Effects of Accented Speech on Listening Effort and Speech Perception in College Students

Sophia Rosene [1] and Sridhar Krishnamurti [2]

[1] Undergraduate Student, Department of Speech, Language, and Hearing Sciences, Auburn University
[2] Professor of Audiology, Department of Speech, Language, and Hearing Sciences, Auburn University

As the United States is becoming more multicultural and diverse, Americans are becoming more exposed to foreign accents. According to Van Engen and Peelle (2014), degraded speech caused by foreign accents requires additional cognitive processes for listener comprehension; the brain must recruit more neurons from the cingulo-opercular attention network when under stressful listening conditions. Furthermore, an increase in cognitive load can cause an increase in pupillary dilation (Porretta and Tucker 2019). Because of this, our study was able to use pupillometry to objectively measure whether more listening effort and cognitive load are required when listening to an accented speaker versus an unaccented speaker.

There were three main aims to our study: Aim 1 was an acoustic analysis of accented versus unaccented speech, Aim 2 tested the effects of accented speech on listening effort using pupillometry, and Aim 3 measured speech perception (speech intelligibility and speech comprehensibility).

The first step of our study was to acoustically analyze audio recordings of accented and unaccented speech by creating spectrograms in Adobe Audition (Fig. 1). The audio recordings contained 40 sentences total: 20 spoken by a male and a female from the United States whose native language was English (unaccented speech); 20 spoken by a male and a female from Québec, Canada whose native language was French (accented speech). The spectrograms showed that accented speakers paused more frequently between words than unaccented speakers. This resulted in clear differences in speech timing, which can impact speech understanding (Smith and Rathcke 2010). Accented speakers also produced mispronunciations, which caused slight distortions in the spectrograms. However, pitch and loudness were not significantly different between accented and unaccented speakers (a female was compared to a female and a male was compared to a male).

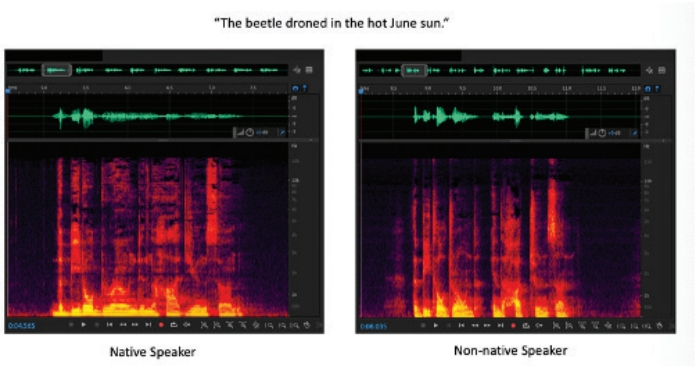


Fig. 1 Spectrograms show a native speaker of English (unaccented) and a non-native speaker of English (accented) saying "The beetle droned in the hot June sun."

After the audio recordings were acoustically analyzed, we began to collect data. The study was approved by Auburn University's Human Subjects IRB. We recruited nine American, college-aged students whose native language was English to participate. Before participating, subjects were administered vision, audiometry, and tympanometry tests to ensure they had normal vision, hearing, and middle ear function. Luminescence tests were also completed to ensure normal pupillary response to light. Next, the participants completed the pupillometry listening task. During the task, the participants listened to the audio recordings of accented and unaccented speech as they wore Micromedical Videonystagmography (VNG) eye goggles, which measured their initial and final pupil diameters (Fig. 2). Participants would hear a sentence and repeat back what they heard verbatim, which was scored for accuracy. This gave us speech intelligibility scores (how well someone is understood when speaking). The participants would also be asked to rate how difficult it was to understand

[1]Corresponding author: sfr0006@auburn.edu

each speaker on a scale from 1 to 5 (1 being very easy; 5 being very difficult). This subjective data gave us information on speech comprehensibility (how easily the listener can understand what the speaker is trying to say). All the while, the eye goggles were measuring changes in pupil diameter.

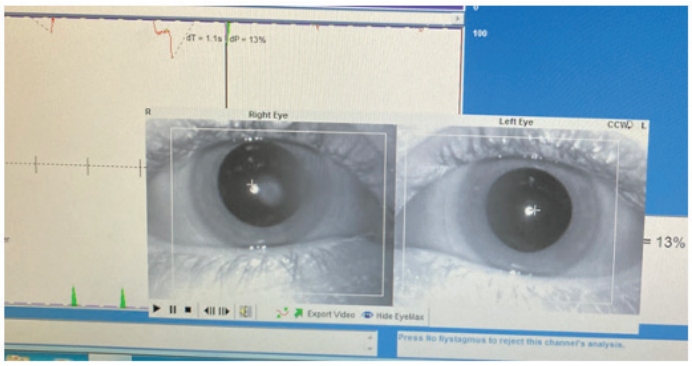


Fig. 2 Micromedical Videonystagmography (VNG) eye goggles measured initial and final pupil diameter during the pupillometry listening task.

After collecting the data, we averaged speech comprehensibility ratings for each speaker. For males, the unaccented speaker received a 1.2 while the accented speaker received a 2.2. For females, the unaccented speaker received a 1.2 while the accented speaker received a 2.3. Therefore, the participants found the unaccented speakers to be very easy to understand and the accented speakers to be more difficult to understand. While there were notable differences in speech comprehensibility, speech intelligibility scores were not significant.

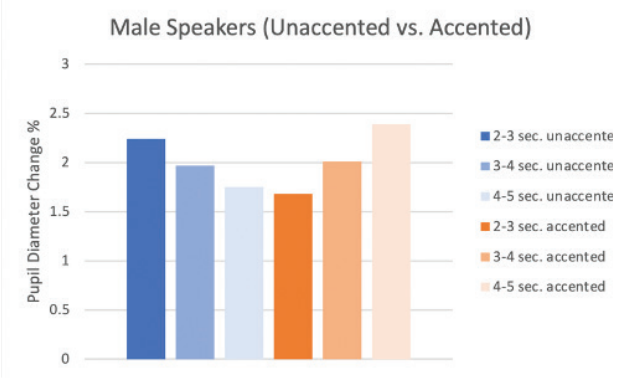


Fig. 3 Pupil diameter change by time interval for the unaccented and accented male speakers.

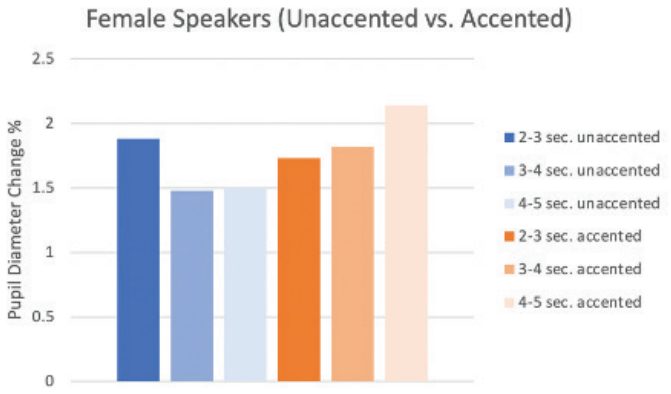


Fig. 4 Pupil diameter change by time interval for the unaccented and accented female speakers.

Lastly, statistical analyses were completed using IBM-SPSS software Version 23. The between-subjects independent variable was unaccented speech versus accented speech. The within-subjects independent variable was time interval during the task (2-3, 3-4, and 4-5 seconds). The dependent variable was the change in pupil diameter measured in percentage. These variables can be seen in Figures 3 and 4. The repeated measures ANOVA procedure was completed to look for significant differences across the six means for each speaker (Table 1). Paired T-test comparisons were completed to look for significant differences between unaccented and accented speech conditions (Table 2).

There were statistically significant differences when comparing the male accented speaker to the male unaccented speaker (Table 1). The male accented speaker caused greater pupil diameter changes in listeners, meaning he required greater listener effort and more cognitive load. Furthermore, the 4-5 second time interval showed statistically significant differences for both male and female speakers (Table 2), which means accented speech caused greater changes in pupil diameter than unaccented speech at this specific time interval. We believe peak dilation was consistently occurring at the 4-5 second time interval because at that moment, the speaker was finished saying the sentence, and it was time for the listener to repeat back what they had just heard; this brief moment of stress was creating the largest changes in pupil diameter that we were seeing, and listening to accented speech was proving to be more stressful than listening to unaccented speech. Greater changes in pupil diameter from listening to accent-

ed speakers can also be attributed to the poor speech comprehensibility ratings they received from listeners. Lastly, we found that our participants required more processing time to listen and respond to accented speech than they required for unaccented speech.

Table 1 ANOVA Results.

	dF	F	sig
Female Speakers (accented vs. unaccented)	5	1.85	0.10
Male Speakers (accented vs. unaccented)	5	2.14	0.05*

Table 2 Paired T-test Results.

Talker	Interval	Probability of Significance
Female	2-3 seconds	0.6
Female	3-4 seconds	0.2
Female	4-5 seconds	0.007*
Male	2-3 seconds	0.04*
Male	3-4 seconds	0.8
Male	4-5 seconds	0.03*

We can reasonably and objectively say that accented speech can cause greater changes in pupil diameter, require more listening effort, and place greater cognitive demands on a listener than unaccented speech. Accented speech can also take a longer time to process. Finally, listeners find accented speakers more difficult to understand in general. With these findings, we can better understand ourselves and the ways we react to degraded speech and stressful listening situations.

Statement of Research Advisor

Sophia Rosene has a passion for research in human listening behavior, and this is reflected in her selection of 'accented speech' as a variable in listening for college-aged students. She willingly learned the methodology for pupillometry and conducted the testing and analysis required for all participants. We appreciate the support for this study from the Undergraduate Research Fellowship Program in terms of mentoring, funds for participants, and providing a forum for presenting our results.

- Sridhar Krishnamurti, Speech, Language, and Hearing Sciences

References

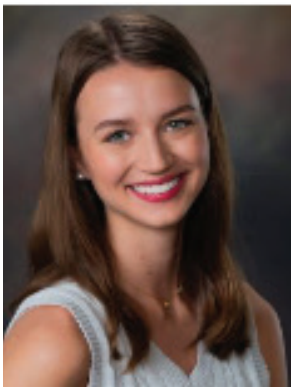
[1] Porretta, V. and Tucker, B.V. (2019). Eyes Wide Open: Pupillary Response to a Foreign Accent Varying in Intelligibility. Front. Commun. 4:8. doi: 10.3389/fcomm.2019.00008

[2] Rathcke, T., Smith, R. (2011). Exploring Timing in Accents of British English. Proceedings of the 17th International Conference on Phonetic Sciences, pp. 1666-1669.

[3] Van Engen, K. J., and McLaughlin, D. J. (2018). Eyes and ears: Using eye tracking and pupillometry to understand challenges to speech recognition. Hearing Research, 369, 56–66. https://doi.org/10.1016/j.heares.2018.04.013

[4] Van Engen, K.J. and Peelle, J.E. (2014). Listening effort and accented speech. Front. Hum. Neurosci. 8:577. doi: 10.3389/fnhum.2014.00577

Authors Biography



Sophia Rosene is a senior-year student pursuing a B.S. degree in Speech, Language, and Hearing Sciences at Auburn University. She will begin the master's program in speech-language pathology at the University of Alabama in the Fall of 2023. She is interested in accented speech and foreign languages.

Sridhar Krishnamurti is a professor of Audiology in the department of Speech, Language, and Hearing Sciences at Auburn University. He has authored and co-authored articles and book chapters in electrophysiology, aging, hearing conservation, auditory processing disorders, and hearing aids.