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Differentiation of the Presence and Severity of Apraxia of Speech in English and Spanish Speakers

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Differentiation of the Presence and Severity of Apraxia of Speech in English and Spanish Speakers

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Report

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Dedication

To Mom, Dad, and Toby. Thank you for all your love and support.

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Abstract

Differentiation of the Presence and Severity of Apraxia of Speech in English and Spanish Speakers

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As the Spanish speaking population in the U.S. increases, the number of individuals with AOS presenting with symptoms of AOS will increase. Assessment and treatment of AOS in Spanish is critical to allow individuals with AOS to receive appropriate speech and language services. A current assessment tool, the *Apraxia of Speech Rating Scale* (ASRS-V1), was developed for use with English-speaking individuals (Strand, Duffy, Clark, & Josephs, 2014). No clinical assessment exists that quantifies the presence or absence, relative frequency, and severity of characteristics associated with AOS in Spanish speaking individuals. The purpose of this report is to explore the linguistic differences between English and Spanish as they relate to the presence and severity of characteristics associated with AOS in English and Spanish monolingual and English-Spanish bilingual speakers.

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Introduction

Apraxia of speech (AOS) is a neurogenic motor speech disorder characterized by the inability to plan and execute motor commands for voluntary speech production (Freed, 2011). An individual with AOS exhibits difficulty in accurately producing articulatory postures for phoneme production as well as in sequencing of articulatory postures for word production (Darley, Aronson, & Brown, 1975).

AOS frequently co-occurs with aphasia or dysarthria. The National Institute of Neurological Disorders and Stroke (NINDS) estimated that approximately 1 million people have aphasia, a language disorder due to brain damage; the incidence of dysarthria is unknown because dysarthria can occur due to a variety of causes (e.g., stroke, brain injury, tumor, Huntington's disease, etc.) (NINDS, 2015). AOS was documented as the primary but not the only communication disorder in 6.9% of all motor speech disorders at the Mayo Clinic. The incidence of AOS would increase if the data included cases in which AOS was secondary to other communication disorders (e.g., aphasia or dysarthria) (Duffy, 2013).

There are 41 million native Spanish and 11.6 million bilingual speakers in the United States (U.S.). The U.S. Census Office projects the U.S. to have 138 million Spanish speakers by 2050, making the U.S. the largest Spanish-speaking nation on Earth (U.S. Census Bureau, 2013). The increase in Spanish-speaking individuals has increased the need for bilingual research and bilingual speech-language pathologists (SLP). Assessing and treating an individual who speaks English and Spanish, is a challenge because a SLP is required to assess the skills of each language independently. The bilingual SLP must understand speech patterns in culturally and linguistically diverse individuals to accurately differentiate between a language difference or a language disorder. Linguistic differences are present in each language which affect the degree, and severity of specific characteristics of a disorder (i.e., AOS).

This review explores the linguistic differences between English and Spanish as they relate to the presence and severity of characteristics associated with AOS in English-Spanish bilingual speakers. As the Spanish speaking population in the U.S. increases, the number of individuals presenting with symptoms of AOS will increase. Assessment and treatment of AOS in Spanish is critical to allow individuals with AOS to receive appropriate speech and language services. A current assessment tool, the *Apraxia of Speech Rating Scale* (ASRS-V1), was developed for use in English-speaking individuals (Strand, Duffy, Clark, & Josephs, 2014). No clinical assessment exists that quantifies the presence or absence, relative frequency, and severity of characteristics associated with AOS in Spanish speaking individuals.

A less complex language, relative to English, would result in less severe or prominent articulation symptoms typical of AOS individuals. More specifically, Spanish is a motorically less complex language than English containing fewer consonants, vowels, and clusters (e.g., /br/), as well as a simple syllable structure. Spanish is dominated by the CV syllable type and 83% of words are comprised of two syllables (Goldstein & Citron, 2001). With the development and implementation of a rating scale in Spanish, AOS severity may be reduced as rated in Spanish due to Spanish being a less complex language than English.

Apraxia of Speech

Individuals with AOS are impaired in their ability to coordinate the sequential, articulatory movements necessary to produce speech sounds to form syllables, words, phrases, and sentences (Wertz, LaPointe, & Rosenbek, 1984). As a result, individuals produce inconsistent articulatory errors approximating a target word, show articulatory groping and often have an associated disruption in prosody and rate of speech (Ogar, Willock, Baldo, Wilkins, Ludy, & Dronkers, 2006).

AOS is a distinct motor speech disorder even though symptoms of AOS typically co-occur and overlap with neuromuscular deficits of dysarthria and the linguistic errors of aphasia (Ogar, Slama, Dronkers, Amici, & Gorno-Tempini, 2005). AOS may be caused by vascular lesions (e.g., stroke), head trauma, tumors, or other neurological diseases and has been found to be the first and most prominent symptom in degenerative conditions such as primary progressive aphasia (Gorno-Tempini et al., 2004) and corticobasal degeneration (Rosenfield, 1991). AOS was reported as the primary communication disorder in 7.6% of 6101 neurogenic motor speech disorders at the Mayo Clinic, but occurs even more frequently as a secondary diagnosis (e.g., aphasia) (Duffy, 2005). Rarely does AOS occur solely in its “pure” form (i.e., with no language and/or muscular deficits).

Neuropathology

The neuroanatomical correlates of AOS are controversial. There are multiple brain areas that have been associated with AOS, including: the insula (Dronkers, 1996), Broca's area (Hillis et al., 2004), the parietal lobe (Square, Roy, & Martin, 1997), and subcortical regions (Peach & Tonkovich, 2003). Numerous neuroanatomical correlates of AOS have been identified due to different study designs, the patient populations studied, the common co-occurrence of AOS and aphasia, and the theory of more than one region being responsible for motor planning.

A comparison between chronic stroke patients diagnosed with AOS and without AOS found patients with AOS had lesions in the left superior precentral gyrus of the insula (SPGI) (Dronkers, 1996). Patients that were not diagnosed with AOS did not have lesions to the same SPGI. In a similar study by Ogar et al. (2006), SPGI lesions were present in all patients with AOS. However, larger lesions extending into Broca's area or the basal ganglia were associated with more severe AOS. High resolution MRI scans and perfusion weighted imaging determined Broca's area damage predominately predicted AOS rather than damage to the precentral gyrus or the premotor region (Richardson, Fillmore, Rorden, LaPointe, & Fridriksson, 2012). No association was found between AOS and insula damage, but instead AOS was associated with ischemia in Broca's area (Hillis et al., 2004).

The left posterior inferior frontal gyrus (Broca's area) was found to be the neuroanatomical lesion site of AOS (Hillis et al., 2004). The findings were replicated by Richardson et al. (2012) using high-resolution structural and perfusion magnetic resonance imagining (MRI). MRI is a technique that uses a magnetic field and radio waves to create detailed images of the organs and tissues of the body. Using perfusion MRI allowed for the identification of areas outside the lesion site that are dysfunctional, but will eventually recover from ischemic insult. Studies using only traditional MRI or computed tomography (CT) scans may miss areas that were dysfunctional, but later recovered. (Hillis et al., 2004). Broca's area was found to be hypoperfused but not infarcted in some patients with AOS.

The occurrence of pure AOS is rare because the most common cause of AOS, middle cerebral artery infarction, most often results in aphasia. Graff-Radford et al. (2014) sought to determine the common area of infarction in patients with AOS with minimal or absent aphasia. The area of infarction may be smaller in patients with AOS and allow for more precise identification of the area or areas of the brain crucial to the development of AOS. A neuroanatomical correlate for AOS was found in the premotor cortex and adjacent precentral gyrus. A case study involving severe AOS (aphemia) indicated a lesion similar to the area of overlap at the junction of Brodmann areas (BA) 4 and 6, or the area between the premotor cortex and precentral gyrus (Fox, Kasner, Chatterjee, & Chalela, 2001). Patients in the study by Hillis et al. (2004) had lesions of the precentral gyrus without involvement of Broca's area.

Voxel-based morphometry (VBM) uses statistical analyses to identify differences in brain anatomy between groups of subjects, which in turn can be used to infer the presence of atrophy. VBM found gray matter atrophy in the superior premotor cortex spreading to the precentral gyrus, as well as the supplemental motor area in patients with neurodegenerative AOS in the absence of aphasia (Josephs et al., 2006). Patients with neurodegenerative AOS with accompanying aphasia had atrophy of the premotor cortex and had greater involvement of Broca's area. The degree and severity of AOS correlates with greater involvement of the premotor cortex; whereas, agrammatic aphasia severity correlates with Broca's area and is congruent with findings by Hillis et al. (2004). When AOS occurs with aphasia, Broca's area is damaged consistently; when AOS occurs without the presence of aphasia, damage is observed in both the premotor cortex and the precentral gyrus.

Pinpointing a singular brain region associated with AOS has been controversial. However, improved neuroimaging methods and analyses have allowed identification of functional and structural connectivity within the speech network that differs in persons with disordered speech. Although no consensus on the specific site of lesion for AOS has been established, studies by Richardson et al. (2012), Graff-Radford et al. (2014), Fox et al., 2001, Hillis et al. (2004), and Josephs et al. (2006) have implicated damage to the premotor cortex (BA6) to strongly predict presence and severity of AOS. Additionally, gray matter volume in the premotor cortex of individuals with isolated AOS correlated significantly with an AOS severity rating measure (Whitwell et al., 2013). Consensus is building that the critical area damaged in individuals with AOS encompasses the immediate area surrounding the left premotor cortex (BA6).

Speech Characteristics

The characterization of AOS has shifted with an increase in research leading to more refined definitions of the disorder. Early research used broad phonetic transcription to describe speech sound errors of AOS speakers, followed by more objective measures such as acoustic analysis (Ogar et al, 2005). More recently, an emphasis on deficient sequencing and timing features have been utilized to determine the presence of AOS (Itoh, Sasanuma, & Ushijima, 1979; Kent & Rosenbek, 1983).

Kent and Rosenbek (1983) described AOS as presenting "errors in sequencing, timing, coordination, initiation, and vocal tract shaping" (p. 245). Articulation errors and prosodic abnormalities are the most distinct characteristics in AOS. Articulation errors are highly variable and embedded in a pattern of speech made slow and effortful by trial-and-error groping for the desired articulatory postures (Darley et al., 1975, p. 267). Off-target productions usually are complications of articulatory performance; that is, substitutions, additions, repetitions, and prolongations. Less frequently the errors are simplifications; that is, distortions and omissions.

The affects of AOS on prosody are not completely understood. Wertz, LaPointe, and Rosenbek (1991) suggested that prosodic errors are a secondary effect of impaired articulation. Individuals may speak in a slow, halting manner because of the anticipation of speaking with difficulty. Prosodic abnormalities result in slower than normal connected speech, equal stress placed on all syllables in an utterance, and reduced variations in pitch and loudness. Silent pauses may occur at different and unnatural (i.e., in the middle of the word) positions. Silent pauses are either the result of articulatory groping, or because the syllables of a word are being produced individually (Duffy, 2005).

Brookshire (2007) noted that substitution errors are more frequent than distortion, omission, and addition errors (Darley et al., 1975; Wertz et al., 1991). However, Kearns and Simmons (1988) suggest that what listeners perceive as substitutions may be extreme phonetic distortion errors. Substitution errors usually replace easy-to articulate sounds with a more difficult sound (e.g., *thun* for *sun*). Errors are more likely to be in placement of the articulators, especially back-of-the-mouth sounds, as opposed to errors of voicing, manner, or resonance, and front-of-the-mouth sounds. Overall, the error patterns described define the relationship between articulatory or linguistic variables and error probabilities.

Articulatory inconsistency is the correct production of phonemes at one time and incorrect productions of phonemes at another time, which is often times unpredictable (Darley et al., 1975; Wertz et al., 1984; Kearns and Simmons, 1988). However, variations in the context can have direct effects on articulatory inconsistency. For example, a phoneme occurring repeatedly in the initial position in one context (e.g., ***T****im* ***T****ook the* ***T****imer*) will result in a decrease of articulatory inconsistency as opposed to a context in which phonemes would differ in the same target initial word position (e.g., ***P****eter* ***K****icked a* ***D****oe*). Errors are most often on consonants occurring initially in words, predominately on those phonemes and clusters of phonemes requiring more complex muscular adjustment. (Darley et al., 1975). A decrease in articulatory inconsistency is more often observed in natural situations as opposed to artificial ones, or settings/situations not typical for the individual (e.g., therapy room, hospital room, speaking to doctors or therapist as opposed to family members). This is referred to as "islands of fluent, error-free speech" by Darley et al. (1975). Islands of fluent, error-free speech occur when fluent words, phrases, or sentence are produced by an AOS speaker in the middle of effortful, struggling speech. In addition, periods of fluent speech are indicative of the presence of AOS as opposed to dysarthria, where intermittent periods of fluent speech rarely occur (Brookshire, 2007). Errors are exacerbated by an increase in the complexity of words, phrases, and sentences. The linguistic and psychological "weight" of speech also has an effect on errors (Darley et al., 1975).

The most common AOS errors involve place of articulation, with affricates and fricatives most affected (e.g., a word with affricate sounds such as the "ch" in "church" will be more difficult than a word with bilabial phonemes, such as the "m" in "mom"). Errors are common on consonants clusters, rather than singleton consonants (e..g, "strict" will be more difficult than "sit") (Ogar et al., 2005). Individuals with AOS are more likely to produce errors when asked to repeat nonsense words, as opposed to meaningful words, as well as assign equal stress to each word (Duffy, 1995). Pauses between syllables and words are common, as is an overall slowed rate of speech (Duffy, 1995).

Differential Diagnosis

To diagnose AOS, the distinctive differences between AOS and Broca's aphasia, conduction aphasia, and dysarthria must be determined (Ogar et al., 2005). Differential diagnosis is the identification of a particular disorder from others that present with similar symptoms. Speech errors are analyzed then compared to errors most closely associated with AOS. A diagnosis of AOS can be determined when a significant number of speech errors match errors that are known to occur is AOS (Duffy, 2005).

AOS frequently is associated with Broca's aphasia since the two disorders often occur together (Duffy, 2005). However, Square, Roy, and Martin (1997) determined that AOS is distinguishable from Broca's aphasia. AOS was shown to be present in non-aphasia individuals who did not manifest linguistic deficits such as agrammatism and naming deficits.

Sound level errors such as substitution, additions, transposition, or omissions, are present in both AOS and conduction aphasia. However, the manifestation of the errors are different (McNeil, Pratt, & Fossett, 2004; Duffy, 2005). Sound errors in conduction aphasia are due to a deficit in the selection of phonemes, reflecting a linguistic deficit. Individuals with AOS are able to select the correct phoneme to produce, but the deficit lies with the motor execution of the phoneme (Ogar et al., 2005). Also, normal prosody is observed in individuals with conduction aphasia, whereas abnormal prosody is a prominent characteristic of AOS (Wertz et al., 1991). Square et al. (1997) reported the individuals with conduction aphasia lack awareness of speech errors leading to a lack of self-correction, while individuals with AOS are able to identify and modify speech errors.

McNeil, Robin, and Schmidt (2007) and Wambaugh, Duffy, McNeil, Robin, and Rogers (2006) have used the following descriptors to facilitate the diagnoses of AOS: (1) slow speech rate, (2) sound distortions (3) distorted sound substitutions, (4) sound errors consistent in type and location, and (5) prosodic abnormalities. More specifically, Wambaugh et al., (2006) developed four categories of behaviors based on reviews of AOS treatment studies to determine whether or not the individuals in those studies had been correctly diagnosed with AOS. The four categories were: (1) primary clinical characteristics, contains behaviors that as a whole are almost exclusively found in individuals with AOS, (2) nondiscriminative clinical characteristics, contains behaviors that can be found in individuals with AOS but are also found in other disorders, (3) clinical characteristics usually found in other disorders other than AOS, and (4) clinical characteristics ruling out apraxia of speech completely. The complete categories with specific behaviors to observe is included in Appendix A. The four categories with behavioral characteristics can be used to assist in the diagnosis of AOS. Following an analysis of an individual's speech characteristics from a motor speech evaluation, a clinician can use the items in the four diagnostic categories to determine a high, moderate, low, or no probability of AOS.

Apraxia of Speech Versus Dysarthria

Dysarthria results from impairment of muscle strength, tone, range of motion, and/or coordination, which can affect phonation, resonance, articulation or prosody. The primary disruption in AOS is articulation with no impairment in resonance or phonation. Furthermore, damage to the central or peripheral nervous system results in dysarthria, whereas AOS is caused by damage by the central nervous system alone (Darley et al., 1975). Errors in the speech of an individual with dysarthria are consistent and predictable, while the errors in the speech of an individual with AOS are highly irregular (Yorkston, Beukelman, & Bell, 1988).

Dysarthria must be identified in the speech of the individual. Dysarthria is a disorder of speech production that is perceived by the listener utilizing auditory perceptual measures (Justice, 2005). A comprehensive motor speech evaluation includes speech and non-speech motor tasks, as well as assessment of each of the subsystems separately: respiration, phonation, resonation, articulation, and prosody. A diagnosis for dysarthria type based on abnormal physiologic or kinematic variables alone has not been demonstrated (McNeil, Robin, & Schmidt, 2008). Tone and reflex abnormalities are associated with pathologies of any neural system of speech production except higher conceptual planning and programming. Disorders of planning and programming do not typically co-occur with disorders of tone and reflex abnormalities (Schmidt & Lee, 2005). Darley et al. (1975) suggested that in the absence of tone and reflex abnormalities during speech or non-speech activities, as well as a clear differentiation between movement disorders present only in individuals with AOS and not in comparable non-speech behaviors, should aid in differential diagnosis. Wertz et al. (1991) proposed AOS was differentiable from dysarthria following a comprehensive, large-scale review and analysis of clinical science. The foundation for the specific characteristics unique to AOS were based on published research, a wealth of clinical experience, and a profusion of reason and logic. Table 1 represents the differentiating characteristics of AOS and dysarthria.

Table 1: Differentiating Characteristics of AOS and Dysarthria

Feature	AOS	Dysarthria
Lesion location	Unilateral/anterior	Bilateral if cortical, usually subcortical
Psychophysiological level mechanism	Motor programming	Movement execution
Observed deviant speech behavior	Speech initiation, sequencing, phoneme substitution, abnormal prosody, infrequent metathetic errors	Sound-level distortions
Speech processes involved	Essentially normal:	Frequent disturbance of
	1. Resonance	1. Resonance
	2. Respiration	2. Respiration
	3. Phonation	3. Phonation
Physiological manifestations	Free from paralysis, paresis, ataxia, involuntary movements	Presence of paralysis, paresis, ataxia, involuntary movements
Influence of non-phonological (phonetic factors)	Effected by word length, error inconsistency	Less effected by word length, errors are more consistent
Oral nonverbal apraxia	Frequently present	Absent

Source: From Wertz, R. T., LaPointe, L. L., & Rosenbek, J. C. (1991). *Apraxia of speech in adults: The disorder and its management.* Clifton Park, NY: Delmar, Cengage Learning.

Apraxia of Speech Versus Phonemic Paraphasia

Haley, Jacks, and Cunningham (2013) defined phonemic paraphasia as the "behavioral representation of sound substitutions" and are "conceptualized as one manifestation of aphasia, rather than as a distinct disorder" (p. 891). Martin (1974) argued that speech errors in studies by Aten, Johns, and Darley (1971), Deal and Darley (1972), and Rosenbek, Wertz, and Darley (1973) could be accounted for by linguistic or motor-programming concepts.

Research studies determined error variability between dysarthria and AOS, but clinical metrics were not deemed appropriate in the differentiation between phonemic paraphasia and AOS (Darley et al., 1975; Johns & Darley, 1970). Miller (1992) was the first to compare differences between AOS and phonemic paraphasia by analyzing word production variability. No significant differences were found indicating word production variability may be a shared feature of the two disorders. Errors were found to be relatively consistent in location and invariable in type relative to phonemic paraphasia, which prompted a revision of diagnostic guidelines for AOS in the clinical setting (McNeil, Odell, Miller, & Hunter, 1995). However, consistent and invariable sound errors in AOS have been challenged by Staiger, Finger-Berg, Aichert, and Ziegler (2012). Staiger et al. (2012) found moderate to high levels of variability in word- and segmental-level analysis of error location and error type, but these variables are not diagnostically valid because of lack of use of a control group. A control group with no underlying neurological deficits would need to be included to confirm moderate to high levels of variability at word- and segmental-level analysis was due to AOS alone, and no other contributing factor.

Haley et al. (2013) did not support the use of error variability to differentiate between AOS and phonemic paraphasia. Results indicated that variable speech productions are salient features existing in both disorders and the magnitude of variability can differ on how the measure is defined and quantified. Error variability may be important clinical markers that precede or accompany a period of behavioral change (Zanone & Kelso, 1992). Also, error stability may be an indicator of resistance to change that precludes a positive response to intervention. Furthermore, operationalized metrics (e.g., error token and total token variability) were found to be alternative measures showing strong relationships in perceptual scaling that would allow for broad characterization of the type of variability for distinguishing between AOS and phonemic paraphasia. Other characteristics that are suggested to differentiate between AOS from phonemic paraphasia are shown in Table 2.

Table 2: Differentiating Characteristics of AOS and Phonemic Paraphasia

AOS	Phonemic Paraphasia
Disturbed Prosody	
Overall Rate	
Slow rate in phonetically on-target or off-target phrases and sentences	Near-normal rate in phonemically on-target phrases and sentences
Inability to increase rate while maintaining phonemic integrity	Variable ability to increase rate, but within normal ranges, while maintaining phonemic itegrity
Microsegmental Rate	
Variable, but overall prolonged movement transitions	Variable, but normal movement transition durations
Variable, but abnormally long vowels in multi-syllabic words or words in sentences	Variable, but normal vowel duration in multisyllabic words or words in sentences
Stress Assignment	
Presence of errors on stressed syllables	No clear relationship between syllabic stress and errors frequency
Phonological Characteristics	
With distorted perseverative, anticipatory and exchange phoneme or phoneme cluster errors	With undistorted perseverative, anticipatory and phoneme exchange or phoneme cluster errors
With phoneme distortions	Without phoneme distortions
Presence of distorted sound substitutions, primarily of prolonged phonemes and secondarily devoiced phonemes	Absence of distorted sound substitutions
Other Characteristics	
The location of errors in the utterance are consistent from trial to trial	The location of errors in the utterance are not consistent from trial to trial
The types of errors in the utterance are not variable from trial to trial	The types of errors in the utterance are variable from trial to trial

Source: From McNeil, M. R., Robin, D. A., & Schmidt, R. A. (2008). Apraxia of speech: Definition and differential diagnosis. In T. Y. Hiscock (Ed.) *Clinical management of sensorimotor speech disorders* (2nd Ed.) (pp. 249-268). New York, NY: Thieme.

Whether there is a single speech symptom that is exclusive to AOS remains debatable. Many of the typical speech errors in conduction aphasia, such as the transposing of sounds or perseverative errors, can also be found in individuals with AOS. McNeil et al. (2004) suggested that there are three characteristics of pure AOS that do not occur in any other sound-level production disorder: sound distortions, prolonged segment durations (e.g., prolonged vowels or consonants) and prolonged intersegment durations (e.g., abnormal pauses within sounds, syllables and words).

The Apraxia of Speech Rating Scale

The ASRS-V1 was developed to quantify the presence or absence, relative frequency, and severity of characteristics associated with AOS (Strand, Duffy, Clark, & Josephs, 2014). Auditory perception is critical for clinical practice in speech-language pathology (Kent, 1996). Currently, auditory perceptual assessment is the primary method for establishing the presence and differentiation of motor speech disorders (Duffy, 2013). Kent (1996) commented on the limitations of auditory perceptual assessment: (1) there are no equivalent definitions of dimensions to be rated, (2) there is no consensus on which perceptual dimensions should be rated for a given disorder, (3) perceptual ratings are not independent and may be influence by co-occurring dimensions of the disorder, (4) there is no uniform reliability for perceptual ratings, and (5) differences among expert judges are larger than differences needed for diagnostic classification or to determine treatment effects. The universal application of auditory perception is accompanied by failings and limitations (Kent, 1996). Knowing the nature of failings and limitations is critical to minimize their undesired effects.

Limitations on auditory perceptual assessment led Strand, Duffy, Clark, and Josephs (2014) to develop a rating scale that would allow clinicians to specify and quantify the presence and severity of the characteristics of AOS that have been identified as consistent with the diagnostic label (Haley, Jacks, de Riesthal, Abou-Khalil, & Roth, 2012). The scale may reduce errors in perceptual judgment and improve consistency across clinicians, both for description and diagnosis (Strand et al., 2014).

The purpose of the ASRS-V1 is to describe and quantify the characteristics of AOS using a 5-point rating scale (see Table 3). The 5-point rating scale not only determines the presence or absence of particular speech characteristics, but also their prominence and severity. The 16 items on the ASRS-V1 are scored during and/or after samples of conversational speech, picture, description, word and sentence repetition, and speech-like alternating and sequential motion rate (AMR and SMR) tasks (Strand et al., 2014). The 16 items are organized to indicate whether they (a) are discriminative of AOS; (b) can be present in individuals with AOS, but also in individuals with aphasia; (c) can be present in individuals with AOS, but also in individuals with dysarthria; or (d) can be present in individuals with AOS, but also in individuals with aphasia or dysarthria. The total number of items noted, as well as the total score over all items, is calculated.

Table 3: Scoring for Each of the 16 items on the ASRS-V1

Score	Description
0	Not Present
1	Detectable but Infrequent
2	Frequent but Not Pervasive
3	Nearly Always Evident - Not Severe
4	Nearly Always Evident - Severe

Source: From Strand, E. A., Duffy, J. R., Clark, H. M., & Josephs, K. (2014). The apraxia of speech rating scale: A tool for diagnosis and description of apraxia of speech. *Journal of Communication Disorders, 51,* 43-50.

The ASRS-V1 was intended for research purposes only, but the limited clinical validity and reliability of available measures for quantifying AOS has made the ASRS-V1 a possible scale to be utilized in the general clinical setting. Reliability was measured through intra-class correlations (ICC) with inter-judge ICC at 0.94 among three clinicians for the total score and 0.91 for the number of items present (Strand et al., 2014). Inter-judge ICCs ranged from 0.87 to 0.91 and intra-judge ICCs ranged from 0.91 to 0.98. No substantial differences were present for item-level agreement (97%). A cutoff of score of 8 on the ASRS-V1 was used to calculate specificity and sensitivity. Specificity, the proportion of individuals without AOS, was calculated at 100%. Sensitivity, the proportion of individuals with AOS that the ASRS-V1 indicated to have AOS, was calculated at 96%. Clinical judgment of AOS severity, performed prior to ASRS-V1 implementation by "expert" clinicians, strongly correlated with ASRS-V1 scores. Expert clinicians were reported to have had many years of clinical experience in motor speech disorders. In conclusion, the ASRS-V1 adequately represents differences in clinically judged severity. The ASRS-V1 is included in Appendix B.

Linguistic Differences

Words are syllabified in English but syllable boundaries are not well defined. Syllable boundaries can be modified by stress and examples of phonemes that could belong to either the preceding or following syllables (ambisyllabicity) are common (Selkirk, 1982). Additionally, syllabification does not always preserve morphological structure (Sánchez-Casas, 1996). In contrast, Spanish has a transparent orthography with a very close grapheme-to-phoneme correspondence. Spanish has a very regular syllabic structure with clearly defined syllable boundaries that are resistant to stress movement, and there is almost no ambisyllabicity (Harris, 1983; Sánchez-Casas, 1996). Phonemic and syllabic differences between English and Spanish may aid in the quantification of the presence or absence, relative frequency, and severity of characteristics associated with AOS in Spanish speaking individuals.

Phonemic Implications and Differences

Major differences exist between the vocalic phonemes of Spanish and English. There are five vowels that represent the single tense vowel sounds in Spanish (see Table 4) (Goldstein, 2001). In contrast, 12 vowels represent tense and lax vowel sounds in English (see Table 4). The five shared vocalic phonemes between Spanish and English are as follows: /a/, /e/, /i/, /o/, and /u/. Vowels in Spanish have the same relative tongue height and tongue placement as their English counterparts except for /a/, which is low and central (Cotton & Sharp, 1988). Spanish and English share the following consonantal phonemes: the stop sounds /p/, /t/, /k/, /b/, /d/, and /g/; the nasals /m/, and /n/; the fricatives /s/ and /f/; the affricate /tʃ/; the liquid /l/; the glides /w/ and /j/ (Cotton & Sharp, 1988). However, despite common phonetic symbols, acoustic differences exist due to differences in voicing, aspiration, and precise place of articulation. A complete inventory of English and Spanish consonants and vowels is shown in Tables 5 and 6.

Spanish voiceless stops (/p/, /t/, and /k/) are less plosive, meaning they are produced with less air pressure than English plosives. English speakers perceive Spanish voiceless stops as voiced consonants /b/, /d/, and /g/ and are associated with spirants /β/ (voiced bilabial), /ð/, and /ɣ/ (voiced velar), respectively (Goldstein, 2001). For example, "*bear*" may be produced as "*pear,*" or "*time*" as "*dime*" (Iglesias & Goldstein, 1998). Voice onset time (VOT) is the duration of vocal fold vibration before the release of air pressure (Goldstein & Washington, 2001). Spanish voiceless stops in the initial word position are produced with relatively short VOT compared to English. English voiceless stops are produced with long VOT, and voiced stops are produced with short VOT. The differences between VOT Spanish and English results in the perception of voiced rather than voiceless sounds. English phonemes /t/ and /d/ are produced on the alveolar ridge above the teeth; whereas in Spanish, they are produced with the tip of the tongue placed on the back of the teeth, giving them a dentalized quality (Perez, 1994; Whitley, 1986).

Phonemes /s/ and /f/ are the only two fricatives that are present in Spanish and English. English contains fricatives /θ/, /ʃ/, /z/, /v/, /ð/, and /ʒ/ which do not occur in Spanish, while the phoneme /x/, present in Spanish only, represents a voiceless sound produced with velar friction (Cárdenas, 1960). Forward transfer is often used to substitute Spanish fricatives for similar English fricatives (Iglesias & Goldstein, 1998). For example, the next closest Spanish phonemes to the English phonemes /θ/ and /ð/ are /t/ and /d/, respectively. When forward transfer occurs, the English word "*think*" may be produced as "*tink,*" or "*this*" may be produced as "*dis.*" Phonemes /z/ or /v/ are often substituted for phonemes /s/ or /b/, respectively, which may result in "*zipper*" produced as "*sipper,*" or "*very*" produced as "*bery.*" Even though Spanish contains orthographic symbols for "b" and "v," both letters represent the same phoneme, /b/. The phoneme /ʃ/, which does not occur in Spanish, may be substituted for the phoneme /tʃ/, which does occur in Spanish, resulting in "*shop*" produced as "*chop.*"

The phoneme /dʒ/ does not occur in Spanish and may be substituted by /tʃ/. However, because the co-articulatory movements of /dʒ/ and /j/ are quite similar, the two phonemes may be perceived as allophones instead (Iglesias and Goldstein, 1998). The phoneme /dʒ/ will more often be substituted for the glide /j/, as opposed to /tʃ/, resulting in "*yesterday*" produced as "*justerday.*" The /w/ sound may be produced with slight velar constriction in Spanish and /j/ may be produced with varying degrees of palatization.

The /r/ is produced as a rhotic (e.g, "*far,*" "*sister*") or retroflexed (e.g., "*rat,*" "*run*") /r/ in English. In Spanish, the /r/ is produced as a tap, as in the "*tt*" in "*butter*" or a trill (e.g., "*perro*") (Cárdenas, 1960). The open glottal phoneme /h/ does not exist in most Spanish dialects, but it does in English.

Phonemes /m/ and /n/ are produced in the same manner in both languages. However, when /m/ and /n/ occur in clusters (e.g., "sometimes"), Spanish speakers substitute the /m/ sound for the /n/ sound, or vice versa (Merino, 1992). The phoneme /ŋ/ does not occur in the Spanish language. More often, the /n/ is substituted for /ŋ/ and result in "*long*" produced as "*lon.*"

Phonotactic rules dictate which phonemes can occur in which positions in syllables and words and in what combinations (Merino, 1992). Nearly all English consonants can occur in the final word position; whereas, only a few consonants occur in the final word position in Spanish (Goldstein, 2001). Consonant clusters are common and occur in any word position in English. In Spanish, consonant clusters occur less frequent and are subject to more constraints. For example, initial /s/ clusters can only occur in Spanish if preceded by the letter "e" (Perez, 1994). Also, consonant clusters cannot occur in the final word position. Other phonemic differences between English and Spanish are included in Table 4.

Table 4: Phonemic Differences Between English and Spanish

English	**Spanish**
24 Consonants	17 Consonants
12 Vowels	5 Vowels
Many consonants occur in the final position	Only 5 consonants (/s, n, r, l, d/)occur in the final position
/t/ and /d/ are produced apical and aspirated	/t/ and /d/ are produced dentalized and unaspirated
/s/ clusters in the initial position DO occur	/s/ clusters in the initial position DO NOT occur
Many final clusters occur	Final clusters rarely occur
Many consonant clusters occur	Consonant clusters rarely occur
Consonantal production are lax	Consonantal productions are tense
Dialects are affected by vowel differences	Dialects are affected by consonantal changes in fricatives, liquids, and nasals

Table 5: English Phonemic Inventory (Consonants)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar	Glottal
Plosive	p b			t d			k g	
Nasal	m			n			ŋ	
Trill								
Tap or Flap								
Fricative		f v	θ ð	s z		ʃ ʒ		h
Affricate					tʃ dʒ			
Glides (Approximant)	w			r		j		
Liquid (Lateral Approximant)				l				

Table 6: Spanish Phonemic Inventory (Consonants)

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Palatal	Velar	Glottal
Plosive	p b			t d			k g	
Nasal	m			n		ɲ		
Trill				r				
Tap or Flap				ɾ				
Fricative		f		s			x	
Affricate					tʃ			
Glides (Approximant)	w					j		
Liquid (Lateral Approximant)				l				

Figure 1: English Phonetic Inventory (Vowels)

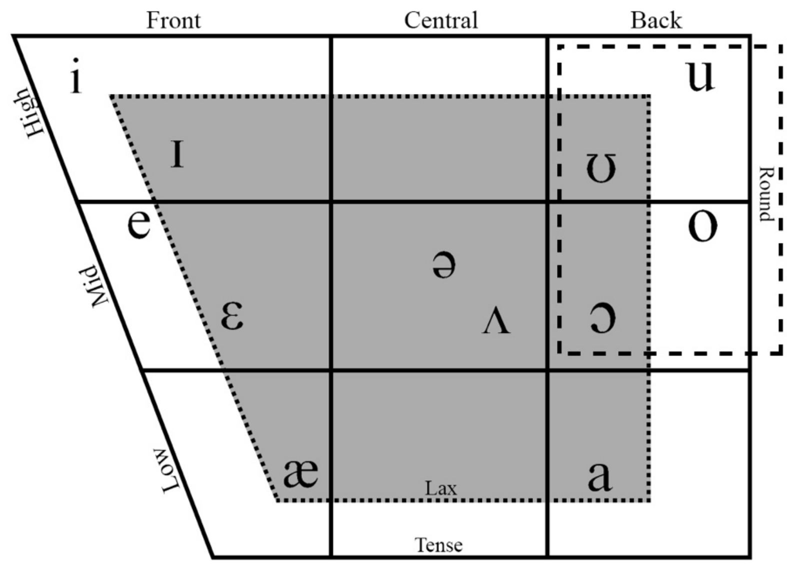
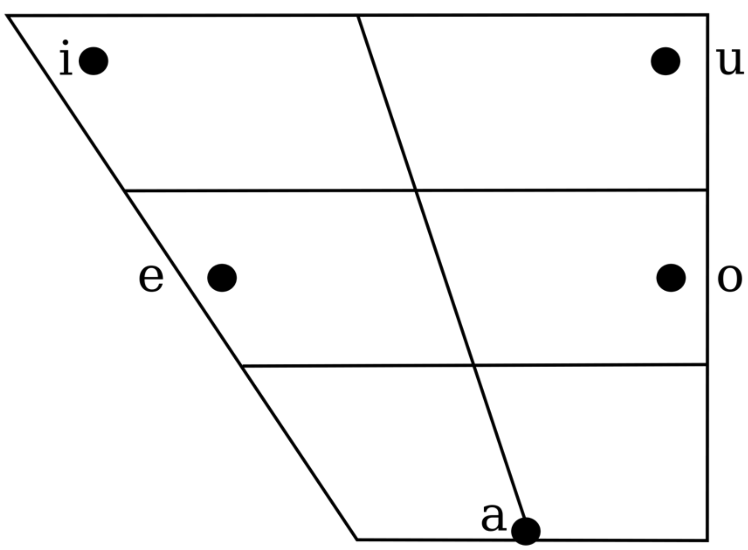


Figure 2: Spanish Phonetic Inventory (Vowels)



Syllabic Implications and Differences

The production of phonemes in isolation is a rare behavior in both English and Spanish. Not only do isolated phonemes occur rarely in natural speech, but isolated phonemes do not play a role in normal language acquisition (Aichert & Ziegler, 2013). Speech motor learning in babbling infants appears to be based on syllabic units, not on phonemes (MacNeilage & Davis, 2000; 2001). Studies by Rochet-Capellan and Ostry (2011) and Tremblay, Houle, and Ostry (2008) on adults have shown that the learning of speech movements is highly sensitive to their local context, demonstrating that articulation is critically constrained by the contextual embedding of segments.

The syllable is the basic unit of articulatory programming in adult speech. Phonetically, the syllable consists of the center, or nucleus, which has little to no obstruction of airflow and sounds comparatively louder than sounds before and after, the onset and coda, respectively (Chomsky & Halle, 1991). Levelt, Roelofs, and Meyer (1999) mention a long-term store of motor patterns for frequently occurring syllables, the "mental syllabary." The mental syllabary allows speakers to access a store of holistic articulatory-phonetic programs for the frequently occurring syllables of a particular language during phonetic encoding. Syllables have been shown to play a role in AOS. Syllable structure (Romani & Galluzzi, 2005) and syllable frequency (Laganaro, 2008; Staiger & Ziegler, 2008) influence production accuracy at the segmental level. The influence of syllabic factors on AOS error patterns is suggestive that individuals with AOS have access to a mental syllabary, but that the motor programs stored must be partly destroyed (Aichert &

Ziegler, 2004). Furthermore, Edmonds and Marquardt (2004) concluded that "the syllable is maintained and appears to be the core unit in AOS" (p. 1132).

Articulatory complexity influences the accuracy of speech production in individuals with AOS. Errors occur on increasingly complex speech units and systematically replace complex units with less complex ones (e.g., consonant clusters with single phonemes). Error susceptibility of a consonant cluster is related to its position within a syllable or across a syllable boundary, respectively (Aichert & Ziegler, 2004). Consonant clusters occur significantly far less in any position in Spanish than they do in English. Inferences on articulatory complexity in reference to clusters in both languages is indicative that the accuracy of speech production in individuals with AOS will be better in Spanish speakers.

Complexity of syllable structure has been emphasized and largely confirmed as an influencing factor in theoretical frameworks that incorporate the syllable as a representational unit. Romani & Galluzzi (2005) referred to a complexity measure that scales the syllable templates on a markedness continuum. Any deviation from the simple CV syllable structure is considered a complication (Clements & Keyser, 1983).

Staiger and Ziegler (2008) found the proportion of errors produced over all syllable structures was significantly higher on low- than high-frequency syllables. Syllables, due to their high frequency of occurrence are considered particularly overlearned and were produced more accurately by the participants. A strong influence of syllable structures on error rates infers that syllables that comprise intra-syllabic clusters are demanding and therefore have an impact on production accuracy. No influence of syllable structure was found among high-frequency syllables while the opposite was found among low-frequency syllables. Within low-frequency syllables, the complexity of the syllables had an impact on error rates, resulting in a higher vulnerability of the complex units. High-frequency syllables may be overlearned to such an extent that an increasing degree of complexity will not affect their production and the opposite is true for syllables with lower frequencies of occurrence since they possess lower degrees of being learned. Motor patterns stored in the mental syllabary are arranged along a continuum, with structurally simple, high-frequency syllables constituting the most accessible and least vulnerable ones and structurally complex, low-frequency syllables being particularly unstable (Aichert & Ziegler, 2008).

English and Spanish show similarities and differences in syllable structure. In both languages, the nucleus is essential while the coda and the onset are optional. Table 7 shows similar syllable types present in both languages with examples (Martínez, 2011). Final consonant clusters in Spanish are not as common as in English. In Spanish, there is an almost direct correspondence between spelling and sound whereas in English one grapheme may have different pronunciations and some are not produced. The syllable structures in Spanish are highly dominated by CV sequences (Goldstein & Citron, 2001; Guerra, 1983). Guerra (1983) reported on the frequency of syllable structures in spoken Spanish. Distribution of results are as follows: CV (55.81%), CVC (21.61%), V (9.91%), VC (8.39%), CCV (3.14%), CCVC (0.98%), VCC (0.13%), CVCC (0.02%), CCVCC (0.01%).

Table 7: Similar Syllable Types Between Spanish and English

Spanish	Syllable Type	English
me.sa	CV	co.lic
cie.lo	CVV	rai.ny
buey	CVVV	beau.ty
cap.tu.rar	CVC	lim.bo
cien.to	CVVC	pain.less
cru.cial	CCV	tra.ge.dy
true.que	CCVV	trai.ning
trac.tor	CCVC	trom.bo.ne
trein.tena	CCVVC	train
cons.tru.ir	CVCC	land.lord
trans.por.tar	CCVCC	trans.port
a.la	V	e.vil
ai.re	VV	ai.ry
ac.tor	VC	al.co.hol
ais.lar	VVC	aim
ins.truc.ción	VCC	ins.tru.ment

Source: Martínez, S. G. (2011). The syllable structure: Understanding Spanish speakers pronunciation of English as a L2. *Revista Electrónica de Lingüística Aplicada, 10,* 1-7.

The number of vowels present can vary from one, to two (dipthongs) or three (tripthongs). There are two types of dipthongs: (a) raising dipthongs in which the first vowel is a semi-consonant and the second vowel is the nucleus (/je/, /jo/, /ja/, /wa/, /we/, /wi/, /wo/) and (b) falling dipthongs where the vowel which constitutes the nucleus is placed initially (/ai/, /ei/, /oi/, /eu/, /ou/). Tripthongs are composed of a central vowel, which makes up the nucleus, flanked by two semi-consonants or semivowels (/uai/, /uei/).

The onset is the initial phase of the syllable which precedes the nucleus and is represented by consonants, following the sonority sequencing of the syllable structure. The Principle of Sonority sequencing states that sonority must always go up until it reaches its peak and then falls (Roca & Johnson, 1999). Therefore, the first consonant must be less sonorous than the second so as to reach its peak in the vowel (i.e., the nucleus coming afterwards). The sonority hierarchy is a scale which ranks the segment classes on the basis of sonority. The sonority hierarchy is as follows: (1) vowels, (2) liquids, (3) nasals, (4) obstruents. When two consonants contravene the Principle of Sonority, the two consonants would be split into two different syllables (Martínez, 2011). One consonant would constitute the code of the preceding syllable and the other consonant would be the onset of the following one. When a syllable is complex, the two consonants must fulfill the Obligatory Contour Principle, which does not accept two consonants with similar places of articulation to be placed together (Roca & Johnson, 1999).

The coda is the final part of the syllable which is constituted by a consonant representing a decrease in sonority and indicates the end of the syllable. The consonants which form a coda are either in the implosive position at the end of the syllable (/b/, /p/, /d/, /t/, /g/, /l/, /m/, /n/, /r/, /z/, /s/) or at the end of the word (/d/, /z/, /s/, /n/, /r/, /j/), and are the only options in Spanish (Martínez, 2011). Spanish differs from English in which Spanish lacks complex codas and has a high occurrence of open syllables. An open syllable is a syllable which ends in a vowel, in contrast to close syllables which end in on or more consonants (Quilis, 1993).

The average length of words in any language is directly related to syllable structure. When a language, such as Spanish, does not support final consonants, there is a limited number of one-syllable words. The number of one-syllable words would be restricted to the finite combination of C+V (Quilis, 1999). Goldstein and Citron (2001) determined word length using syllable count of Spanish-speaking children and noted that 83% of the words created were two-syllables.

The Lack of Standardized Assessment in Spanish

Aphasia is the primary neurologically-based communication disorder assessed and treated by SLP's in the Spanish health care system (Melle, Martín-Aragoneses, & Gallego, 2012). However, systematic data on the diagnosis AOS and dysarthria is needed. Until 2012 there was no epidemiological data on the incidence or prevalence of AOS in Spanish, as well as defined procedures for evaluation, diagnosis, and treatment derived from systematic research studies. Data from a survey by Melle, Martín-Aragoneses, and Gallego (2012), revealed that 18.95% of individuals were diagnosed with AOS. The data indicates the incidence of AOS as slightly higher than comparable studies conducted by the Mayo Clinic from 1987-1990 and 1993-2001 in which AOS was diagnosed in 8% of individuals (Duffy, 2005).

The evaluation of articulatory structures and functions associated with AOS includes three dimensions: perceptual assessment (characterization of disordered speech), neurophysiological exploration (determination of the integrity of nerve pathways and structures associated with speech production), and instrumental evaluation (objective measurement of neurophysiologic function and speech sound properties) (Duffy, 2005). General standardized tests for perceptual and neurophysiologic assessment, such as the *Frenchay Dysarthria Assessment* (FDA-2) (Enderby & Palmer, 2008), exist for English, but not for Spanish.

The proportion of individuals diagnosed with AOS in Spanish differs significantly from those in English (Melle et al., 2012). Differences in the diagnosis of AOS can be attributed to the variability of instruments and criteria used in assessment and diagnosis.

The development of tools and procedures to consider all components present in motor speech disorders, specifically AOS, will allow the Spanish health care system to reliably assess, diagnosis, and treat individuals with AOS, and other motor speech disorders.

The Apraxia of Speech Rating Scale - Spanish

The purpose of the Apraxia of Speech Rating Scale – Spanish (ASRS-Spanish) is to describe and quantify the characteristics of AOS using a 100-millimeter scale in Spanish speaking individuals. The 100-millimeter rating scale not only determines the presence or absence of particular speech characteristics, but also their prominence and severity. The six items on the ASRS-Spanish are scored during and/or after samples of conversational speech, picture, description, word and sentence repetition, and speech-like alternating and sequential motion rate (AMR and SMR) tasks (Strand et al., 2014). The six distinguishing features are as follows: distorted sound substitutions; distorted sound additions (not including intrusive schwa); increased sound distortions or distorted sound substitutions with increased utterance length or increased syllable/word articulatory complexity; increased sound distortions or distorted sound substitutions with increased speech rate; inaccurate (off-target in place or manner) speech AMR's (alternating motion rates, as in rapid repetition of "puh puh puh"; reduced words per breath group relative to maximum vowel duration. Only the six distinguishing features of the original ASRS-V1 were used in the creation of the ASRS-Spanish. The goal of the ASRS-Spanish is to determine severity of AOS, not distinguish AOS from aphasia or dysarthria. The total number of items noted, as well as the total score over all items, is calculated. A translated version of the ASRS-Spanish, La Escala de la Clasificación de Apraxia del Habla, is included in Appendix C.

Proposal for Differentiation of the Presence and Severity of Apraxia of Speech in English and Spanish Speakers

Rationale

The purpose of this study is to explore the linguistic differences between English and Spanish as they relate to the presence and severity of characteristics associated with AOS in English and Spanish speakers. A less complex language, relative to English, would result in less severe or prominent articulation symptoms typical of AOS individuals. More specifically, Spanish is a motorically less complex language than English containing fewer consonants, vowels, and clusters (e.g., /br/), as well as a simple syllable structure. Spanish is dominated by the CV syllable type and 83% of words are comprised of two syllables (Goldstein & Citron, 2001). With the development and implementation of a rating scale in Spanish, AOS severity may be reduced as rated in Spanish due to Spanish being a less complex language than English.

Participants and Criteria

Thirty adults with a history of a single left hemisphere cerebrovascular accident and apraxia were recruited for this study. Fifteen participants were native speakers of American English while the other 15 were native speakers of Mexican Spanish. Participants had limited knowledge of another language other than their native language. Participants were between the ages of 25-75 and had obtained at least a high school diploma. No constraints on gender were placed on choosing of participants. Participants had no history of speech or language impairment, developmental disorders or neurological deficits prior to brain injury responsible for AOS. Participants passed a hearing screening at 25 dB HL in the better ear at 500 Hz, 1000 Hz, and 2000 Hz. Participants had pre-morbid right-hand preference. The *Frenchay Dysarthria Assessment* (FDA-2) (Enderby & Palmer, 2008) and the Motor Speech Evaluation (Wertz et al., 1984, p. 98) were used to rule out the presence of significant dysarthria. With the sequence of /ptk/, there may be initiation difficulty, substitution, omission, or rearrangement of the syllables; slow rate; equal and even stress; stops, starts, and reattempts to produce the sequence. Similar errors should be evident with multisyllabic words and short phrases. Repeated trials on the same word may show inconsistent errors. Words of increasing length should show more errors on the longer words. Sentences and picture description will produce errors consistent with AOS in articulation and prosody. Counting forward and backward contrasts automatic speech versus volitional speech, with more errors expected on the latter. Three English-Spanish bilingual SLPs with experience in aphasia, dysarthria, and AOS were utilized to confirm that the observed deficits in the selection of participants are consistent with AOS. The rationale for criteria used in selecting participants is as follows:

Sample Size: 30

- Power increases as the number of participants increases. However, constraints on finding 15 participants who speak English or who speak Spanish only limits the sample size to what is attainable/feasible.

Lesion Site and Type: Left Cerebral Lesion Secondary to Stroke

- The left hemisphere is the dominant area of language. Strokes are the main cause of lesions in the left cerebral hemisphere.

Lesion Timeline: 6-Month Post Onset

- A 6-month post onset was selected because some degree of spontaneous recovery occurs up to 6 months after stroke.

Age and Education: Ages 25-75 with No More than a High School Education

- Most stroke occurs in individuals between the ages of 25 and 75. Age, as well as education, both play an important factor in recovery post-stroke.

Aphasia Type: Broca's

- In Broca's aphasia, apraxia of speech is a secondary symptom with varying severity.

Tests for Aphasia: Bilingual Aphasia Test (BAT)

- The Bilingual Aphasia Test (BAT) was chosen because it is the most widely used test to quantify aphasia in different language independently. Many other tests exist to identify aphasia in English speaking individuals only, but not in Spanish speaking individuals. The BAT offers the ability to determine similarities and differences in the presence of aphasia in accordance to language alone.

Gender: No Constraints

- Even though more women have a stroke than men because they live longer, it does not affect the presence of a particular aphasia, or severity in apraxia of speech.

Hearing Screening: 25 dB HL in the Better Ear at 500 Hz, 1000 Hz, and 2000 Hz

- Passing a hearing screening indicates that not being able to hear directions, or one's own speech has a bearing on testing, data, or results. It indicates that aphasia, or apraxia of speech, alone was the only contributing factor to whether or not aphasia, or apraxia of speech is present and to what degree.

Dysarthria: FDA-2 and Motor Speech Evaluation

- The absence of dysarthria ensures that errors consistent with apraxia of speech are not due to muscle weakness or incoordination. Inter-observer agreement increases the likelihood that errors consistent with apraxia of speech are due to apraxia of speech presence and not due to dysarthria.

Handedness: Right-Handed Only

- The left hemisphere is dominant for language in 99% of right-handed individuals. In left-handed individuals, 70% have language control in the left hemisphere, 15% in the right hemisphere, and 15% in both hemispheres. Including participants that are right-handed ensures that the probability of errors presented in aphasia or apraxia of speech are due to damage to the left cerebral hemisphere.

Procedure

All participants were administered either English or Spanish versions of the BAT, dependent upon their heritage language by a English-Spanish bilingual speech-language pathologist. Following, all participants were assessed with the FDA-2 and the Motor Speech Evaluation to rule out dysarthria and confirm intact oral-motor structure, musculature, and function. Data for the conversational sample, word repetition, and speech-like AMR ("puh puh puh") and SMR ("puh tuh kuh") tasks were obtained during the initial screening for participants. During the conversational sample of the BAT, participants asked about illnesses, work, experiences in other countries, and their family. Word repetition tasks were scored using the scoring conventions from *The Apraxia Profile* (Hickman, 1997) (omissions, distortions, substitutions, additions). Further testing was required for the picture description and sentence repetition tasks. Participants described the cookie theft picture from the *Boston Diagnostic Aphasia Examination-Third Edition* (BDAE-3) (Goodglass, Kaplan, & Barresi, 2001). Ten randomly selected sentences composed of frequent and infrequent word choices (e.g. "In the summer they sell vegetables," "Arthur was an oozy, oily sneak") in English and Spanish were used for the sentence repetition tasks. All testing will be conducted in the language of the individual with AOS.

The presence and severity of AOS was established using a continuum 100 millimeter scale, independent of the ASRS measure. The initial rating of AOS was made by the clinician administering the tasks. A score near 1 would indicate no presence of AOS with a score near 100 indicating severe AOS. A score near the lower end of the continuum will be assigned if the characteristic was not noted in any task. A score around the 25th percentile of the continuum will indicate the item was observed, but very infrequently. A score near the middle of the continuum will indicate the item was observed fairly frequently, but not necessarily across all tasks and not on most utterances. A score near the 75th percentile of the continuum will indicate the characteristic was pervasive (nearly always evident) but not marked in severity; that is, the feature was mild enough that intelligibility was not significantly affected. A score near the higher end of the continuum will be assigned if the feature is noted across tasks on most utterances and was severe enough that targets were difficult to recognize. Following the initial rating, a second and third clinician repeated the rating of AOS severity from video and audio recordings.

The same procedure is executed using the ASRS in English and in Spanish. The scoring of AOS severity on the English version of the ASRS would be modified to include a 100 millimeter scale as opposed to a 4-point scale. The clinicians would use the same 100 millimeter scale to score the ASRS in both languages. A rating would be given for each of six distinguishing features of AOS that do not overlap with aphasia or dysarthria. The six distinguishing features are as follows: distorted sound substitutions; distorted sound additions (not including intrusive schwa); increased sound distortions or distorted sound substitutions with increased utterance length or increased syllable/word articulatory complexity; increased sound distortions or distorted sound substitutions with increased speech rate; inaccurate (off-target in place or manner) speech AMR's (alternating motion rates, as in rapid repetition of "puh puh puh"; reduced words per breath group relative to maximum vowel duration. Only the six distinguishing features of AOS from the original ASRS-V1 were used for this study. The goal of this study was to determine severity of AOS in English and Spanish, not to distinguish AOS from aphasia or dysarthria. Aphasia and dysarthria was ruled out initially when choosing participants.

Statistical Analysis

A multiple-factor analysis of variance will be completed using a 2x2 factorial design. One factor will be the distinguishing characteristics of AOS; its levels will correspond to each of the six distinguishing characteristics[1]. The second factor will correspond between English-only and Spanish-only speaking participants. The dependent variable is rated severity of AOS on each of the scales. A multiple-factor analysis of variance provides methods for testing whether language of the speaker or differences rating between categories are significant.

- Null Hypothesis: There will be no statistical difference in severity of AOS between English and Spanish
- Experimental Hypothesis: There will be a statistical difference in severity of AOS between English and Spanish.

Table 8: Diagram of the Two-Factor Sample Experiment

		Distinguishing Characteristics of AOS					
		(A)	(B)	(C)	(D)	(E)	(F)
Language	English (e)	μ_{Ae}	μ_{Be}	μ_{Ce}	μ_{De}	μ_{Ee}	μ_{Fe}
	Spanish (s)	μ_{As}	μ_{Bs}	μ_{Cs}	μ_{Ds}	μ_{Es}	μ_{Fs}

[1](A) distorted sound substitutions, (B) distorted sound additions (not including intrusive schwa), (C) increased sound distortions or distorted sound substitutions with increased utterance length or increased syllable/word articulatory complexity, (D) increased sound distortions or distorted sound substitutions with increased speech rate, (E) inaccurate (off-target in place and manner) speech AMR's (alternating motion rates, as in rapid repetition of "puh puh puh"), (F) reduced words per breath group relative to maximum vowel duration.

Conclusion

The ASRS-V1 and ASRS-Spanish provide a foundation on which to build on the quantification of the presence and severity of AOS. The ASRS-V1 and the ASRS-Spanish would be compared with one another in studies utilizing English-only and Spanish-speaking individuals to determine whether there are significant differences in the presence and severity of AOS or not between the two languages. The null hypothesis utilizing the ASRS-V1 and the ASRS-Spanish is that there will be no significant statistical differences in the severity of AOS between English and Spanish AOS participants. However, our experimental hypothesis would constitute a significant statistical difference in AOS severity between English and Spanish. AOS severity is predicted to be reduced in Spanish because of fewer clusters, vowels, and consonants, fricatives, a simpler syllable structure, and Spanish being an overall less motorically complex language**.**

Future Directions and Summary

The Future in the Differentiation of AOS in English and Spanish Speakers

The ASRS-V1 provides a foundation on which to build on the quantification of the presence and severity of AOS. Initially, further research is needed on larger, more controlled populations to determine if the scale can be used in the general clinical setting and adequately represent differences in clinically judged severity (Strand et al., 2014). Secondly, the ASRS-Spanish would need to be utilized in research studies to determine whether or not it is an effective tool in quantifying the presence and severity of AOS in Spanish-speaking individuals. Finally, the ASRS-V1 and the ASRS-Spanish would be compared with one another in studies utilizing English-only and Spanish-speaking individuals to determine whether there are significant differences in the presence and severity of AOS or not between the two languages. The null hypothesis utilizing the ASRS-V1 and the ASRS-Spanish is that there will be no significant statistical differences in the severity of AOS between English and Spanish. However, our experimental hypothesis would constitute a significant statistical difference in AOS severity between English and Spanish.

Summary

As the Spanish-speaking population of the U.S. continues to increase, the need to assess and treat communication disorders in Spanish will increase. Bilingual SLPs will need to take into consideration linguistic differences that are present in each language which affect the presence or absence, degree, and severity of specific characteristics of AOS.

In comparison to English, Spanish has a very regular syllabic structure with clearly defined syllable boundaries that are resistant to stress movement (Harris, 1983; Sánchez-Casas, 1996). There are five vowels that represent the single tense vowel sounds in Spanish (Goldstein, 2001), while English has twelve. Spanish contains 17 vowels while English contains 24. Of those 17 consonants in Spanish, only two are fricatives; whereas in English, there are eight. Nearly all English consonants can occur in the final word position; whereas, only a few consonants occur in the final word position in Spanish (Goldstein, 2001). Consonant clusters are common and occur in any word position in English while consonant clusters occur less frequent and are subject to more constraints in Spanish. Phonemic and syllabic differences between English and Spanish may aid in the quantification of the presence or absence, relative frequency, and severity of characteristics associated with AOS in Spanish speaking individuals.

The ASRS-V1 and ASRS-Spanish provide a basis to test the hypothesis if there is a statistical difference in AOS severity between the English and Spanish language. Based on differences in language, AOS severity would be reduced in Spanish because of fewer clusters, vowels, and consonants, fricatives, a simpler syllable structure, and Spanish being an overall less motorically complex language.

Appendices

Appendix A: Diagnostic Characteristics of Apraxia of Speech

Primary Clinical Characteristics[a]	
1.	Demonstration of prosodic abnormalities.
2.	Slow speech rate further characterized by lengthened production of vowels, consonants, or both.
3.	Slow speech rate with pauses between phrases, words, syllables, or phonemes. Pauses may often be filled with a schwa.
4.	Presence of consonants and vowels being distorted.
5.	Presence of phoneme substitutions being distorted.
6.	Demonstration of articulation errors during repeated utterances that generally are consistent for type of error (omission, distortion, substitution) and for location.
Nondiscriminative Clinical Characteristics[b]	
1.	Short periods of error-free speech.
2.	Automatic, overlearned speech (e.g., counting from 1 to 10) is produced better than propositional speech (e.g., describing what you did yesterday).
3.	Self-corrects errors and shows other signs of error awareness.
4.	Difficulty initiating speech.
5.	Presence of speech errors increasing as word length increases.
6.	Presence of perseverative errors or movements.
7.	Demonstration of articulatory groping, either visually, audibly, or both.
Clinical Characteristics Usually Found in Other Disorders[c]	
1.	Demonstration in a difference between expressive and receptive speech and and language abilities.
2.	Presence of transposition errors on phonemes and syllables.
3.	Presence of anticipatory articulation errors.
4.	Presence of limb apraxia or nonverbal oral apraxia does not necessarily indicate a diagnosis of apraxia of speech.
Clinical Characteristics Ruling Out Apraxia of Speech[d]	
1.	Demonstration of a fast rate of speech.
2.	Demonstration of a normal rate of speech.
3.	Demonstration of normal prosody.

[a]Indicative of AOS when, as a group, are present in an individual's speech.
[b]Suggestive of AOS when present in an individual's speech because they are frequently found in other disorders. Behaviors should not be used to make the diagnosis of AOS, alone.
[c]Behaviors are more likely to be found in other disorders and should not be used to make t diagnosis of AOS.
[d]Behaviors are exclusionary characteristics and do not occur in the speech of individual's with AOS. The presence should immediately rule out the presence of AOS.

Source: From Duffy, J.R. (2005). *Motor speech disorders. Substrates, differential diagnosis, and management* (2[nd] ed.). St. Louis, MO: Elsevier Mosby.

Appendix B: The Apraxia of Speech Rating Scale (ASRS-V1)

Name: __________________________ #: ________ Date: ________ Examiner: ______________________
Total of Ratings: __________________ # of items rated present: ________________
Aphasia present Y N Severity (0-4)_____ AOS present Y N Severity (0-4)_____
Dysarthria present Y N (type=______________________); Severity (0-4)______

1	AOS – primary distinguishing features[a] (no overlap with dysarthria or aphasia). One or more must be present for diagnosis of AOS.	Score (0-4)
1.1	Distorted sound substitutions	
1.2	Distorted sound additions (not including intrusive schwa)	
1.3	Increased sound distortions or distorted sound substitutions with increased utterance length or increased syllable/word articulatory complexity	
1.4	Increased sound distortions or distorted sound substitutions with increased speech rate	
1.5	Inaccurate (off-target in place or manner) speech AMR's (alternating motion rates, as in rapid repetition of "puh puh puh")	
1.6	Reduced words per breath group relative to maximum vowel duration	
2	Distinguishing features unless dysarthria present[b]	Score (0-4)
2.1	Syllable segmentation within words > 1 syllable	
2.2	Syllable segmentation across words in phrases/sentences	
2.3	Sound distortions	
2.4	Slow overall speech rate	
2.5	Lengthened vowel &/or consonant segments	
2.6	Lengthened intersegment durations (between sounds, syllables, words, or phrases; possibly filled, including intrusive schwa)	
3	Distinguishing features unless aphasia present[c]	Score (0-4)
3.1	Deliberate, slowly sequenced, segmented &/or distorted (including distorted substitutions) speech SMRs in comparison to speech AMRs	
3.2	Audible or visible articulatory groping; speech initiation difficulty; false starts/restarts	
4	Distinguishing features unless dysarthria &/or aphasia present[d]	Score (0-4)
4.1	Sound or syllable repetitions	
4.2	Sound prolongations (beyond lengthened segments)	

0 = not present
1 = detectable by infrequent
2 = frequent but not pervasive
3 = nearly always evident but not marked in severity
4 = nearly always evident and marked in severity

[a] Present in AOS and not a feature of aphasia or dysarthria.
[b] Associated with AOS but can also occur in dysarthria. Consider as characteristic of dysarthria if primary distinguishing characteristics of AOS not present, and other features of dysarthria are present. If dysarthria present with AOS, score with the modifier "d" (e.g., 2d).
[c] Associated with AOS but can also occur in aphasia. Consider as characteristic of aphasia if primary distinguishing characteristics of AOS not present, and other features of aphasia are present. If aphasia present with AOS, score with the modifier "a" (e.g., 2a).
[d] Associated with AOS but can also occur in aphasia and dysarthria. Consider as characteristic of dysarthria or aphasia if primary distinguishing characteristics of AOS not present. If aphasia or dysarthria also present with AOS, score with the modifier "d," "a," or "ad" (e.g., 2ad).

Source: From Strand, E. A., Duffy, J. R., Clark, H. M., & Josephs, K. (2014). The apraxia of speech rating scale: A tool for diagnosis and description of apraxia of speech. *Journal of Communication Disorders, 51,* 43-50.

Appendix C: La Escala de la Clasificación de Apraxia del Habla

Nombre: ________________________ #: ________ Fecha: ________ Examinador: ___________________

1	Apraxia del habla – principal característicos distintivos[a] (no superposicióne con disartria o afasia). Uno o mas debe estar presente para diagnósticar apraxia de habla.	Clasificación (0-100)
1.1	Substituciónes de sonidos distorsionados	
1.2	Adición de sonidos distorsionados (no incluyendo vocal neutral entrometida)	
1.3	Aumentado sonidos distorsionados o substituciónes de sonidos distorsionados con aumento de duración de la declaración o aumento de el articulatorio complejidad de sílabas/palabras	
1.4	Aumentado sonidos distorsionados o substituciónes de sonidos distorsionados con aumento de la velocidad del habla	
1.5	Equivocado (objetivo errado en lugar y modo) en la tasa de movimientos secuenciales (repetición rápido de "puh puh puh")	
1.6	Reducción de palabras por grupo de respiración relativo a duración máximo de vocales	

Clasificación 1.1

____

Clasificación 1.2

____

Clasificación 1.3

____

Clasificación 1.4

____

Clasificación 1.5

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Clasificación 1.6

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