STUDY OF LIP MUSCULATURE DURING SPEECH AND NONSPEECH PRODUCTION TASKS USING EMG-BASED OUTCOME MEASURES

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Abstract: Non-speech Oral-Motor Exercises (NSOMEs) are oral activities that are thought to influence speech production without actually executing speech (Forrest, 2002). A recurring question among studies investigating the clinical utility of NSOMEs is the possible transfer of treatment effects of NSOMES to speech production (Hodge, 2002; Weismer & Liss, 1991). Despite the ongoing controversy, a majority of speech-language pathologists continue to use NSOMEs to treat speech production deficits. At present, there is insufficient evidence to support or refute the use of NSOMEs. So, it is critical that we continue to investigate the transfer effects of NSOMEs to speech production, if any through empirical approaches. The current study aimed to address this ongoing controversy by employing electromyography (EMG) as the outcome measure. A total of 24 participants in the age range of 19– 27 years participated in the current experiment. All the participants were involved in a series of speech production and comparable nonspeech tasks. Data was collected through EMG sensors that were affixed to participants' four quadrants of the lips during the speech and nonspeech tasks. The outcome measure was maximum voluntary contraction (MVC), which is an objective measure of the muscle strength and is typically obtained during isometric muscle contractions (Meldrum, Cahalane, Keogan, & Hardiman, 2003). Statistical analyses revealed that there was a significant main effect of the task, lip quadrants, and the stimulus. However, these main effects were qualified by a significant interaction effect between the task and the lip quadrant. The findings suggest that lip musculature behaves differently during speech and nonspeech tasks as evidenced by the %MVC values. The results of this study have implications to influence the use of NSOMEs in clinical practice, and subsequently service delivery models in speech-language pathology.

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CHAPTER 1

INTRODUCTION

Non-speech Oral-Motor Exercises (NSOMEs) are oral activities that are thought to influence speech production without actually executing speech (Forrest, 2002). They include activities such as pursing, blowing, puffing of cheeks, and lateral tongue among other oral activities. There is ongoing debate regarding the use of NSOMEs to treat speech production deficits (McCauley, et al., 2009). A recurring question among studies investigating the clinical utility of NSOMEs is the possible transfer of treatment effects of NSOMES to speech production (Hodge, 2002; Weismer & Liss, 1991). One line of thought argues against the use of NSOMEs in treating speech production deficits (Forrest, 2002; Ziegler, 2003; Weismer, 2006). According to this school of thought, the acoustic signal is an integral part of speech motor control. NSOMEs tasks do not involve speech production so it is unlikely that these tasks transfer to speech production.

Ziegler (2003) opposed using NSOMEs in the assessment or treatment of speech disorders. He mentioned that speech motor control is task-dependent or task-specific, whereby movements of the tongue, lips, and larynx are controlled in fundamentally different ways depending on whether they are involved in a speech or a nonspeech activity. Furthermore, Zeigler mentioned that the various speech subsystems (respiratory, phonatory, resonatory and articulatory subsystems) are separate to the extent that each of them has unique properties, are subserved by a neural circuitry, and can be impaired selectively after brain lesions. Based on this evidence, Zeigler advocated that speech deficits are best treated utilizing speech tasks instead of NSOMEs.

Weismer (2006) also supported Ziegler's perspective on task specificity of speech production. Wesimer mentioned that there is neither theoretical nor clinical support for the implementation of nonspeech oral motor tasks in the assessment and treatment of speech disorders, specifically, motor speech disorders. Furthermore, he stated that the relation between disordered speech and speech acoustics could not be observed in studies concerning nonspeech oral motor behavior, but rather in studies of speech production in individuals with speech disorders. Similar to Weismer, Bunton (2008) also emphasized the notion of task specificity in regard to speech production. Bunton mentioned that the speech mechanism and nonspeech mechanisms differ from one another based on four perspectives: (1) movement characteristics of non-speech oral motor behaviors and speech production, (2) treatment studies, (3) basis of motor learning, and (4) neuroanatomical underpinnings. She suggested that data from these four domains indicate that there is little theoretical or clinical evidence to use nonspeech activities to assess or treat speech deficits. Polmanteer and Fields (2002) compared the differences between traditional speech treatment versus using NSOMEs treatment. One group of children received a mixture of traditional speech and non-speech treatment and the other group received traditional speech treatment alone. The findings indicated that participants who received the combination of methods (NSOMEs & traditional speech treatment) displayed higher speech improvements compared to those who received only traditional speech treatment. Caviness et al., (2006) also supported the concept of task specificity of speech. The researchers studied the speech and nonspeech task mechanisms in in individuals with Parkinson’s disease (PD) and healthy controls through a measure known as Electroencephalographic-Electromyographic (EEG-EMG) coherence. Coherence is a correlation measure of linear relatedness between two waveforms as a function of frequency, and the coherence values range from 0 to 1. This measure is thought to reflect the coupling between electrophysiology mechanisms in the control of nonspeech and speech movement production. They recruited 20 individuals with PD and 20 healthy controls for this study. All the participants were required to carry out two nonspeech and four speech tasks and while they did this, the EEG-EMG coherence was simultaneously measured. The results revealed varied coherence values between speech and nonspeech tasks in both the groups, thus supporting the notion of task specificity of speech.

The other line of thought advocates the use of NSOMEs in the treatment of speech deficits (Folkins, Moon, Luschei, Robin, Tye-Murray, & Moll, 1995; Ballard, Robin, & Folkins, 2003). According to this view, the underlying cause of speech deficits is a motor problem. For example, Ballard et al. mentioned that the inclusion of speech tasks to treat motor-based speech deficits might fail to separate the linguistic factors in speech performance. The authors emphasized that it is important to consider parts of the speech mechanism independently of other parts. So, including NSOMEs to treat speech deficits may seem favorable to dissociate the linguistic from motoric factors. Clark (2003) advocated the idea that specific NSOMEs may have clinical relevance to treat speech deficits based on the neural underpinnings of the speech deficits. Clark emphasized that it is critical for clinicians to understand the theoretical framework of specific NSOMES, and the type of speech disorder they could be applied to. For example, strengthening exercises could be relevant to treating execution-based speech deficits like dysarthria instead of apraxia of speech, which is a speech motor planning disorder.

In spite of the ongoing controversy, a majority of practicing speech-language pathologists continue to use NSOMEs to treat speech production deficits. For example, Lof & Watson (2008) surveyed 537 speech-language pathologists nationwide to conclude that 85% of them use NSOMEs in their practice. Most of the practicing speech-language pathologists mentioned that these non-speech excerises generate a “warming up” phase for oral articulators to produce speech. According to the survey, SLPs believe that NSOMEs are beneficial to treating speech sound disorders in children. Lee & Moore (2014) surveyed speech-language therapists in Ireland and found that 56% of the SLPs make use of NSOMEs in their practice to “warm-up for children with various disorders such as down syndrome, apraxia of speech, and dysarthria. The respondents in this survey believed that children with speech disorders and swallowing deficits could benefit from NSOMEs. Thomas & Kaipa (2015) surveyed 127 practicing speech-language pathologists in India where 91% of the participants indicated that they used NSOMEs to treat a range of speech disorders, including apraxia of speech, dysarthria, and speech sound disorders. These results suggest that the percentage of SLPs who use NSOMEs in their practice is similar to the findings of surveys conducted in the USA. Most of the SLPs (96%) reported using NSOMEs under the condition of improving motor abilities such as strengthening the articulators. Other SLPs (65%) used NSOMEs to improve sensory deficits and another (61%) to treat feeding problems.

McCauley, Strand, Lof, Schooling and Frymark (2009) examined the peer-reviewed literature from 1960 to 2007 for articles on the use of NSOMEs that affect speech physiology, production, or functional outcomes (i.e., intelligibility). They found insufficient evidence to support or refute the use of NSOMEs to assist with improving speech-motor control. Similarly, Lee and Gibbon (2015) examined the argument by reviewing numerous databases to explore the relevant studies that focused on the use of NSOMEs. The findings from the review of the literature found that there is not enough substantial evidence to support or refute the use of NSOMEs.

In recent years, there has been an emphasis that the application of NSOMEs should be guided by evidence-based practice (Clark, 2003; Lass & Pannbacker, 2008; Muttiah, Georges, & Brackenbury, 2010). The term ‘evidence-based practice’ (EBP) refers to using the best, research-proven assessment and treatment techniques to deliver the most effective services to patients [American Speech, Language, and Hearing Association (ASHA), 2005]. So, it is critical that we continue to investigate the transfer effects of NSOMEs to speech production if any using an empirically supported approach. This line of research will help us to address the ongoing controversy about the clinical relevance of NSOMEs to treat speech production deficits. However, the challenge of identifying a suitable method to address the transfer effect between nonspeech and speech production continues to linger.

Current study

The current study aimed to address this ongoing controversy by employing electromyography (EMG), which is an electrophysiological measure as the outcome measure.

EMG is an electrophysiological measure that has been frequently used to track motor learning outcomes due to its accuracy and objectivity (Osu et al., 2002). However, its application has been limited in oral and speech motor learning just to a handful of studies (Wong, Ma, & Yiu, 2011; Kaipa & Kaipa, 2018). For example, Kaipa & Kaipa (2018) used EMG to compare the role of constant, blocked and random practice conditions. The EMG findings revealed that random practice facilitated oral motor learning task compared to two other practice conditions. Considering the validity of EMG to track oral and speech motor learning, the researchers in the current study investigated the issue of the transfer effect from nonspeech to speech gestures. To this end, the current study investigated the behavior of lip musculature (orbicularis oris) using EMG during a series of speech and comparable nonspeech gestures. We hypothesized that there would be differences between speech and nonspeech tasks as a function of the stimuli.

CHAPTER 2

METHODS

Participants

A total of 24 participants in the age range of 19– 27 years (9 males & 36 females) participated in the current experiment. The participants were non-randomly recruited from the OSU student community. Participants with a prior history of motor, sensory and cognitive deficits were excluded from participation. The current study was approved by the OSU IRB and all participants provided written consent to participate in the experiment.

Procedure

The participants were seated in front of a computer monitor. Prior to the initiation of the experiment, each participant was instructed on the nature of the experiment. A wireless sEMG mini sensor capable of streaming data to Trigno wireless EMG system (Delsys Inc., MA) was affixed to the participants' four quadrants of the orbicularis oris (OO) using adhesive skin interfaces. Prior to attaching the sensors, the participants' lip surface was wiped with alcohol as this allows sensors to accurately pick up the muscle potential of your lips. The dimensions of the sEMG sensor used in the current experiment were 25 mm x 12 mm x 7 mm and it weighed 19 g. The Delsys sEMG sensor has two parallel silver bars that serve as detection sites for the sEMG signal, and these bars are separated by a fixed distance of less than 10 mm. This arrangement has proven to significantly reduce crosstalk contamination of neighboring muscle groups (De Luca, Kuznetsov, Gilmore, & Roy, 2012). Additionally, this fixed distance between the bars ensures the replicability of measurements as the differing distance between detection sites can affect the quality of the sEMG signal. The sensor was placed on the longitudinal midline of the course of the muscle with the parallel bar detection sites transecting the muscle fibers, which is the recommended placement for detecting the ideal EMG signal (Salmons, 1995). The researcher exercised caution to avoid placing the EMG sensor outside the boundaries of the OO muscle to avoid crosstalk from the neighboring muscle group. An illustration of the placement of the Delsys EMG sensor on the participant's lips is shown in Figure 1.

Following this, all the participants were instructed to produce specific speech sounds and phrases and their comparable nonspeech gestures that involved silently mouthing the articulatory gestures of the speech stimuli. For example, if the participant produced the bilabial CV syllable /ba/, he/she was also required to produce the comparable nonspeech gesture of /ba/, which involved bilabial contact of both the lips but without the acoustic signal. After instructing the participants, a powerpoint (PPT) presentation was played to each participant to guide their speech and nonspeech productions. Each PPT slide contained the visual stimulus of the specific word or the phrase the participant was required to produce. Once the PPT slide containing the specific word or the phrase was displayed to the participant, the researcher encouraged the participant to produce that syllable or phrase verbally and this was followed by the production of the comparable nonspeech gesture. Once the participant produced the speech and the comparable nonspeech gesture of the displayed stimulus, the researcher entered the “return” key on the computer keyboard, and this brought up the next stimulus. In a similar fashion, each participant produced all the speech and nonspeech stimuli. It took about 15-20 minutes for each participant to complete the entire experiment. The speech stimuli included the word “pop” and the phrase “Buy Bobby a puppy” and the nonspeech stimuli included the comparable nonspeech gestures.

Data Analysis

It is well known that EMG signals have a user-dependent nature, and this causes EMG recordings to differ even when measured from the same muscular location with the same motion**.** Considering the inter-participant variability in lip contraction during the production of speech and nonspeech gestures, the EMG data that was obtained from each quadrant of the OO was normalized to the maximum voluntary contraction (MVC) obtained from the respective lip quadrant. MVC is an objective measure of the muscle strength and is typically obtained during isometric muscle contractions (Meldrum, Cahalane, Keogan, & Hardiman, 2003). MVC normalization can be used to eliminate the inter-participant variance and allows for data comparison across participants. The output is displayed as a percentage of the MVC (%MVC) value, which can be used to easily establish a common ground when comparing data between participants.

The reference MVC was obtained from a healthy female participant. To obtain the reference MVC, the female participant was instructed to perform three isometric contractions of her lips by pushing them against the resistance offered by a tongue depressor that was oriented vertically. During these isometric contractions, a single sEMG sensor was affixed to just one lip quadrant, and in a similar fashion, the reference MVC was obtained for each of the four lip quadrants. The reference MVC obtained from each lip quadrant will be used to normalize the EMG data obtained from each of the four lip quadrants of the participants during speech and comparable nonspeech gestures. A visual representation of the MVC measurement is shown in Figure 2.

The speech and nonspeech EMG data obtained during the production of CV syllables, words, and phrases obtained from each lip quadrant were normalized to the MVC value to the respective lip quadrant. The normalized values were obtained in terms of %MVC, which were in turn exported to a spreadsheet for further data analysis.

Statistical analyses

The statistical analyses were carried out using SPSS 26.0. The mean MVC values from each of the four lip quadrants during the production of speech and comparable nonspeech gestures were subjected to a 2 X 4 X 2 repeated measures analysis of variance. The three within-group (independent) variables were the task (speech and nonspeech), lip quadrants (upper right, lower right, upper left, and lower left), and the stimulus (word and phrase). This allowed us to investigate the main effect of task, quadrants, and stimuli as well as interactive effects between these factors, if any. The alpha will be set at 0.05.

CHAPTER 3

RESULTS

Statistical analyses revealed that there was a significant main effect of the task, lip quadrants, and the stimulus. However, these main effects were qualified by a significant interaction effect between task and the lip quadrant, $F(2.05, 47.09) = 3.74$, $p < 0.05$, $\eta^2 = 0.11$. Pairwise comparisons indicated that during the speech production task, the %MVC at upper right quadrant was significantly higher than the lower left quadrant, the %MVC at upper left quadrant was significantly higher than the lower left quadrant, and the %MVC at upper left quadrant was significantly higher than the lower left quadrant. In the case of nonspeech production, the %MVC at lower right was significantly higher than the lower left. There were no other significant interaction effects. The absolute %MVC values for sentence and word production during speech and nonspeech tasks across the four lip quadrants are depicted in Table 1. The average %MVC values when participants produced the sentence “buy Bobby a puppy” and the corresponding nonspeech gestures across the four quadrants are depicted in Figure 3. The average %MVC values when participants produced the word “pop” and the corresponding nonspeech gestures across the four quadrants are depicted in Figure 4.

CHAPTER 4

DISCUSSION

The aim of the current study was to investigate if the lip musculature behavior during speech and comparable nonspeech tasks. The results indicated that there are significant differences between not only speech and nonspeech tasks but also across different lip quadrants. These results support our initial hypotheses.

The concept of “task specificity of speech” has been feverishly debated over the last three decades (Weismer, 2006). This has resulted in two schools of thought over the years. One school of thought considers speech to be “task dependent”. According to this view, the acoustic signal is an integral part of speech-motor control. Non speech oral tasks do not involve speech production so it is unlikely that these tasks provide insight into speech productions. As per task-dependent model, the movements of the tongue, lips, and larynx are controlled in fundamentally different ways depending on the particular motor activity. Furthermore, the task dependent model explains that the various subsystems of speech production (respiratory, phonatory, resonatory and articulatory subsystems) are separate to the extent that each of them has unique properties, are subserved by a neural circuitry, and can be impaired selectively after brain lesions (Ziegler, 2003). Additionally, it has been suggested that cortical activation sites differ for nonspeech versus speech movements. For example, Wildgruber et al. (1996) compared cortical activation during speaking to a nonspeech task of vertical tongue movements using functional magnetic resonance imaging (fMRI). The fMRI findings revealed that the speech task resulted in increased activation of the left motor strip, whereas the nonspeech task resulted in bilateral symmetric activation.

Research examining EMG activity in mandibular muscle tasks suggests differing activation patterns for speech versus nonspeech tasks, providing further evidence of task-specificity (Moore, Smith, & Ringel, 1988). Ruark and Moore (1997) used EMG recordings to examine upper and lower lip activity in two-year-old children during the production of speech and nonspeech tasks. The researchers found differing coordinative organization of the upper and lower lip during speech and nonspeech tasks.

The other line of thought supports the support the transfer of nonspeech oral movements to speech production, more commonly referred to as the integrative model (Folkins, 1985; Folkins, Moon, Luschei, Robin, Tye-Murray, & Moll, 1995; Ballard, Robin, & Folkins, 2003). According to this model, speech and volitional nonspeech motor control are integrated into the functioning of a more general motor system where neural and behavioral systems demonstrate areas of overlap. Folkins (1985) postulated an integrated motor approach to speech production in which speech is organized ultimately to produce the holistic behavior of communication. Folkins' model was developed to argue against the need to use linguistic units as organizing structures for the motor aspects of speech. The integrative model does not claim complete task-dependence or task dependence, rather it takes a stand between the two, wherein certain volitional nonspeech tasks share principles in common with speech and therefore with speech motor anomalies (e.g. dysarthria). This model strongly hypothesizes that at complex behavioral levels, there must be overlapping functional components and therefore overlapping and integrative neural pathways or networks. Folkins et al (1995) reported the possible role of nonspeech tasks in assessment of individuals with motor speech disorders. The researchers explained that individuals with motor speech disorders have an inability to control the movements of the structures that produce speech and such inabilities separate a speaker's abilities or inabilities to use the psycholinguistic processes that code meaning in the production of speech and language. So, to assess motoric deficits in an individual with motor speech disorder it is necessary to separate the motoric deficits from the psycholinguistic deficits if present. Nonspeech tasks can be designed to measure the pure motoric deficits and gives better insight to understand the nature of the prevailing motor speech disorder and in addition it also separates the co-occurring psycholinguistic deficit, if any.

The findings from the current study are in agreement with the findings of Moore, Smith, and Ringel (1988) and Ruark and Moore (1997), thus supporting the notion of “task specificity”. This begs the question, “why did the EMG findings differ between the tasks?”. The answer to this question can be better explained by understanding the anatomical and physiological substrates of the lip musculature. The bulk of the human lip is comprised of orbicularis oris (OO) which is a multi-layered muscle that is attached through a thin, superficial aponeurosis to the upper and lower lip. The OO has four quadrants with interdigitating muscle fibers during isometric muscle movements. During the contraction of OO, nerve impulses from alpha motor neurons reach motor end plates at the neuromuscular junction. These pulses cause all muscle fibers innervated by that motor neuron’s axon to discharge nearly synchronously to create a motor unit action potential (MUAP) (Stepp, 2012). It is well established that the strength of the MUAPs arising from the OO differs as a function of the task. In the current study, the difference in %MVC between speech and nonspeech tasks across the lip quadrants indicates the differences in the physiological makeup of OO between the speech and nonspeech tasks.

Limitations

Although the current study presents interesting findings, it is not without limitations. First, the sample size was not large which makes it challenging to extrapolate the findings to a larger population. Second, the data was collected from young adults, it remains to be see if these findings would vary as a function of age. Third, although care was taken to reduce cross-talk from neighboring muscle groups, the possibility of interference from other muscle groups cannot be ruled out completely.

Conclusion

The current study supports the concept of “task specificity”, which suggests that there is lack of transfer effect between nonspeech and speech tasks. The findings are of significant relevance especially to practicing clinicians. A majority of the speech-language pathologists continue to use nonspeech oral exercised to treat speech disorders. With mounting evidence that argue against the transfer effect from nonspeech to speech production, the practice of using nonspeech oral exercises in clinical practice need to be carefully evaluated. ASHA continued to encourage clinicians to engaged in evidence-based practice, so, clinician need to carefully consider the clinical relevance of using nonspeech oral exercises to either assess or treat patients. This study indicated that NSOMEs should not be used by clinicians.

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Table 1. % MVC values in speech and nonspeech tasks for sentence and word productions. UR-upper right quadrant; LR-lower right quadrant; UL – upper left quadrant; LL- lower left quadrant

Speech								Nonspeech							
Sentence				Word				Sentence				Word			
UR	LR	UL	LL	UR	LR	UL	LL	UR	LR	UL	LL	UR	LR	UL	LL
86.83	100.34	50.7	114.5	44.49	128.9	43.68	101.6	38.76	93.01	41.75	120.49	32.6	48.74	34.13	39.2
81.14	40.89	90.3	28.96	87.68	53.82	95.28	23.55	53.29	30.39	66.95	27.75	47.4	17.67	44.63	23.4
49.07	50.16	84.8	60.93	42.76	32.1	55.57	32.26	33.54	28.62	41.83	27.03	22.9	17.01	26.38	22.8
70.57	59.12	76.3	51.95	43.43	38.85	62.64	38.12	37.15	50.72	38.35	39.35	27.0	45.68	25.53	34.0
135.5	48.29	133.	23.25	73.13	47.77	116.3	23.77	109.6	45.41	129.3	20.18	83.4	46.16	112.8	18.6
63.54	101.06	76.7	45.08	42.4	69.02	58.58	29.57	48.33	73.79	56.46	42.8	29.8	73.86	42.17	39.5
76.59	82.11	88.8	39.63	70.36	48.01	99.35	23.55	49.35	62.64	42.72	29.9	61.2	28.48	55.77	22.0
65.61	22.65	60.0	16.49	56.26	13.93	61.1	10.36	46.42	22.37	43.94	19.64	45.7	17.17	36.26	8.27
48.78	31.73	63.9	26.62	24.42	14.66	42.36	18.56	61.13	21.8	58.17	18.06	50.4	20.14	36.77	17.8
52.44	47.39	46.4	62.13	49.92	31.31	39.43	34.19	36.99	35.06	22.13	37.97	31.3	23.77	16.62	26.1
74.27	58.94	71.0	80.71	60.58	30.79	67.16	69.33	58.09	35.43	57.76	44.23	44.0	12.11	40.33	27.5
33.39	56.38	59.3	37.22	29.82	38.67	40.16	46.71	20.24	36.37	39.35	31.59	18.4	17.72	23.07	20.0
75.24	75.8	57.8	62.72	45.12	44.74	36.99	36.83	59.88	59.56	54.49	31.85	18.6	23.93	16.62	23.4
46.83	45.47	52.3	37.15	20.67	31.14	26.23	24.02	27.42	35.37	33.48	27.61	13.7	24.07	16.08	27.7
41.73	43.92	48.1	34.49	35.79	32.67	47.76	23.97	34.42	38.24	40.24	28.39	28.6	24.61	32.84	21.4
37.78	53.33	51.7	34.25	30.43	46.22	53.9	23.33	35.39	59.47	50.12	34.65	35.8	37.83	47.85	34.7
64.23	50	56.2	20.88	44.88	51.63	46.1	31.1	49.39	39.53	42.8	20.88	24.7	24.86	28.5	17.0
59.11	36.87	54.3	30.06	65.81	14.68	64.59	12.15	45.98	17.21	35.59	13.2	28.5	15.38	18.1	12.0
78.25	77.11	55.9	48.37	62.4	58.54	48.7	38.17	74.88	62.6	61.63	39.07	47.3	58.56	41.89	32.0
84.31	64.11	70.4	53.83	86.28	39.41	64.56	38.66	75.28	40.28	62.03	33.06	69.7	16.37	52.89	24
55.16	72.93	60.2	50.28	57.52	66.83	33.6	31.89	75.85	82.68	60.93	60.08	59.8	66.72	44.84	43.3
58.13	27.8	47.2	37.66	36.36	20.88	32.55	25.12	36.61	20.37	33.19	29	23.8	17.33	24.71	20.7
60.97	79.13	58.9	63.52	38.01	43.15	38.58	33.69	42.23	61.7	53.08	38.55	29.2	24.97	18.75	24.7
88.6	89.84	76.8	82.8	57.15	58.58	58.86	45.04	50.93	64.35	61.18	66.81	47.2	76.71	38.33	76.4

Figure 1. Placement of the surface EMG sensor

Figure 2. MVC measurement from the lower left lip quadrant based on three isometric lip contractions

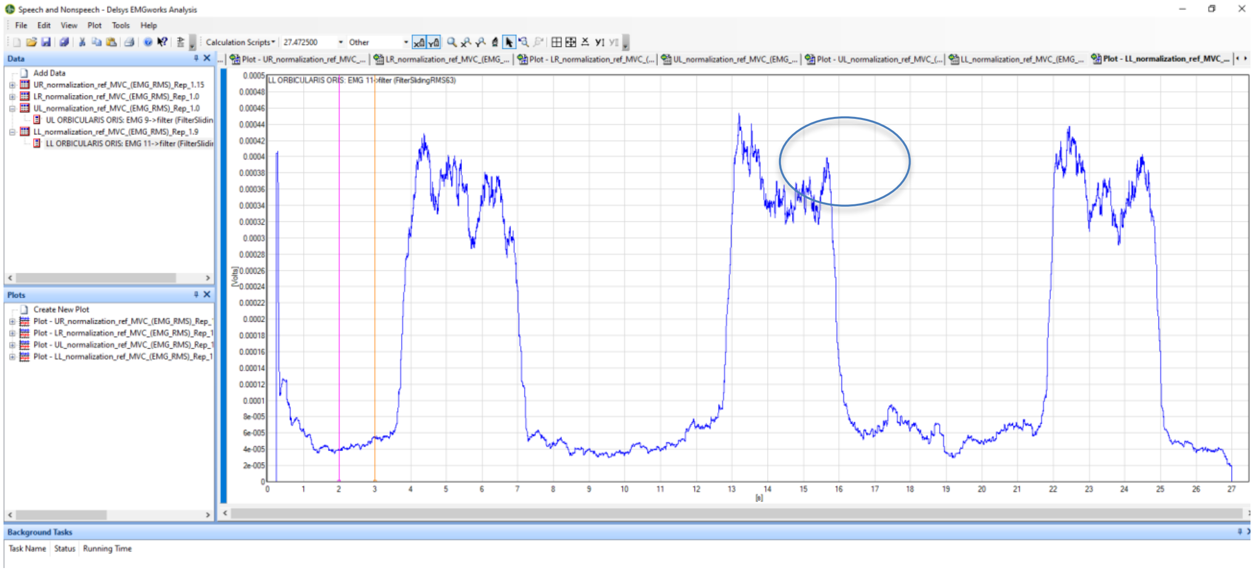


Figure 3. % MVC values while producing the sentence “buy Bobby a puppy” and the corresponding nonspeech gestures. Quadrants 1, 2, 3, & 4 represent the upper right, lower right, upper left, and lower left lip quadrants, respectively. Tasks 1 & 2 represent speech and nonspeech tasks, respectively.

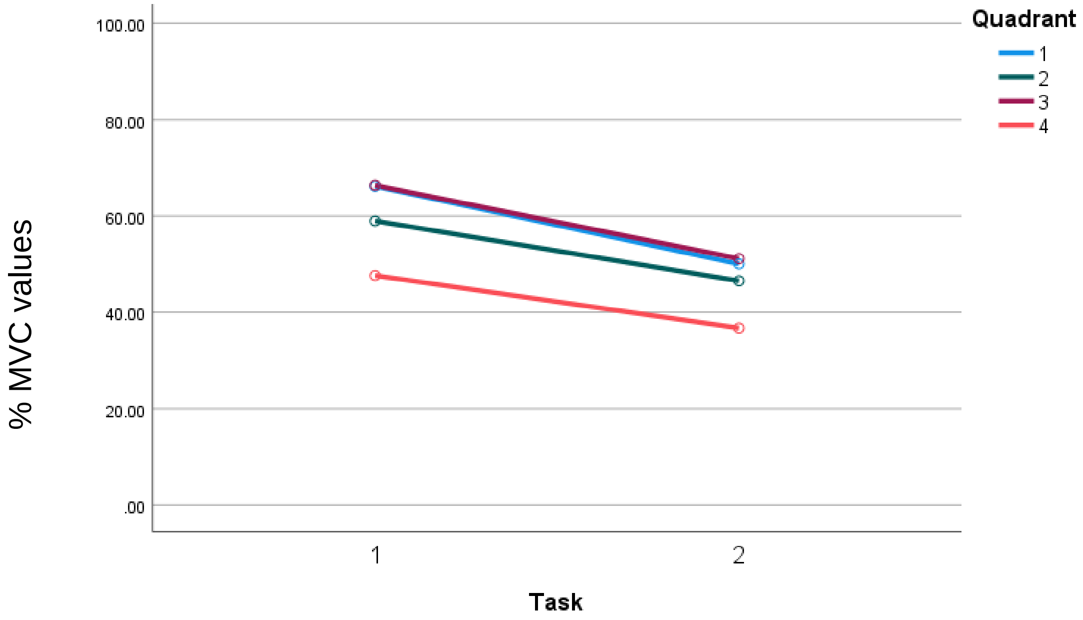
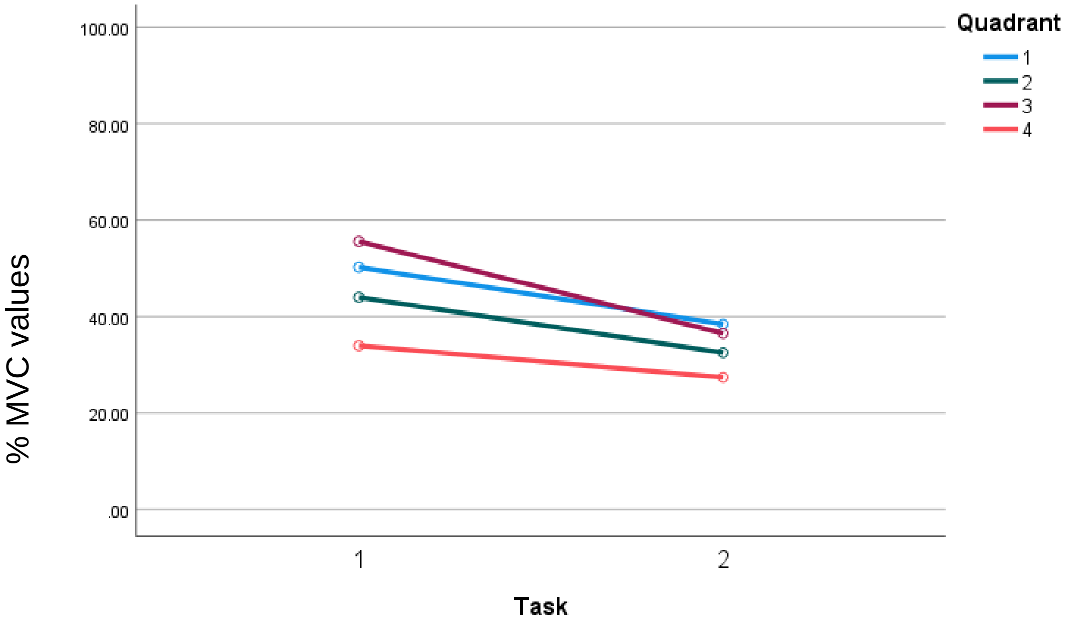


Figure 4. % MVC values while producing the word “pop” and the corresponding nonspeech gestures. Quadrants 1, 2, 3, & 4 represent the upper right, lower right, upper left, and lower left lip quadrants, respectively. Tasks 1 & 2 represent speech and nonspeech tasks, respectively.



VITA

Ericca Renee Carter

Candidate for the Degree of

Masters of Science

Thesis: STUDY OF LIP MUSCULATURE DURING SPEECH AND NONSPEECH PRODUCTION TASKS USING EMG-BASED OUTCOME MEASURES

Major Field: COMMUNICATION SCIENCES AND DISORDERS

Biographical:

Ericca Carter was born and raised in Amarillo, Texas. She attended Oklahoma State University in Stillwater, OK, where she earned a Bachelor of Science in Communication Sciences and Disorders in May 2021. She continued her education at Oklahoma State University, where she received a Master of Science in Communication Sciences and Disorders in May 2023.

While at OSU, Ericca served as a graduate research assistant in the Motor Speech Lab under Dr. Ramesh Kaipa. She collected data for a project that treats speech intelligibility deficits in individuals with Parkinson’s Disease using Delayed Auditory Feedback.

Currently, Ericca’s clinical interests include serving clients in acute care and outpatient settings.