planning , unlike healthy controls (Huber et al., 2012).

Studies examining information content in discourse production tasks have reported that persons with PD demonstrate a similar number of words per production, yet their messages are less informative *(fewer content words)* when compared to neurologically healthy controls (Berg et al., 2003; McNamara & Durso, 2003). Studies have reported that articulatory planning is not compromised in persons with PD, irrespective of speech-motor complexity demand. Then, the inter-relationship between language production and speech-motor control would not differ between a syllable production tasks and the reading of an entire passage (Darling & Huber, 2020). For example, Walsh and Smith (2011) used longer, sentence-level utterances to measure for articulatory coordination consistency and accuracy of speech production. Increased syntactic complexity and sentence length were both negatively affected in both the PD participants' and healthy controls' language production.

Past studies have investigated two types of influences on speech production in PD: the role of cognitive load (Darling & Huber, 2020; Ho et al., 2002; Marquardt, 2016), and syntactic complexity (Berg et al., 2003; Chu et al., 2020; Walsh & Smith, 2011). Some studies have found that articulatory imprecision increases with increasing cognitive load and increasing syntactic complexity (Marquardt, 2016), while other studies do not (Darling & Huber, 2020; Huber et al., 2012). If an increase in dysarthric severity is associated with an eventual decrease in syntactic complexity in production tasks, PD speakers are expected to produce narrative language that conveys the most content-driven information, defined by compact and single sentence delivery as found in studies focused on neurologically healthy participants (Maner et al., 2000). Less is known regarding the degree to which speech-motor impairment affects specific language abilities, if they are affected at all, in early stage Parkinson's Disease. We predict that PD speakers will demonstrate a positive correlation between selected measures of morphosyntactic complexity in narrative speech and speech severity scores, suggesting that speakers with better articulation skills will produce utterances characterized by greater morphosyntactic complexity (Chu et al., 2020; Marquardt, 2016; Walsh & Smith, 2011).

Relationship between Intelligibility and Morphosyntax in L2 Speakers

The transference of language phonemic characteristics from a speaker's L1 to L2 has shown significant influence on a native speaker's perception of intelligibility (Bakhtiarvand, 2008). At the segmental level, a second language learner's accent has been characterized by the omission, insertion, or the substitution of phones for ones that do not belong in the target language inventory (Munro, Murray, 2008). Older studies have identified strong relationships between later L2 learners and severity of accent impact on "native-like" intelligibility (Flege et al., 1995). Environmental influence, high speaker motivation, and sense of identity, are important factors to consider in analysis but difficult to control when studying such a relationship in this population (Moyer, 2004).

Recent studies have focused on articulatory differences that reflect identifiable accents and influence L2 intelligibility (Bakhtiarvand, 2008). Some studies have reported that when untrained listeners rate the severity of accent for produced utterances in a blind recording, rater scores are directly correlated to the number of insertions, omissions, and substitutions made in the speech sample (Anderson-Hsieh et al., 1992). Errors made by sequential second language learners are not arbitrary attempts to produce unfamiliar sounds. Instead, errors are reflections of the phonemic inventory, rules regarding combining sounds, the stress, and intonation patterns of their native languages. Therefore, it is important to understand the language attributes of English and Farsi for the purposes of this study.

Bakhtiarvand (2008) reported an analysis of anticipated articulatory difficulties in sequential Iranian learners of English that would impact intelligibility for a native speaker of English. Firstly, many sounds (/θ/, /w/) do not exist in the Farsi phonemic inventory. This would cause omissions, distortions, or substitutions of sounds in English reading based tasks. Second, Farsi subscribed to different syllable types as compared to English and would impact the rules followed for combining sounds into words. For example, Farsi follows a (C)V(C)/(C)V(C)(C) form in its phonological representation and CV(C)(C) in its phonetic representation, and does not allow for multiple vowels to assume the medial position of a word (Cruz-Ferreira, 2007). Unlike English, a Farsi syllable cannot start with a consonant cluster or be initiated with vowels. If a word starts with a vowel, a glottal stop /ʔ/ is inserted at the syllable onset as a substitution. At the suprasegmental level, Farsi and English also differ in patterns of stress and intonation (i.e. Farsi is syllable-timed vs. English is stress-timed, pitch accent vs. stress accent). Farsi sentences use the order: Subject (S), Object (O), Verb (V). When using an adverb, for example, the order demonstrated is: Subject (S), Adverb (AD), Object (O), Verb (V), differing from English (Bakhtiarvand, 2008).

Historically, articulatory precision of whole words has also been strongly correlated with the effectiveness of a second language learner's communication attempts (Acton, 1989). More recent studies posit that it is equally true that if a speaker's first language differs significantly enough from their second language, the perfection of separate phoneme production does not guarantee native-like intelligibility or smooth communication exchanges with native speakers (Bakhtiarvand, 2008). In regards to language abilities, studies have reported lower syntactic complexity in intermediate proficiency L2 speakers (Bartning & Schlyter, 2004) as compared to native speakers in a variety of narrative tasks (Wolfe-Quintero et al., 1998). Hence, intelligibility of narrative discourse is decreased. Less is known about the specific sociolinguistic and culture-specific discourse knowledge, but are not to be neglected when discussing the influence of accent on intelligibility in sequential L2 speakers of English (Cruz-Ferreira, 2007; Flege et al., 1995). We predict that L2 speakers will demonstrate an association between intelligibility, morphosyntactic ability, and mean “native” English quality on ratings by native English speakers, suggesting that speakers with more perceivable “non-native” accents are less intelligible as a reflection of the phonemic inventory, rules regarding combining sounds, the stress, and intonation patterns of their native languages (Bakhtiarvand, 2008).

Summary

To summarize, there are three potential mechanisms by which differences in the quality of narrative language production in PD and L2 speakers (compared to neurotypical controls) can be impacted:

1) Compromised procedural memory in PD and under-utilized procedural learning in L2 speakers results in weakness in implementing morphosyntactic features of language (Ullman, 2001). Studies provide some support for the assumption that both PD and L2 speakers produce more ungrammatical utterances (Hoshino et al., 2010; Murray, 2000) and fewer syntactically complex utterances (Dick et al., 2018; Wolfe-Quintero et al., 1998).

2) Unique action verb deficits in PD speakers (Bocanegra et al., 2017) and reliance on light verbs in L2 speakers (Kim & Rah, 2016). There appears to be more limited action verb naming in PD speakers, perhaps based on limited embodied cognition and isolated dysfunction to the prefrontal network (Barsalou, 1999; Bocanegra et al., 2017). There also appears to be larger proportionate production of light verbs in L2 narrative production, likely due to their less specific semantic features and greater utility in varied contexts (Li et al., 2019).

3) A third potential mechanism explores a possible inter-relationship between language production and speech-motor control in PD (Marquardt, 2016). There may be an inverse relationship between dysarthric severity and syntactic complexity in spoken language (Chu et al., 2020; Walsh & Smith, 2011). Research exists both for (Illes et al., 1988) and against (Darling & Huber, 2020; McDonald & Roussel, 2010; Terzi et al., 2005) the identified potential mechanisms. No studies (to our knowledge) have directly compared the two groups. Therefore, a study directly comparing PD and L2 speakers can inform the impact of limited morphosyntactic production, verb production, the inter-relationship between language production and speech-

motor control in PD, and inter-relationship between accent, intelligibility, and morphosyntax in L2 during narrative language production (Bakhtiarvand, 2008; Flege et al., 1995). Findings may enable assessment and benchmarking across PD disease severities and L2 proficiencies.

Research Questions and Hypotheses

This study examined narrative language samples produced by speakers with early stage Parkinson's Disease and L2 English speakers with intermediate proficiency. The following research questions and hypotheses were posed:

1. Do morphosyntactic patterns in narrative language samples of speakers with early stage Parkinson's Disease and L2 speakers of English with intermediate proficiency support the DP model? Based on Ullman's Declarative-Procedural Model, it is hypothesized that both groups will score lower on measures tapping procedural aspects of language (grammaticality, morphosyntactic complexity, and regular past-tense verb productions) compared to neurologically healthy native speakers of English (Hoshino et al., 2010; Illes et al., 1988; McDonald & Roussel, 2010; Troche & Altmann, 2012).

2. What are the patterns of verb use in early stage Parkinson's Disease speakers and L2 speakers of English with intermediate proficiency, when compared to neurologically healthy native speakers of English? Based on theories of embodied cognition (Barsalou, 1999), it is hypothesized that PD speakers will produce proportionately fewer action verbs in narrative language tasks compared to neurologically healthy controls (Bocanegra et al., 2017). For L2 speakers, it is hypothesized that they will produce proportionately more light verbs compared to neurologically healthy native speakers of English (Kim & Rah, 2016).

3. This question asks how syntactic ability relates to a different speech measure in each group. Is there a relationship between the degree of speech-motor impairment and syntactic abilities in early stage Parkinson's Disease speakers? What is the relationship between intelligibility and morphosyntax in L2 speakers? It is hypothesized that PD speakers will show a positive correlation between morphosyntactic complexity of spoken language samples and motor speech abilities, such that persons with better morphosyntactic complexity will be those with better speech abilities (Berg et al., 2003; Walsh & Smith, 2011). It is also hypothesized that L2 speakers will show a strong relationship between intelligibility and morphosyntax in controlled, scripted language samples (Bakhtiarvand, 2008; Munro, Murray, 2008).

Methods

Overall design

This study had two parts: de-identified retrospective data analysis from Dr. Mefferd's research focused on early stage PD and neurologically healthy native speakers of English (Vanderbilt University Medical Center), and prospective data collection focused on L2 speakers of English with intermediate proficiency. This study analyzed three types of language samples, 1) description of three pictures: Cookie Theft Picture (Goodglass & Kaplan, 1972) (See Appendix A), a Family Picnic picture (Kertesz, 1979) (See Appendix B), and an Outdoor Kite picture (Kertesz, 1979) (See Appendix C); 2) reading of the first three sentences of the Rainbow Passage (Fairbanks, 1960) (See Appendix D); and 3) a Morning Routine extemporaneous prompt. There were three groups of participants (independent variable): neurologically healthy native speakers of English (NH), persons diagnosed with early stage non-dementia PD (henceforth referred as PD), and L2 speakers of English with intermediate proficiency in which

Farsi is their first language (L2). The dependent variables were productions of targeted aspects of language production (grammaticality, complexity, verb use, etc.).

Participants

This study included three groups of participants (Table 1). The first group of participants included 24 neurologically healthy native speakers of English between the ages of 53 and 85 (Mean age = 67.87, SD = 9.49; 13 female, 11 male). The second group of participants included twenty-three persons diagnosed with Parkinson's disease between the ages of 57 and 84 (Mean age = 67.20, SD = 6.67; 10 female, 13 male). The third group of participants included thirteen Farsi-English speakers (L2), between the ages of 50 and 85 (Mean age = 61.69, SD = 4.99; 9 female, 4 male). L2 speakers were recruited from a local community of native Farsi speakers.

Two PD participants (PDM23, PDM24) were excluded for not meeting the minimum sample length criteria for language sample analysis through CLAN programs. PD participants were recruited and tested by Dr. Mefferd's research program at Vanderbilt University Medical Center. To screen for cognitive deficits, inclusionary criteria for all participants was a score of at least 25 (out of 30) on the Mini-Mental State Examination (MMSE) (Burdick et al., 2014; Folstein et al., 1975). Retrospective data from neurologically healthy adults and PD participants included the sex, age, years since diagnosis, MMSE scores of each participant and Speech Intelligibility Test (SIT) scores (Yorkston & Beukelman, 1981). The SIT indicates the severity of speech impairment for PD participants, with higher scores indicating better articulatory abilities.

Participants among the three groups did not differ in age (Mean= 65.64, df(2,54) = 2.87, p>.05). All participants had a minimum of high school education. Detailed education data was not available for the retrospective data (PD and monolingual English) and therefore, could not be matched across participant groups.

Table 1

Individual Data for PD Participants and Group Means for Neurologically Healthy Controls and L2 Participants.

Code	Sex	Age	MMSE Score	Years Since Diagnosis	SIT Score
PDM11	Male	70	30	-	99.1
PDM13	Male	69	26	5	94.8
PDM14	Male	84	27	4	93.2
PDM15	Male	75	29	4	95.9
PDM16	Male	63	29	6	99.5
PDM17	Male	72	25	12	92.7
PDM19	Male	66	29	7	97.3
PDM21	Male	73	27	5	93.64
PDM22	Male	58	28	10	97.7
PDM25	Male	66	29	9	99.5
PDM26	Male	58	29	4	-
PDF10	Female	73	26	1	95.2
PDF11	Female	57	30	14	97.3
PDF12	Female	61	30	0.5	99.1
PDF15	Female	74	29	1	99.7
PDF16	Female	61	30	4	100
PDF17	Female	60	26	4	99.4
PDF18	Female	66	25	7	99.1
PDF19	Female	70	30	2	99.4
PDF20	Female	66	28	5	97.8
PDF21	Female	68	30	11	-
PD Mean (SD)	67.20 (6.67)				
NH Mean (SD)	67.74 (9.68)				
L2 Mean (SD)	61.69 (4.99)		(for MoCA) 28.77 (1.64)		

PD: Parkinson's Disease group; NH: Neurologically Healthy Control group; L2: L2 speakers of English group; SIT: electronic version of the Assessment of Intelligibility of Dysarthric Speech (AIDS, Max score = 100); MMSE: Mini-Mental State Examination; MoCA: Montreal Cognitive Assessment

For L2 participants, a general health history form was administered to screen for history of speech-language diagnoses that may influence comparison in language production profiles against other study variables. Inclusionary criteria were: intermediate proficiency in English (Swender et al., 2012) and a Montreal Cognitive Assessment (MoCA) score of greater than 26 (maximum = 30), administered in Farsi (Nasreddine et al., 2005). Exclusionary criteria were: history of speech-language diagnoses and a score of 26 or lower on the MoCA. The MoCA was administered in the L2 participant's dominant language (Farsi) by the primary investigator via Zoom screen sharing.

The use of the MoCA, as compared to matching MMSE methods appropriately used for retrospective data, was justified through the availability of the MoCA in the speaker's dominant language. This further controlled against cultural and linguistic biases against the study's targeted populations (O'Driscoll & Shaikh, 2017). Performance on the MMSE, based on normed criteria, has been documented to be impacted by demographic variables, including age, education, ethnicity, and therefore may have not accurately demonstrate cognitive status of the L2 speaker group (Milman et al., 2018). Additional inclusionary criteria were the ability to access phone, computer with Internet connection and Zoom downloaded, and a webcam.

Language samples

PD and Neurologically Healthy Native Speakers

Language samples for neurologically healthy native speakers of English and PD participants were obtained from Dr. Mefferd's project. Participants were asked to describe the Cookie Theft Picture (Appendix A), Family Picnic picture (Appendix B), Kite picture (Appendix C), and their morning routine while being audio-recorded.

Procedures for L2 speakers

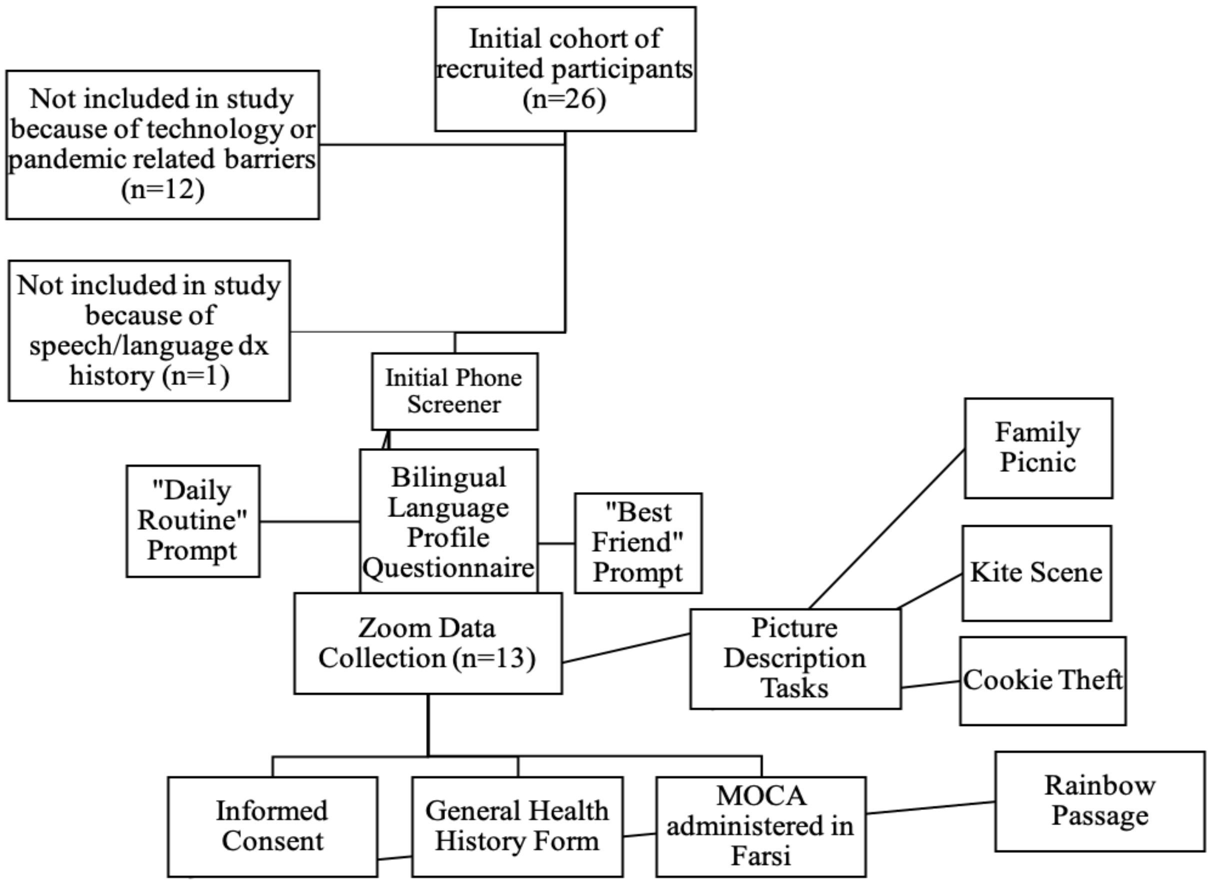
An initial screener (phone call) in English included two culturally relevant and sensitive narrative samples ("Tell me about your typical daily routine"; "Describe the physical appearance of your best friend") to ensure that participants met intermediate English proficiency, as defined by American Council on the Teaching of Foreign Languages (ACTFL) Guidelines (Swender et al., 2012). ACTFL criteria for intermediate language users include the ability to speak about familiar topics related to their daily life, to recombine learned material to express personal meaning, to ask simple questions, to handle straightforward survival situations, and to produce sentence-level language, typically in the present tense (Gertken et al., 2014).

Participants who qualified as intermediate speakers of English (L2) on the phone were asked to complete a self-report questionnaire aimed to assess language history, use, proficiency, and attitudes in both of the participant's languages (Bilingual Language Profile questionnaire (BLP) (Birdsong et al., 2012). One participant completed the initial phone screener and was excluded from the study due to a prior diagnosis of Parkinson's Disease. The BLP questionnaire measured participants' relative language dominance and ensured validity of intermediate status in their reported L2 (Gertken et al., 2014). A BLP dominance score (L2 English dominance – L1 Farsi dominance) of < -50 was taken as evidence of Farsi (L1) dominance.

Procedures for L2 speakers (Figure 1) were designed to match data from retrospective data collected for PD and neurologically healthy speakers by Dr. Mefferd. L2 speakers who met eligibility were scheduled for further testing. L2 participants were not paid for their participation. Testing was completed through an online conference platform via Zoom in a one-hour session. Informed consent and general health history information were obtained by showing the respective forms (pdf) via screen sharing. Informed consent was documented through the electronic signature of each participant and stored in a secure BOX location via University of Maryland. Then, the MoCA was administered via Zoom screen sharing (Nasreddine et al., 2005). Finally, experimental tasks were administered beginning with the narrative description of the three picture description tasks (Goodglass & Kaplan, 1972; Kertesz, 1979) and followed by the description of their morning routine.

Figure 1

Details of Farsi-English (L2) Speakers Procedures.



Language Sample Analysis

The language samples were audio recorded. Language samples were transcribed using the CHAT transcription and coding format used by CLAN (Computerized Language Analysis) (MacWhinney, 2000). Transcription of language samples were completed by the primary investigator.

Analysis of transcribed language samples involved two steps. First, the samples were manually coded for specific linguistic elements whose occurrence is not automatically generated by CLAN utilities. Examples of these are action verbs and utterance grammaticality. Second, language measures were extracted in CLAN (MacWhinney, 2000) using three utilities: EVAL, KIDEVAL and FREQ. EVAL and KIDEVAL provide preset measures, such as mean length of utterance, and delineates percentages for parts of speech. FREQ was used to obtain frequency counts of any specified aspect of interest. This could be a list of specific words (e.g. light verbs) or specifically coded elements, such as action verbs or complex utterances. The specific measures that were extracted are listed in Table 2.

Table 2

Language Sample Analysis Broken Down by Dependent Variable.

DSS: Developmental Sentence Scoring; FREQ: Frequency search ; SIT: Electronic version of the Assessment of Intelligibility of Dysarthric Speech (AIDS); [+comp]: Complex Utterance; [+simp]: Simple Utterance; [+fra]: Fragment/Incomplete Utterance

Measure	**Operational Definition**	**Calculation**
Research Question 1		
Grammatical Accuracy	- Morphosyntactically well-formed utterance, regardless of semantic errors - Errors in word order, grammatical morphology, speech, or lacked required function words (articles, prepositions, conjunctions were all coded as ungrammatical	- Manually coded [*] - FREQ search: (#[*] per speaker/total # of utterances)

Morphosyntactic Complexity - DSS	- Defined by DSS based on procedures for sentence production outcomes described by use of a noun and a verb in the subject-predicate form regardless of grammatical accuracy	- DSS: 15 utterance maximum
Morphosyntactic Complexity – Proportion of Complex Utterances	- Complex sentence type: sentences containing embedded clauses, modifying clauses, or passive sentence construction	- FREQ search: (# of [+comp]/total # of utterances)
Regular Past Tense Verb Production	- Proportion of regular past tense main verbs (versus irregular past)	- Omissions manually coded: [*m: 0ed] → FREQ search: (# [*m: 0ed] per speaker/ total # of verbs

Regular Past Tense Verb Errors	- Omission of regular past tense verbs (versus irregular past)	- Ratio of regular past tense [PAST] : Irregular past tense [&PAST]
	Research Question 2	
Action Verbs	- Defined by actions that humans can perform	- Manually coded : [AV] - FREQ search: (# of [AV] per sample/total # of verbs)
Light Verbs	- Defined by Thorne and Faroqi-Shah (2016) consisting of nine verbs: (come, do, get, give, go, have, make, put, and take)	- Manually coded: [LV] → [LV] search file: (FREQ+search@LightVerb.cut) - FREQ search: (# of [LV] per sample / total # of verbs

Research Question 3	
Morphosyntactic Complexity	- DSS from RQ 1 - Mean Length of Utterance (MLU)
Speech Severity Scores	- Speech severity scores from the SIT (Haley et al., 2011)
Visual Analog Scale Scores	- L2 speakers' audio samples of the Rainbow Passage were blindly scored based on three "speech intelligibility" visual analog scales by blind raters
Grammatical Accuracy	- Grammatical accuracy from RQ 1

The dependent measures for the first research question were: 1) grammatical accuracy, 2) morphosyntactic complexity, and 3) regular past tense verb productions. 1) Grammatical accuracy was defined as a morphosyntactically well-formed utterance, regardless of semantic errors. Ungrammatical utterances were manually coded by the primary investigator using the code [*] as defined in the CLAN manual. Utterances with errors in word order, grammatical morphology, or speech in which content words (nouns, verbs, adjectives) were relatively preserved but lacked required function words (articles, prepositions, conjunctions) were all coded as ungrammatical with [*]. A FREQ search signaled the amount of [*] codes per speaker. The number of [*] codes per speaker was divided by the total number of utterances, generated by EVAL, in order to compute proportion of ungrammatical utterances (MacWhinney, 2021).

Morphosyntactic complexity was documented with two measures. 2a) The Developmental Sentence Scoring (DSS) (Macwhinney, 2021) was obtained using the KIDEVAL program in CLAN. DSS is traditionally used as a child measure based on a developmental scale of syntactic acquisition. This study justifies the use of DSS with adult populations based on significant findings of grammatical impairment in aphasia described by Thorne & Faroqi-Shah (2016). DSS only scores eligible utterances, defined as use of a noun and a verb in the subject-predicate form regardless of grammatical accuracy. For the DSS measure, only the first 15 utterances were taken per language sample and was manually set by the primary investigator (DSS +c15 @+t*PAR +le) as described by the CLAN manual. A 15-utterance minimum accommodated the realistic length of responses anticipated for the three picture description narratives and Daily Routine prompt. This also accommodated the presumed criteria set by DSS to ensure identical computations for all participants.

2b) Syntactic complexity was defined by Hsu and Thompson's (2018) to determine inclusion of complex utterances. A complex utterance was defined by containing either embedded clauses, modifying clauses, or a passive sentence construction and was manually coded using the code [+comp]. A FREQ search gave the number of [+comp] codes per speaker. This was divided by the total number of utterances, generated by EVAL, in order to produce a proportional measure of syntactic complexity.

Regular past tense verb production was examined using two measures. 3a) The proportion of regular produced past tense verbs was obtained through KidEVAL by calculating the ratio of regular past tense (denoted by -PAST) to irregular past tense (denoted by &PAST). 3b) Regular past tense verb omissions were manually coded by the primary investigator using the code [*m: 0ed] through the C-NNLA profiling command. This was defined by the absence of the "-ed" affix of a regular past tense verb. For example, "Yesterday, the mother *wash* the dishes." A FREQ search signaled the amount of [*m:0ed] per speaker. The number of [*m: 0ed] per speaker was divided by the total number of verbs, generated by EVAL, in order to produce a measure of omitted regular past tense verbs (MacWhinney, 2021).

The C-NNLA output was calculated from the %mor and %gra lines through CLAN, and generated several outcome measures related to procedural aspects of language (MacWhinney, 2021). This study focused on the relative distribution of past tense to test Ullman's (2001) DP model. Therefore, the proportion of regular past tense verbs over all verbs was not calculated because verbs may be used in a variety of contexts. For example, only main verbs were considered, excluding auxiliaries such as *was-were* and participles, to align with Ullman's DP hypothesis regarding regular past tense production.

To answer the second research question, counts of action verbs and light verbs were the dependent variables. Action verbs ([AV]) were manually coded. Then, FREQ was used to extract the number of [AV] codes within a language sample. This was divided by the total number of verbs (from EVAL) to get the proportion of action verbs. The list of light verbs ([LV]) was obtained from Thorne and Faroqi-Shah (2016) and consisted of nine verbs (*come*, *do, get, give, go, have, make, put*, and *take*). A [LV] search file was created, through CLAN, including all inflectional variations of the nine determined light verbs. A FREQ search was used (FREQ+search@LightVerb.cut) to extract the number of light verbs in each sample. This was divided by the total number of verbs (from EVAL) to get the proportion of light verbs (Macwhinney, 2021; Thorne & Faroqi-Shah, 2016).

To answer the first part of the third research question, the outcome measures were morphosyntactic complexity (DSS from research question 1) and mean length of utterance. Mean length of utterance (MLU) was also used because utterance length may capture the tendency to shorten utterances due to oromotor difficulties. Each of these measures were correlated with PD participants' respective speech severity scores from the SIT (Haley et al., 2011). The SIT is an electronic version of the Assessment of Intelligibility of Dysarthric Speech (AIDS) (Yorkston & Beukelman, 1984), and audio records participants repeating sentence and word speech samples via randomly generated utterances ranging from five to 15 words in length. Then, the clinician transcribes the perceived words into a textbox through the SIT software, which generates a score report including the proportion of intelligible words, percent intelligibility, total composite duration, speaking rate, intelligibility rate, and communication efficiency ratio. For this study, SIT scores were reported with a maximum score of 100. Higher SIT scores indicated a higher proportion of intelligible words, higher percent intelligibility, and overall better articulatory abilities.

To answer the second part of the third research question, audio samples of the Rainbow Passage were collected from the L2 group for perceptual intelligibility testing. The audio samples were blindly scored based on three "speech intelligibility" visual analog scales. The scales were marked 1-10 and targeted overall intelligibility, native English quality, and severity of accent. Twelve blind, non-trained speakers of standard American English scored each L2 speaker on these three variables. These measures of speech intelligibility and severity of accent were correlated with grammatical accuracy on the Rainbow passage through DSS and MLU.

The third research question aimed to draw a parallel between speech and language for PD and L2 groups. For PD speakers, the direct measure for speech intelligibility was obtained through participants' speech severity scores from the SIT (Haley et al., 2011). For L2 speakers, a direct measure was not available. Therefore, this study relied on perceptual intelligibility ratings and grammatical accuracy measures (DSS and MLU) for L2 analysis. The Rainbow passage was used for the L2 group to match retrospective data collected by visual analog scales for PD and neurologically healthy control groups. Intelligibility and native English quality were measured as additional speech production measures in case they better captured any potential speech production challenges of L2 speakers. For these reasons, only the Rainbow Passage audio samples were used for L2 analysis and the entire language sample was used for PD participants.

Reliability of Transcription

To ensure reliability of transcription, 30% of randomly selected language samples were independently transcribed and coded by a second, University of Maryland Hearing and Speech graduate student (S2) who was blinded to group membership. The primary investigator was not blinded throughout the study. To compare the reliability of transcriptions, intra-class correlations (ICC) were calculated between the primary investigator and the S2. The ICC value obtained was 94%. The variables of focus were utterance segmentation and word by word agreement throughout all participant language samples. The S2 was recruited through the department and was trained in transcription protocol using the CLAN systems by the primary investigator for this study.

Statistical Analysis and Interpretation

Statistical analysis was conducted utilizing SPSS statistical software (SPSS version 24, IBM Corporation). A two-tailed probability value of .05 was used as the significance threshold. Given the modest group sizes, normality of distribution of individual measures across the three groups was tested using Levene's test for equality of variances. If the variances were not different across groups ($p>.05$), parametric tests were used (t-test or ANOVA). If the variances were unequal (which is the more likely outcome), then non-parametric tests were used (Mann-Whitney U test or Kruskal-Wallis test). For the first and second research questions, the three groups were compared on each dependent measure using the analysis of variance (ANOVA) or Kruskal-Wallis non-parametric test. Any significant results were followed by pair-wise comparisons using the t-tests or the non-parametric Mann-Whitney U test. For the third research question, Pearson (or non-parametric Spearman) correlations were used to examine the association between speech severity scores and each language measure.

For research question 1, a significant difference between PD, L2, and neurologically healthy groups for syntactic measures (grammatical accuracy, syntactic complexity and proportion of regular: irregular past verbs), with lower mean values for PD and/or L2 speakers, means that procedural aspects of language are compromised in these groups. For research question 2, a significant difference between PD and neurologically healthy groups for action verb production, with lower mean values for PD speakers, means that a unique action verb deficit exists in PD groups. A significant difference between L2 and neurologically healthy groups for light verb production, with higher mean values for L2 speakers, means that L2 speakers rely more on light verbs in narrative language. For research question 3, a significant positive correlation between speech severity/intelligibility and morphosyntactic measures suggests that speech and language limitations are associated with each other.

Results

Procedural measures of languages in PD and L2 Speakers

The first research question asked whether production patterns of procedural aspects of language (grammaticality, morphosyntactic complexity, and regular past-tense verb production) differed across the three groups. Table 3 provides proportions of ungrammatical utterances, as well as values of procedural measures for the three groups. A significant group effect was shown for ungrammatical utterances. Pairwise comparisons with Bonferroni correction showed that L2 speakers (M=.30, SD=.22) produced a greater proportion of grammatical errors than both the neurologically healthy (M=.09, SD=.07; Mean Difference = .20, SE =.04, $p<.001$) and PD

(M=.14, SD= .10; Mean Difference= .17, SE = .04, p< .002) groups. The neurologically healthy and PD groups did not differ (Mean difference = -.04, SE = .04, p=.991). Pairwise comparisons with Bonferroni correction showed that measures of complex utterances, regular past tense verb production, and regular past tense verb omissions produced p value of 1.00 across the three participant groups.

Table 3

Values of Procedural Measures of Language for Each Participant Group (Research Question 1) along with Results of Statistical Analyses.

Measure	**NH**	**PD**	**L2**	**Between-Groups ANOVA**	**Pairwise comparisons**
		Mean(SD)			
Ungrammatical Utterances	0.09 (0.01)	.14 (.02)	.30 (.06)	F(2, 54)=10.71, p<.001	L2 vs PD** L2 vs NH***
DSS	9.70 (.54)	11.14 (.86)	12.39 (.67)	F(2, 54)=3.18, p=.05	NH vs PD, p=.41 NH vs L2, p=.05 L2 vs PD, p=.79

Complex Utterances	.49 (.04)	.49 (.04)	.47 (.04)	F(2, 54)=.07, p=.93	NH vs PD, p=1.00 NH vs L2, p=1.00 L2 vs PD, p=1.00
Regular Past Tense Verb Production	.65 (.23)	.86 (.22)	.62 (.29)	F(2, 54)=.29, p=.75	NH vs PD, p=1.00 NH vs L2, p=1.00 L2 vs PD, p=1.00
Regular Past Tense Verb Omissions	1.91 (.47)	1.71 (.37)	1.62 (.54)	F(2, 54)=.11, p=.89	NH vs PD, p=1.00 NH vs L2, p=1.00 L2 vs PD, p=1.00

NH: Neurologically healthy controls; PD: Parkinson's Disease group; L2: L2 speakers of English group; $^{**}p<.01$, $^{***}p<.001$

Verb Use in PD and L2 Speakers

The second research question asked whether production of verbs differed across the three groups. The scores and results of statistics are given in Table 4. Between-groups ANOVA showed that neither action verbs ($F(2,54)=2.26$, $p=.11$) nor light verbs ($F(2, 54)=2.56$, $p=.12$) showed a significant group effect.

Table 4

Verb Use for Each Participant Group (Research Question 2) along with Results of Statistical Analyses.

Measure	NH	PD	L2	Between-Groups ANOVA
	Mean (SD)			
Action Verbs	.42 (.03)	.41 (.02)	.34 (.03)	F(2, 54)=2.26, p=.11
Light Verbs	.18 (0.02)	.24 (.03)	.23 (.03)	F(2, 54)=2.56, p=.12

Speech-Motor Impairment's Association with Grammatical Abilities in PD

The third research question asked whether there is a relationship between speech-motor impairment and language abilities in PD speakers. The scores and results of correlations between speech severity in PD, mean length of utterance, and DSS are given in Table 5. Severity of speech impairment in PD (measured by SIT scores) showed no significant correlation with syntactic sophistication (measured as DSS, $p=.16$) or with utterance length (MLU, $p=.31$).

Table 5

Spearman Correlation Coefficients (r_s) for Relationship between Dependent Measures (Research Question 3).

	MLU	DSS
Speech Severity	.27	.34
MLU		-.03

Association between Intelligibility and Morphosyntax in L2 Speakers

The third research question also asked whether there is a relationship between morphosyntax (measured through grammaticality measures DSS and MLU), intelligibility, native English quality, naturalness of accent, and speech severity scores (measured through perceptual intelligibility tasks) in L2 speakers. The relationships with MLU are shown in Figure 2. MLU showed a significant Spearman correlation with native English quality (p=.02) and mean intelligibility (p=.01). As seen in Figure 3, a significant Spearman correlation was shown with MLU vs. naturalness of accent (p=.05), mean intelligibility vs. naturalness of accent (p=.00), and native English quality vs. naturalness of accent (p=.000). The relationships with DSS and intelligibility measures are shown in Figure 4. DSS did not show any significant correlations across all measures, including MLU (p=.91), mean intelligibility (p=.22), native English quality (p=.35), and naturalness of accent (p=.31).

Figure 2

Correlations between Mean Length of Utterance (MLU) and Mean Intelligibility (as measured by Speech Severity Scores), Native English Quality, and Naturalness of Accent in L2 speakers (non-parametric Spearman r).

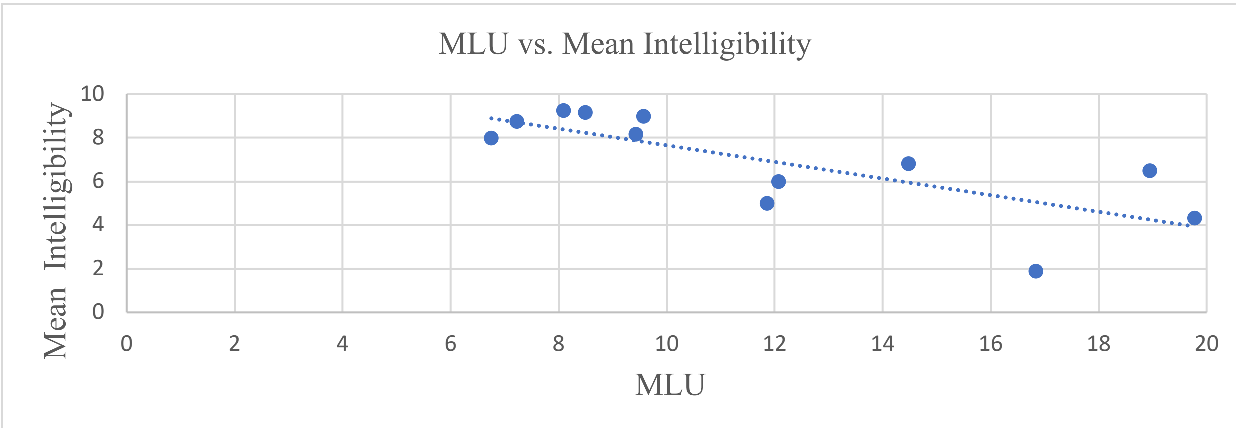


Figure 2a. MLU vs. Mean Intelligibility

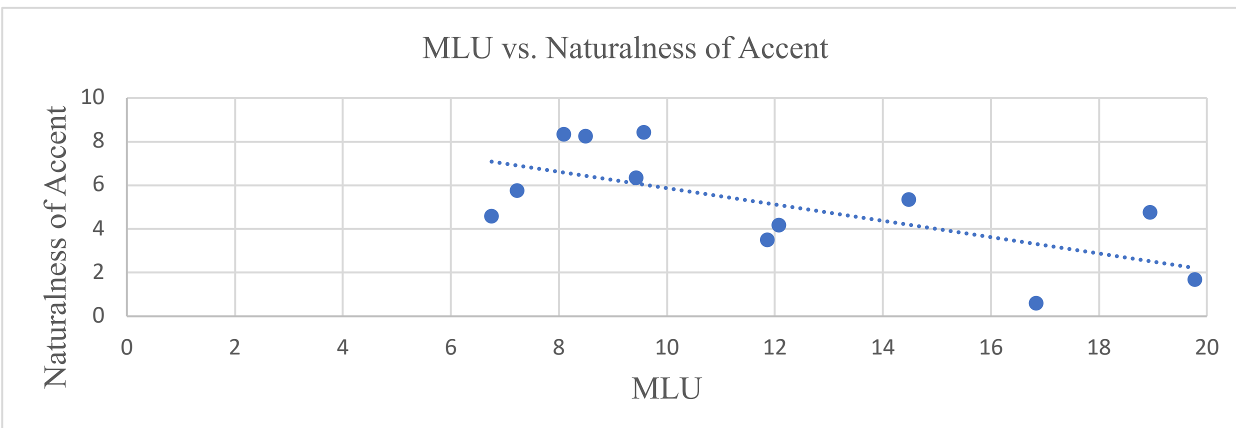


Figure 2b. MLU vs. Naturalness of Accent

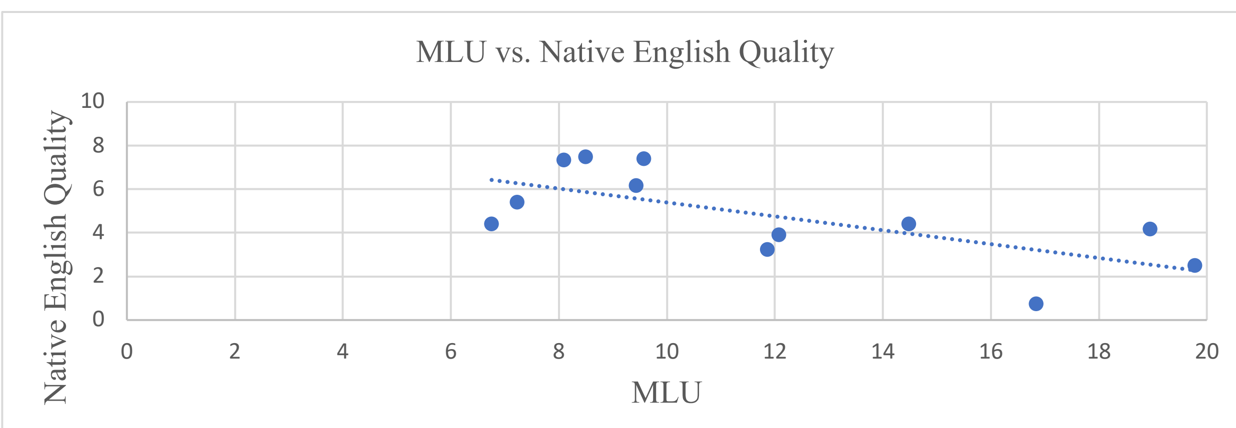


Figure 2c. MLU vs. Native English Quality

Figure 3

Correlations between Naturalness of Accent vs. Mean Intelligibility (as measured by Speech Severity Scores) and Native English Quality in L2 speakers (non-parametric Spearman r).

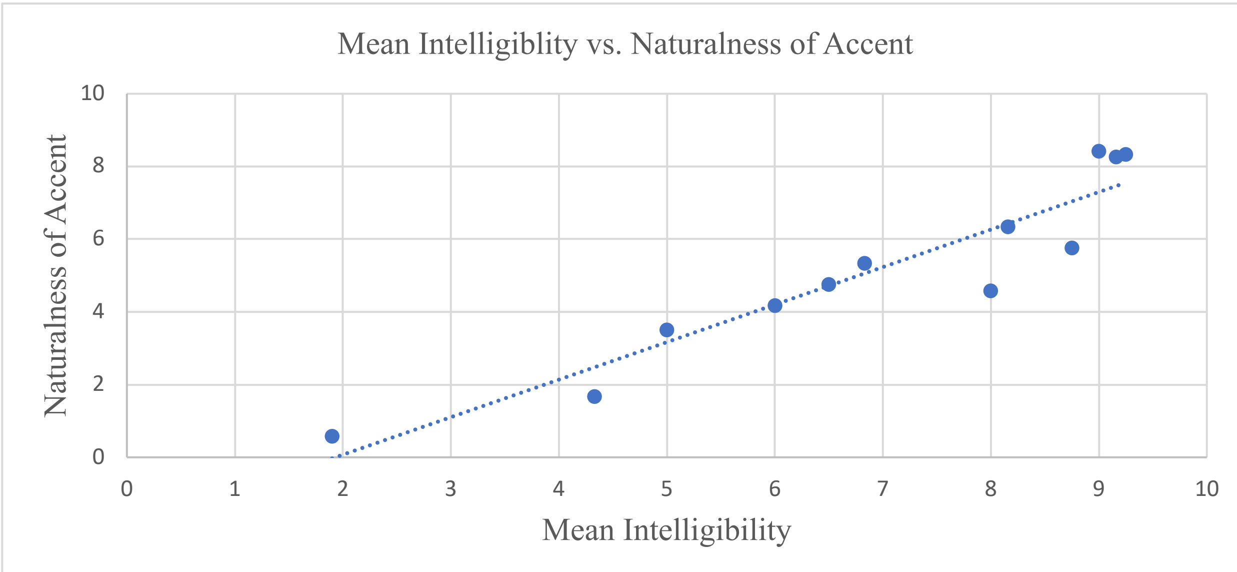


Figure 3a. Mean Intelligibility vs. Naturalness of Accent

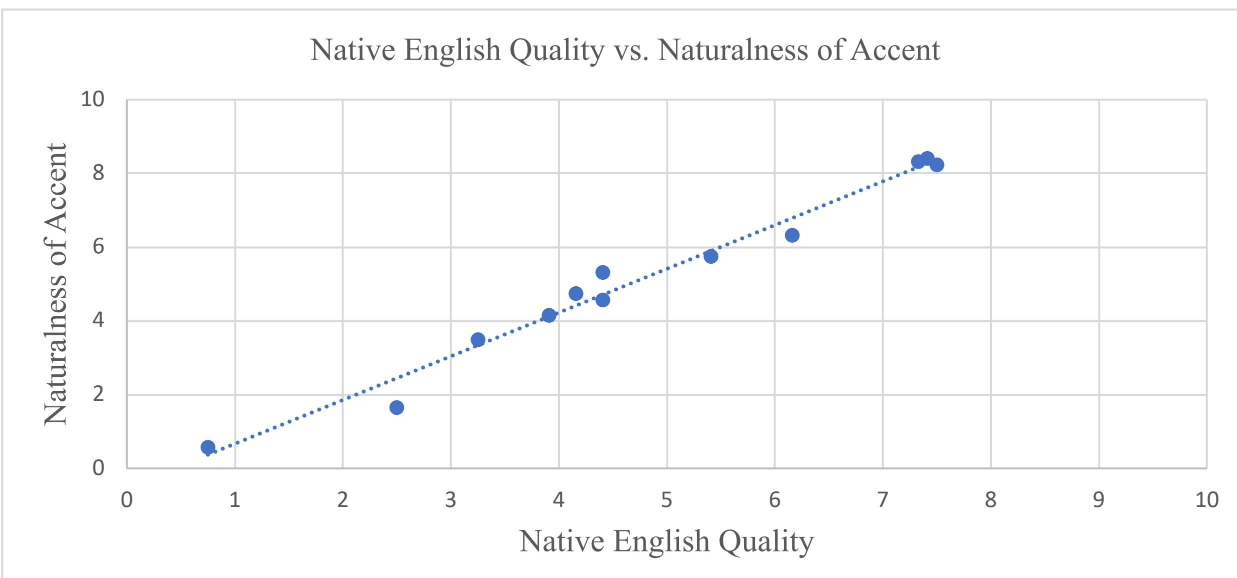


Figure 3b. Native English Quality vs. Naturalness of Accent

Figure 4

Correlations between DSS and Mean Intelligibility (as measured by Speech Severity Scores), Native English Quality, and Naturalness of Accent in L2 speakers (non-parametric Spearman r).

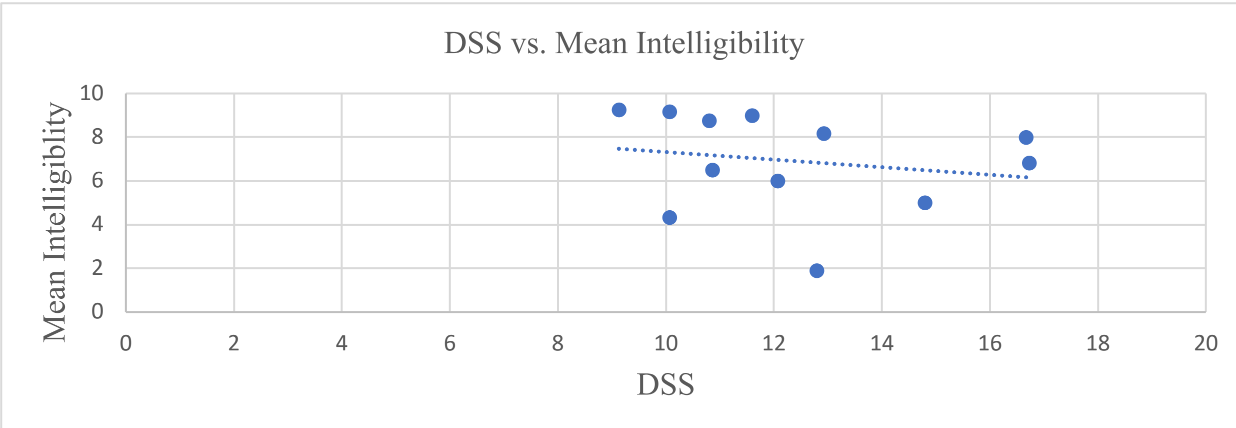


Figure 4a. DSS vs. Mean Intelligibility

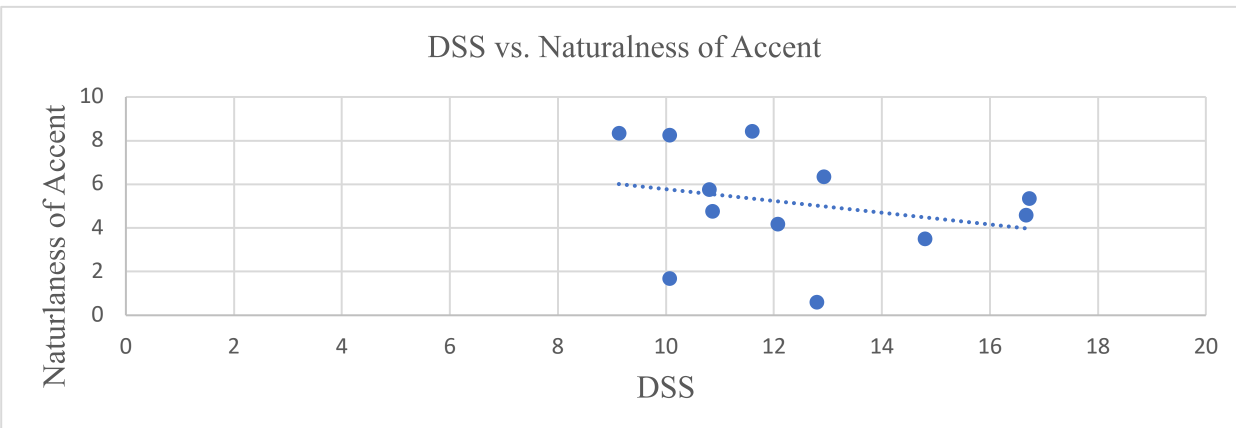


Figure 4b. DSS vs. Naturalness of Accent

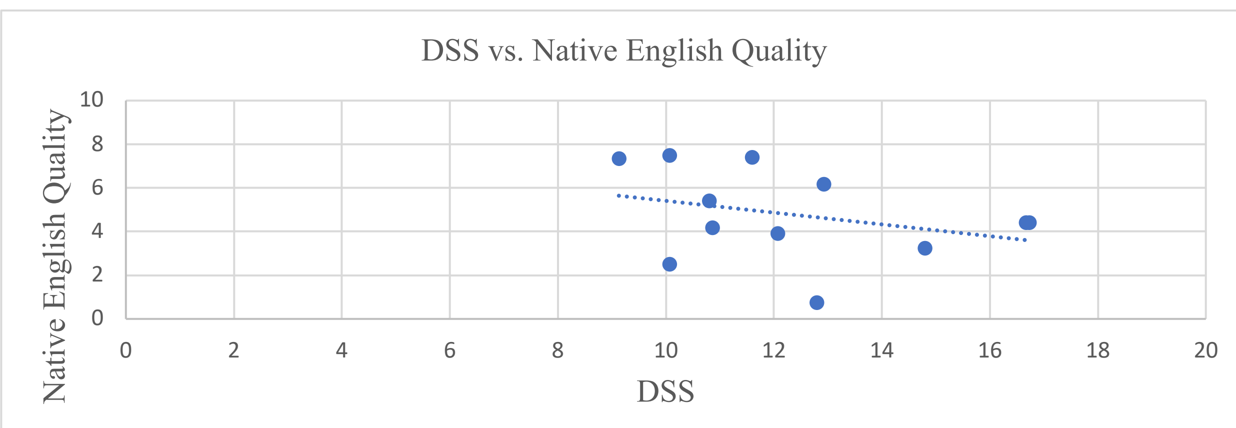


Figure 4c. DSS vs. Native English Quality

Discussion

This study examined narrative language samples produced by speakers with early stage Parkinson's Disease and L2 Farsi-English speakers with intermediate proficiency on three aspects: 1) procedural aspects of language (grammatical accuracy, syntactic complexity, regular past tense verb production), 2) verb production patterns, 3a) speech severity's association on intelligibility, and 3b) the association between intelligibility and grammaticality. This group of non-demented mild (as defined by SIT scores and severity of dysarthria) PD speakers did not show a decrease in procedural measures of language or action verb production relative to neurologically healthy age-matched speakers. They also did not show a trade-off between speech impairment and syntactic complexity.

This group of L2 speakers, however, did demonstrate some indications of language formulation difficulties. The mid-high proficiency Farsi-English speakers of this study produced lower scores than neurologically healthy, native English speakers on two out of three procedural language measures: grammatical accuracy and morphosyntactic complexity. This was not evidenced in proportion of regular past tense verb production. L2 speakers did not differ from native English speakers on light verb production. In the following sections, the implications of these findings are discussed in light of prior research findings and declarative procedural, action cognition, and critical age theories.

In interpreting the data, however, uncontrolled differences among the groups must be considered. The findings are interpreted with caution given the limited sample sizes of participant groups. This study including mild stage PD participants, while most of the prior literature that we are comparing with included participants with severe PD, and who engaged in multiple and more cognitively challenging language tasks. Studies that found significant grammatical deficits in PD recruited more severely impaired PD participants. This study analyzed only 15 utterances through the DSS measure due to the lower number of utterances produced by L2 groups as compared to neurologically healthy and PD participants. This helped equate the sample size across the three groups. The length of the language sample could be another source of difference between our study and other past studies, and could have contributed to non-significant findings.

Testing Ullman's Declarative-Procedural Model in PD and L2 speakers

This study tested the DP model in two different participant groups (PD, L2) and three language measures (grammatical accuracy, morphosyntactic complexity, and regular past tense verb production). Each group's performance will be discussed separately.

PD Speakers

Procedural learning is a part of a larger memory system. Therefore, procedural memory impairments in PD may include any type of action where implicit memory aids the performance of particular types of tasks without conscious awareness of previous experiences. This may include riding a bike, tying your shoes, or cooking a homemade recipe. Ullman's (2001) DP Model exclusively makes claims about procedural memory within the context of language abilities. The conclusions from this study indicate lack of evidence for procedural memory based only on aspects of language, as proposed by Ullman (2001).

Ullman's (2001) DP Model predicted that PD speakers would perform worse on measures of syntactic complexity when compared to neurologically healthy native speakers of English. This prediction was not supported in PD. The absence of a statistically significant finding can be explained by two reasons: 1. the mild disease severity of PD participants 2. the general simplicity of the narrative task. Firstly, it is possible basal ganglia atrophy was not significant enough to manifest in distinct procedural memory weakness due to the mild severity of recruited PD participants for the present study. This is supported by findings from Illes et al. (1988) who reported moderately impaired PD speakers producing sentences with lower syntactic complexity in a narrative task. PD speakers produced a higher proportion of content word phrases (i.e., noun, verb, and adjective phrases) as compared to healthy controls resulting in lower syntactic complexity scores. Some studies have documented syntactic simplification in speakers with PD in non-narrative, story-telling and structured sentence elicitation tasks (Dick et al., 2018; Murray & Lenz, 2001); these tasks tend to be more cognitively complex Altmann & Troche, 2011) as compared to this study.

The second prediction of Ullman's DP model was about regular past tense verb affixes. This too did not show a significant difference between PD speakers and neurologically healthy controls. The present findings are inconsistent with others who found regular past tense production deficits in PD (Friederici et al., 2003; Terzi et al., 2005). Overall, this study failed to find support for the DP model in PD. This could be either that procedural aspects of language in early stages of the disease are unimpaired (Huber et al., 2012). Alternatively, our study's narrative language tasks were not sufficient in length or complexity to challenge procedural memory.

L2 Speakers

L2 speakers produced more morphosyntactic errors than neurologically healthy controls. Specifically, they had lower grammaticality accuracy and lower DSS. However, the proportion of complex utterances and past tense production was not different from neurologically healthy controls. Thus, the present findings are partially consistent with Ullman's (2001) DP Model.

While some studies have found lower grammatical accuracy in L2 speakers (Hoshino et al., 2010; McDonald & Roussel, 2010), our findings of similar past tense are at odds with a conference paper (Lardiere, 2003). We also did not find a lower proportion of complex utterances, unlike other studies (e.g., Bartning & Schlyter, 2004).

While there may have been differences in L2 proficiency across studies, it is also important to consider differences in how proficiency is measured across studies. This study applied ACTFL criteria on a narrative language sample (see phone screen under Procedures) to define intermediate language proficiency (Gertken et al., 2014). Other potential variations of language profiency assessments include the Interagency Language Roundtable Scale for phonemic awareness, writing and reading measures (Stansfield et al., 2010) or speaker self-reports (Birdsong et al., 2012). Due to the use of a narrative language sample, we may have included more grammatically proficient participants. This could be one reason why only some morphosytnactic measures were lower for L2 speakers.

In summary, across PD and L2 speakers, only two (NH vs L2 for grammatical accuracy and DSS) out of eight comparisons were in line with the DP's predictions, lending weak support to the DP model. The finding of lower morphosyntactic performance in L2 speakers is well-documented (Fehringer & Fry, 2007; Hartsuiker & Barkhuysen, 2006) and can be explained even without the DP model.

Verb Use

The second research question of this study hypothesized that PD speakers would produce fewer action verbs compared to neurologically healthy controls in narrative language tasks (Bocanegra et al., 2017), and that L2 speakers would produce more light verbs compared to neurologically healthy native speakers of English (Kim & Rah, 2016). The present findings are not consistent with either of these hypotheses.

A few studies have found greater vulnerability in action verb retrieval in persons with non-demented PD in the absence of mild cognitive impairment (Bocanegra et al., 2015, 2017) and in the presence of significant motor disability as measured through the Unified Parkinson's Disease Rating Scale (UPDRS) (Péran et al., 2003). Literature reporting on statistically significant action verb naming deficits in early stage, mild dysarthria is sparse. These patterns suggest that verb deficits, if any, occur later during advanced stages of PD. Verbs, therefore, cannot be used as an early linguistic marker of PD. Further, given that our participants had a clear diagnosis of PD, we can conclude that the relationship between motor impairment and language deficits is weak. This lends weak support to the Embodied Cognition model for PD.

Kim & Rah (2016) reported that lower level intermediate proficient L2 speakers of English produce more light verbs. Explanations for this finding may be supported by the lower syntactic complexity of light verbs. Therefore, it would be assumed that lower level intermediate L2 speakers, who have demonstrated syntactic difficulties, rely on light verbs more frequently in their narrative productions as compared to native speakers. This study's findings may be alternatively explained by higher overall levels of proficiency of L2 participants as compared to those in Kim & Rah's (2016) intermediate group. Alternatively, light verbs frequently take the form of irregular verbs. Ullman's DP model posits that irregular verb production is mainly subserved by declarative memory. This may support our findings for verb production patterns in L2 narrative speech due to easier and faster lexical access through the declarative memory, as compared to procedural memory (Ullman, 2001).

In summary, the findings of this study did not support our hypothesis of NH vs. PD for action verb production. The findings of this study also did not support our hypothesis of greater light verb use in intermediate proficiency L2 speakers.

Speech-Motor Impairment's Association with Language Abilities in PD

The third research question of this study hypothesized that PD speakers would show a positive correlation between morphosyntactic complexity of spoken language samples and speech severity scores (Berg et al., 2003; Walsh & Smith, 2011). The logic was that PD participant's learned adaptation strategies would result in the same amount of produced utterances, but with fewer grammatical sentences as compared to neurologically healthy controls (Murray, 2000; Troche & Altmann, 2012). The correlation between speech-motor impairment on language abilities was not significant and did not support this hypothesis. Darling and Huber (2020) reported that speech-motor complexity demand of a task does not significantly affect the articulatory planning of PD speakers. This is a potential explanation to support our findings. Therefore, a simple syllable production task, the reading of an entire passage, or narrative discourse would not affect an association between language production and speech-motor control (Walsh & Smith, 2011). An additional explanation of our findings is the study's use of narrative language tasks. Multi-step language tasks have resulted in more severe dysarthric ratings (Maner et al., 2000). These reasons, among other differing variables such as medication control and time since diagnosis, warrant caution when interpreting this study's results.

Role of Medication

The role that medication on speech-motor impairment is important to consider when examining language abilities in PD. Dopamine is the neurotransmitter responsible for producing smooth, purposeful movement. PD damages the neurons that produce dopamine within the basal ganglia, which manifests in motor symptoms (Spencer et al., 2009). Levadopa, a commonly prescribed medication in PD, acts as a facilitating building block to create dopamine and treat motor symptoms. Levodopa medication aims to produce comparable dopamine levels as compared to neurologically healthy controls. However, literature reviewed reported that levodopa medication does not respond to the limb motor system the same way as the motor speech system (Skodda et al., 2010; Spencer et al., 2009). Studies have reported no significant group differences between medication states on measures such as understandability, naturalness of speech, or voice quality (Spencer et al., 2009) in structured reading tasks and narrative discourse tasks (Skodda et al., 2010). Therefore, it may be supported that ON medication conditions do not affect language behaviors or motor speech performance significantly enough to be a critical controlled variable of the study.

Alternatively, this study only included PD participants who used levodopa on a regular basis, and were ON levodopa medication conditions during the completion of their narrative picture description tasks. Aside from the medication's impact on language abilities, studies have emphasized the importance of measuring language performance outcomes in participant's natural conditions while functioning in their daily life routine (Plowman-Prine et al., 2009). Therefore, results measured demonstrated participant's functional and realistic language abilities, as compared to examining how the disease functions naturally while OFF normal levodopa medication regimens.

Association between Intelligibility and Morphosyntax in L2 Speakers

The third research question also hypothesized that L2 speakers would show an association between intelligibility and morphosyntax in controlled, scripted language samples (Bakhtiarvand, 2008; Faroqi-Shah & Thompson, 2003; Munro, Murray, 2008). MLU and DSS were used as measures of morphosyntax. Given that we were unsure how to measure articulatory and phonetic proficiency in L2 speakers, we used three different listener perceptual ratings (accent, intelligibility and nativeness). These speech measures were strongly inter-correlated and demonstrated a strong correlation with MLU. Literature reviewed supported an association among the phonemic differences of two languages and impact of accentedness on a native speaker's intelligibility rating (Anderson-Hsieh et al., 1992).

Theoretical Implications

Our study did not support Ullman's (2001) DP model for PD speakers. Our findings partly support Ullman's (2001) claims for L2 speakers for procedural weakness. However, a review in the literature shows alternative explanations for L2 speakers showing grammatical errors aside from Ullman's (2001) DP model. For example, the lower morphosyntactic performance in L2 speakers could be explained by the earlier critical age for morphosyntax (Hartshorne et al., 2018). The critical age hypothesis suggests that native-like proficiency of a second language is largely dependent on the age of acquisition. Adults are suggested to have lost this option and must rely on using alternative mechanisms to learn a second language. It would be assumed that this significantly impedes their success in proficient language use. Birdsong (2014) analyzed the ability to learn syntax as age increases. They found that the acquisition of syntax does decrease with age; however, this is largely preserved until approximately 17 years of age. The mean age of acquisition of L2 participants for this study was 19.5 years of age. This would provide a potential reason for L2 speaker's difficulty with syntax and support the findings of our study.

Our study did not support Ullman's DP (2001) model for past tense verb use in PD and L2 speakers. A review in the literature shows that this may be due to the lower level of complexity demanded in our language task. Although the DP model states that regular past tense is represented as a whole chunk, our findings may be supported by intact regular past tense verb production regardless of language complexity demanded from a narrative-based task. An alternative explanation for our findings is that processing of action verb production is not impaired but is slowed as compared to neurologically healthy controls (Kemmerer et al., 2013). Existing literature has reported the importance of language task complexity, processing times, and medication conditions when examining action verb deficits in PD speakers, as compared to neurologically healthy controls. For example, Kemmerer (2013) used semantic situational tasks that required the participants to compare subtle variations of the meanings of three action verbs and three non-action verbs. This task is more cognitively demanding as compared to narrative discourse language and therefore, it is assumed to require a longer processing time. Our study included PD participants while ON their medication; however, we did not measure response time. Therefore, this may provide some support and an alternative explanation for the findings of our study.

Limitations and Future Directions

In our study, the PD group included a relatively homogeneous group of mild, early stage participants. A more heterogenous group with more severely involved participants could have affected the results and made our study more comparable to other studies of language in PD. All PD participants were ON levodopa medication during narrative discourse tasks, and this could have minimized the language symptoms. Further, dosage and timing of medication administration were not controlled for.

Education level was not controlled for. Syntax, and the broader aspects of language of interest for this study, are not significantly affected by education level (Hartshorne et al., 2018). A “critical age” for acquisition and exposure to morphosyntactic components have been reported to account for differences in mastery of a language (Birdsong, 2014). However, this study examined adult participants who obtained a minimum of a high school education and learned their second language after the “critical age” range (Chen & Hartshorne, 2021).

Although there were practical and logistical reasons for the presented limitations, future research would benefit from a larger sample size, a more defined definition for the stage of intermediate proficiency expected from the L2 speakers, and the collection of longer language samples for L2 narrative picture language tasks. Moreover, twelve interested L2 participants were unable to complete any aspect of the study due to lack of Zoom/computer access or knowledge. This is understandable given that the data collection was completed via Zoom and during the COVID-19 pandemic for a master’s thesis as compared to data collected at Vanderbilt University’s Medical Center by Dr. Mefferd years prior.

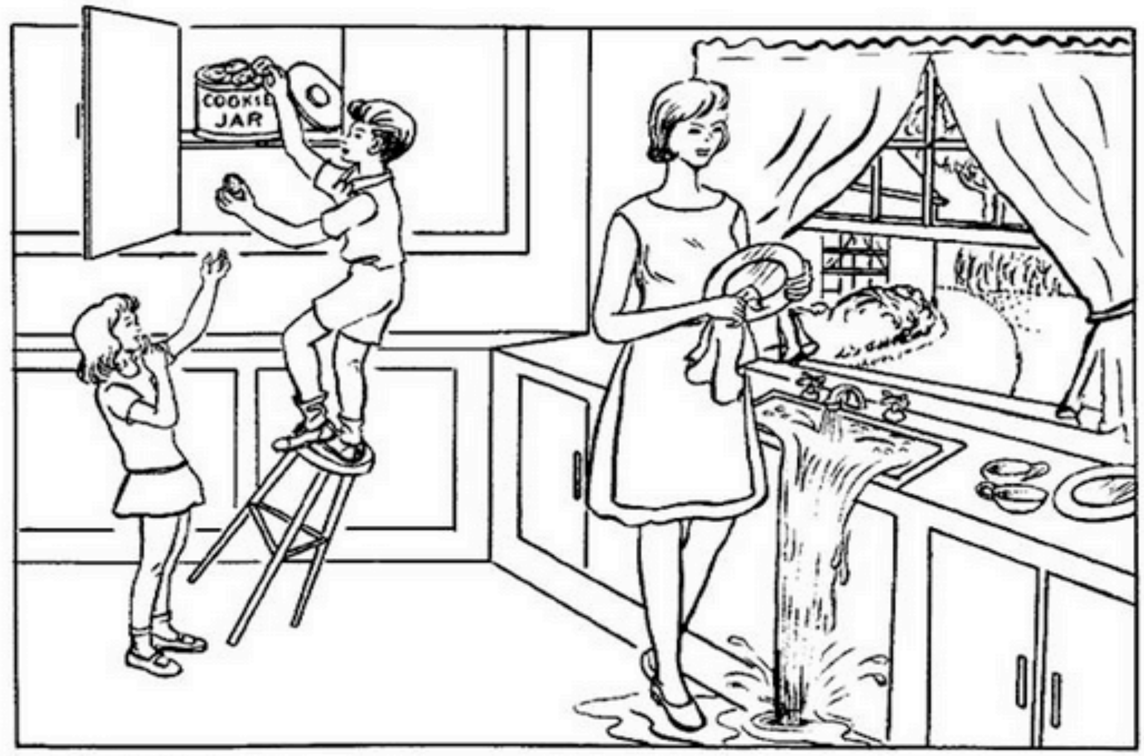
In regards to proficiency criteria, the ACTFL Proficiency Guidelines (Swender et al., 2012) provided this study with relatively strict parameters for inclusionary criteria as compared to literature reviewed (Gertken et al., 2014). But, these guidelines were limiting in analyzing nuances across lower, mid, and upper intermediate proficiency levels and their potential association with light verb preference in narrative language samples. Future studies may find value in creating additional dynamic assessments of language proficiency to ameliorate discrepancies among proficiency levels. Additionally, in order to match retrospective data, our study included one narrative language task. Future research may benefit from varying tasks in complexity and restricting their inclusionary criteria for acceptable responses per task. The selected measures and tasks may not have been sensitive enough to detect nuances within our relatively homogeneous and small sample size. Future research may benefit from exploring more sensitive measures and multi-step language tasks for a similar sample group. It is also important to consider realistic inclusionary criteria when aiming to study this population of PD speakers. Future research may consider the benefits and potential limitations of increasing syntactic complexity of a task in order to elicit more nuanced outcomes of language abilities. This is especially true if increases in syntactic complexity result in increases in cognitive load, lending to decreased grammaticality. Lastly, studies may explore applying the same measures from this study to a larger sample group that compares neurologically healthy aging participants and PD speakers to examine the effect of aging on language abilities.

With these limitations and considerations for future studies noted, the results of this study point to a promising beginning for studies aiming to identify the language characteristics among PD and L2 speakers in narrative language.

Conclusion

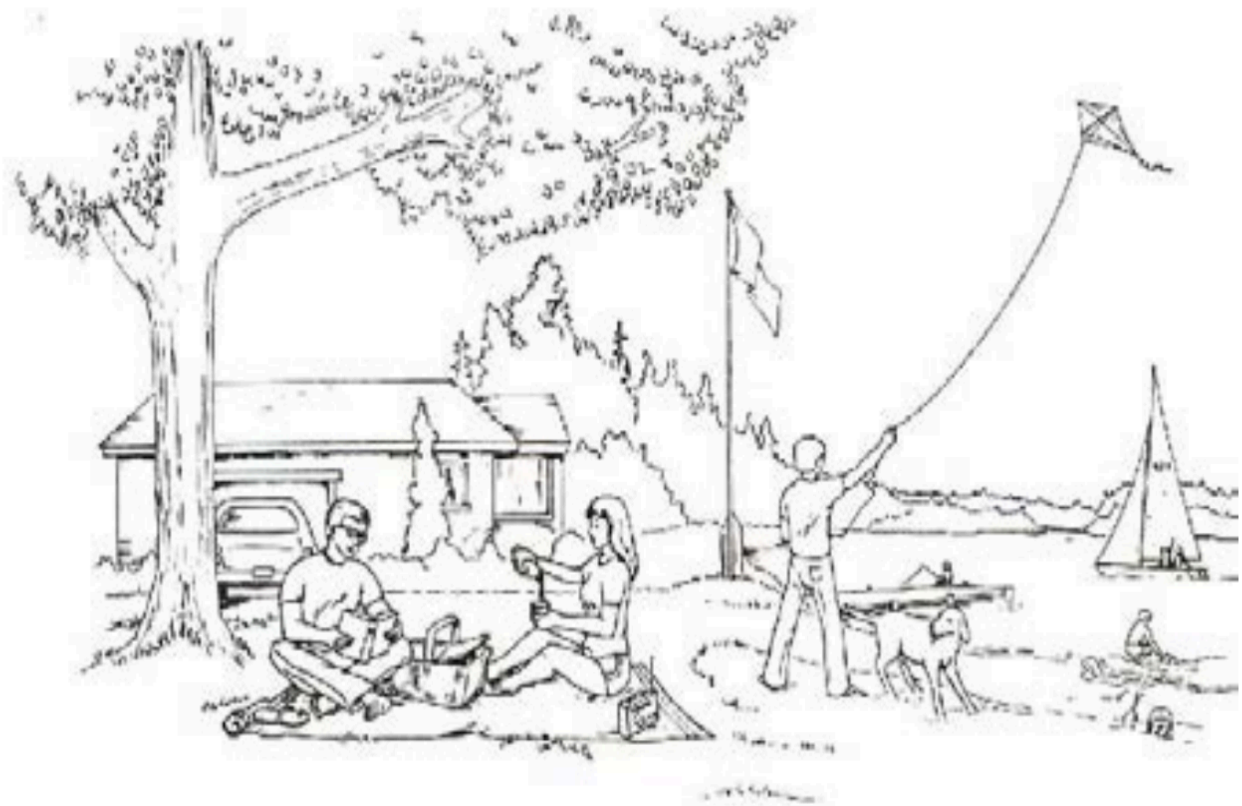
This study aimed to examine narrative language samples produced by speakers with early stage Parkinson's Disease and L2 English speakers with intermediate proficiency. The goals of this study were to: 1) compare procedural aspects of narrative language in early stage PD and intermediate proficiency L2 speakers of English, 2) examine patterns of verb production in early stage PD and intermediate proficiency L2 speakers of English, 3) examine the relationship between speech impairment and language production in PD speakers and 4) examine the relationship between intelligibility and grammaticality in L2 speakers. To conclude, this study found that intermediate proficient L2 speakers show some grammatical weaknesses as posited by Ullman's (2001) DP model. This model was not supported by our findings for early stage PD speakers.

Appendix A



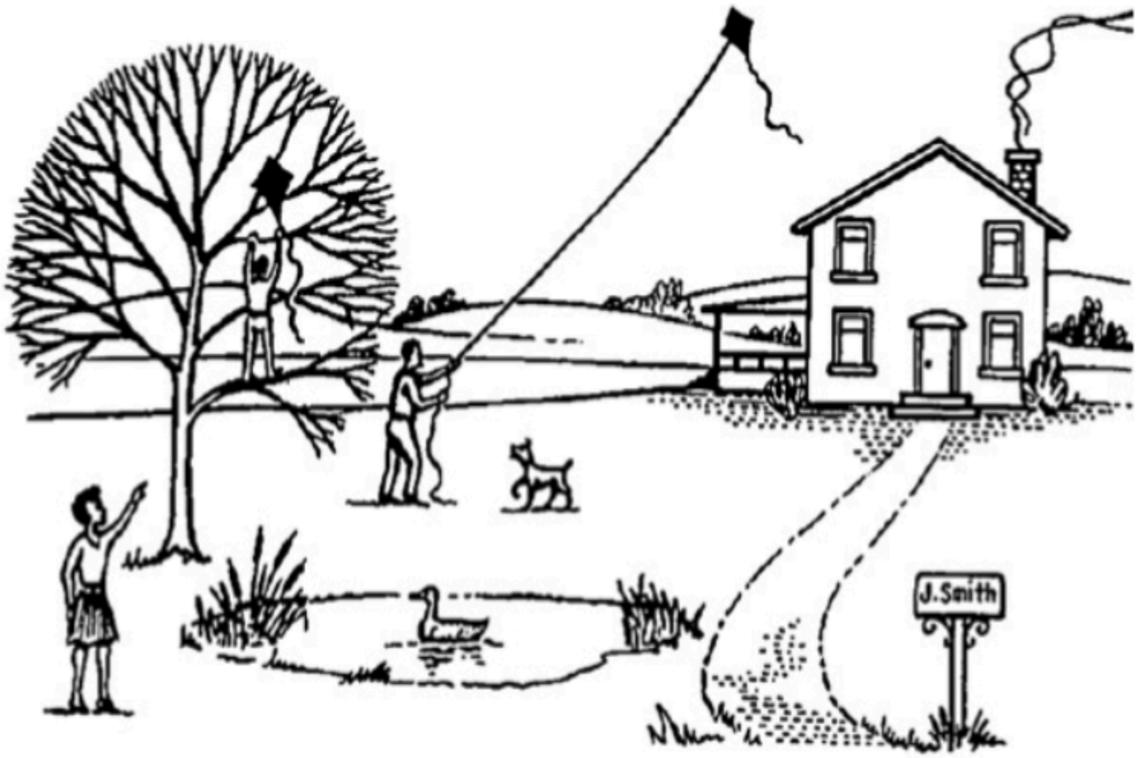
Appendix A. Cookie Theft Picture (Goodglass & Kaplan, 1972)

Appendix B



Appendix B. Family Picnic Picture (Kertesz, 1979)

Appendix C



Appendix C. Outdoor Kite Picture (Kertesz, 1979).

Appendix D

The Rainbow Passage

When the sunlight strikes raindrops in the air, they act as a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is , according to legend, a boiling pot of gold at one end.

Appendix D. The first three sentences of The Rainbow Passage (Fairbanks, 1960)

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