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Quantifying Speech Pause Durations in Speakers With Nonfluent and Fluent Aphasia

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A thesis submitted to the faculty of
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Master of Science

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ABSTRACT

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This study investigates pause duration between and within utterances in the speech of 20 people with different degrees and types of aphasia: 15 with fluent aphasia and five with nonfluent aphasia. It also examines within utterance pause durations as a function of utterance position. Using aphasia speech samples collected in a previous study by Harmon (2018), Praat acoustic analysis software was used to segment words and periods of pause and measure pause duration within and between utterances. The data were analyzed using descriptive statistics, including pause duration mean, standard deviations, and interquartile range. Speech pauses were also categorized by the percentage of pause durations greater than 250 ms, 500 ms, 750 ms, and one second. Nonfluent aphasia presents higher mean durations of both between and within utterance pauses than fluent aphasia. Speakers with fluent and nonfluent aphasia subtypes exhibit a larger proportion of pauses longer than one second between utterances than within them. Between utterances, there is a positive association between increase in aphasia severity and an increase in pause duration. Within utterances, speech from individuals with moderately severe aphasia have longer mean pause durations than mild or very mild cases. Individuals with both fluent and nonfluent aphasia demonstrate increased pause durations in the initial sentence position. Further research will provide insight into how this compares with typical speech and how these pause patterns affect the communicative effectiveness of the speaker.

Keywords: speech pause, aphasia, prosody, nonfluent, fluent

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DESCRIPTION OF THESIS STRUCTURE

This thesis, *Quantifying Speech Pause Durations in Speakers With Nonfluent and Fluent Aphasia,* is part of a larger study exploring the impact of cognitive pause on speech communication in persons with aphasia. It is written in a hybrid format. The hybrid format brings together traditional thesis requirements with journal publication formats. Portions of this thesis may be submitted for publication, with the thesis author being included in the list of contributing coauthors. An annotated bibliography is provided in Appendix A, and the consent form used in this study is provided in Appendix B.

Introduction

Communication involves more than just the words we speak. Nonverbal cues play an integral role in the way we present ourselves to the world. Among these nonverbal cues are pauses. Although the act of pausing may seem like the absence of meaningful content—simply a place to breathe or perhaps organize one's thoughts—pauses also convey meaning. Pauses provide structure to spoken language, often marking syntactic boundaries in discourse, both within and between sentences (Yang, 2004). Pauses can provide emphasis, convey hesitation, and highlight emotions and attitudes (Roberts & Francis, 2013; Tisljár-Szabó & Pléh, 2014). The degree of pause in a person's speech can affect the overall prosody of a speaker's communication, which has been linked not just to comprehension but also to how a speaker is perceived in terms of likability, intelligence, and truthfulness (Baskett & Freedle, 1974; Kraut, 1978; Scherer et al., 1973).

Speech Pause in Typical Speakers

Linguistic Functions

The use of pause in typical speakers follows predictable patterns. One function of pause is grammatical: pauses segment speech and mark boundaries, much like punctuation marks boundaries in written text. One study by Yang (2004) found that 60–88% of pauses marked a boundary, or end of a phrase. The range depended on the source of speech, with narratives having the highest proportion of phrases with a boundary-marking pause. Furthermore, longer pauses were typically correlated with the end of a phrase, while shorter pauses were non-boundary marking. The most frequently measured duration of non-boundary pause was half a second and boundary pause one second. While there was overlap of pause duration in boundary and non-boundary pause, the longer the pause, the more likely it was to mark the end of a phrase

(Yang, 2004). Just as the end of a written sentence is marked with a period, the end of a spoken sentence is typically marked with a pause. Speech-to-text technology even uses information on pause in their algorithms to detect and insert punctuation automatically (Igras-Cybulska et al., 2016). With such a large percentage of pauses serving as boundary markers, it is easy to see how these patterns can be incorporated into technology with increasing accuracy as more information is gathered.

In addition to syntactic function, pause duration and quantity is tied to the semantic context of a speaker's expression. Typical readers use more and longer pauses when semantic context is unpredictable. In one study, participants were asked to read and retell stories. Some participants read typical versions, but others read versions wherein the third sentence's subject and object were reversed. Those reading and retelling the atypical version with unexpected semantic context had an increase in the number and length of pauses. The average number of pauses in the third sentence increased when an atypical semantic context was introduced. The length of pauses during the atypical sentence increased eight ms for one story and 421 ms for another and the length of pause after reading that sentence increased by 416 ms for the first story and 297 ms for the second (O'Connell et al., 1969).

Along with syntactic and semantic information, pausing can also convey emotion. Studies have found that there are differences in the patterns of pause duration and number when a speaker is feeling different emotions. For example, one study modified emotionally neutral speech to increase or decrease the length of pauses. Listeners rated the speaker on scales for the following: angry, sad, disgusted, happy, surprised, scared, positive, and heated. Longer pauses were associated with sad and scared speech, while short pauses were linked with happy and

positive emotions. The authors concluded that pause plays a large role in ascribing emotions which may be partly independent from language content (Tisljár-Szabó & Pléh, 2014).

Emphasis is also a key function of pause. Any class, article, or book on becoming a great public speaker will address the importance of the use of pause in conveying an intended message. This passage from a newspaper article by British psychologist Adrian Furnham provides an example:

> Then there is the art of the pause—pause for effect, pause for reflection, pause for profundity. Too many politicians have forgotten this. In their manic desire to "keep the conch shell" during the Paxman interview, they overlook the power of pauses. They can be interpreted as doubt or dither, but equally they can, and should, be used to great effect. (Furnham, 2013)

Pause is frequently utilized by good public speakers. An analysis of President Barack Obama's speeches found that he relied on pause to the extent that 30–40% of the duration of his speeches were pause (Ichizaki, 2016). Pause as a vehicle for emphasis is demonstrated frequently in public speaking.

Speech context also has an effect on pause. A multilingual study looked at pause patterns in five languages, including English. The researchers divided pause into short (<200 ms), medium (200–1,000 ms), and long (>1,000 ms) durations, and found that spontaneous speech relies more on medium and long pauses, but speaking from a written text leads to more short and medium pauses (Campione & Véronis, 2002).

Another function of pause is cognitive in nature. Speakers plan out the content of their utterances during pauses and may pause more when they need more time to think about what they are going to say. Typical speakers pause more frequently under divided attention conditions

(Oomen & Postma, 2001). Speakers of a second language have longer and more frequent pauses than native speakers and may pause in inappropriate places as they process and plan shorter segments of speech (Bilá & Džambová, 2011).

The placement of pauses has an effect on the perception and comprehension of speech. Sentences with a pause in a structural location (i.e., between clauses) can be recalled with greater speed and accuracy than those with a pause in a nonstructural location (i.e., within a clause) (Reich, 1980). Thus, a pause in an unusual, nonstructural location can undermine the speaker's message. Where written language is divided by punctuation, spoken language is broken up by pause, organizing the speaker's message in comprehensible parts. When pause patterns are unusual, comprehension can be impeded (Bilá & Džambová, 2011).

Listener's Perceptions of Psychological Traits

Pause is known to have some effect on how a speaker is perceived by others. In a study looking at what paralinguistic cues mark confidence in speech, researchers found that speakers who were rated by listeners as confident and knowledgeable used shorter and less frequent pauses (Scherer et al., 1973). Another study looked specifically at pauses after a request or invitation was issued. When the respondent paused over 600 ms before giving an affirmative response, listeners rated them as less willing or enthusiastic (Roberts & Francis, 2013). A longer pause communicated to the listener a different message than the speaker's words conveyed.

A speaker's perceived honesty has also been tied to the length and number of pauses used in discourse. Experiments by social psychologists and linguists in the 1970s investigated the correlation between pause length and perceived honesty. Listeners were more likely to judge a response to question as untrue when there was a longer pause. Further investigation showed that after a seven-second pause, if the answer was self-serving, it was interpreted as a lie, but a self-

damaging answer was judged as truth (Kraut, 1978). Another study asked participants to listen to a speaker self-evaluate whether they had various attributes, saying “true” or “false” after an adjective was read to them. The participants were asked whether they thought the speaker was lying or telling the truth. They found that a response coming too quickly or too slowly was viewed as a lie (Baskett & Freedle, 1974). Pauses can have a large effect on the perceived meaning of an utterance, even contradicting the intended message.

Patterns of Speech Pause in Atypical Speakers

Pause is one aspect of speech that can change in many conditions, whether developmental or acquired. Speakers learning a second language are shown to have a greater number of pauses and greater pause duration (Kahng, 2018). Typical aging and Parkinson’s disease are both associated with increased pauses in less natural communicative locations (Lee et al., 2019), in addition to speakers with fluency disorders (Rodrigues et al., 2017). One study also found that participants with Alzheimer’s disease produced more pauses than their peers, but suggested this could be a positive sign of awareness of their weak processing abilities and used as compensatory mechanisms in early stages of the disease (Pistono et al., 2019). Extended and atypical patterns of pause is also a common speech impairment for individuals with aphasia (Hird & Kirsner, 2010).

Aphasia is an acquired, neurologically-based language disorder that affects receptive and expressive language abilities across communication modalities (Hallowell, 2017). Aphasia can be grouped into fluent and nonfluent types, with atypical patterns of pause appearing more frequently in nonfluent types of aphasia. People with aphasia (PWA) have been shown to be viewed more negatively than typical speakers, with some individuals erroneously perceiving aphasia as an intellectual impairment—a misunderstanding that professionals, people with

aphasia, and their caregivers must work to correct (Hallowell, 2017). One study showed that even the people closest to PWA have less positive perceptions of them. Croteau and Le Dorze (2001) investigated how significant others perceived their partners with aphasia by asking spouses of PWA and a control group to check which adjectives best described their spouse. The study found statistically significant differences in the adjectives selected, and PWA were viewed more negatively than typical speakers. Furthermore, men with aphasia were viewed more negatively than women with aphasia. The authors posit that this may be explained by societal expectations of women to be weaker, more passive, and more dependent, all attributes additionally associated with disability. Moreover, men with aphasia scored lower on achievement and endurance scales, which likely reflected many of the men being unable to continue employment, whereas most of the women in the study had not been previously employed. Characteristics related to endurance and achievement seemed to be perceived as more important associations with men and the loss thereof consequently more salient (Croteau & Le Dorze, 2001).

These difficulties to communicate and the possibility for erroneous perceptions about a PWA's personal attributes may be due to difficulties at the semantic, syntactic, or pragmatic levels of communication. However, challenges may also result from the dysfluent nature of a PWA's speech prosody as a result of frequent and extended pausing.

A study looking at Greek speakers compared the number and duration of pauses in the speech of healthy individuals compared to the speech of PWA. Participants were asked to provide a brief personal history. The mean number of pauses for healthy individuals was 19.75 and the mean number of pauses for PWA was 54.06 (Angelopoulou et al., 2018). Another study compared the patterns of speech pause PWA with and without apraxia of speech and

neurotypical speakers. Each participant retold short stories in a single task, then in a dual task while also distinguishing between high and low tones. Both groups with aphasia had more pause time than the control group under both conditions. In the single task condition, PWA with apraxia group had a median pause time of 36% of the total sample time, the aphasia only group had 40% pause time, and the control group had only 10% pause time. The dual task condition saw an increase in pause time in all groups, suggesting the increased cognitive load had an effect. The median pause time was 53% in the group of PWA and apraxia, 55% for the PWA, and only 20% for the control group (Harmon et al., 2019). Another study found similar results: when retelling a Cinderella narrative, the average pause time was 43% for people with anomic aphasia, 37% for people with latent aphasia, and 6% for the neurotypical controls. The authors posit that PWA have a processing speed deficit, which is displayed in the increased pause time (DeDe & Salis, 2020).

A study by Harmon et al. (2015) compared listener's perceptions of nonfluent and simulated fluent samples from speakers with aphasia and a control group of neurotypical speakers. The simulated fluency samples were created by removing disfluencies, including extended pauses, from the original speech recordings. The simulated fluency samples yielded improved listener perceptions compared to the non-altered speech of PWA. In essence, the speaker's same words without the disfluencies were viewed in a more positive light (Harmon et al., 2015).

The studies reviewed above provide important and valuable insight into how PWA's atypical patterns of pause might impact their communicative effectiveness and how others perceive them. However, there is a need for additional research that quantifies within and between utterance speech pause durations in speakers with both nonfluent and fluent types of

aphasia; an analysis that also examines differences in pause durations as a function of utterance position. Thus, this study specifically aims to:

1. Quantify within and between utterance pause durations in the speech of people with differing degrees and types of aphasia.
2. Describe the within utterance pause durations as a function of utterance position.

Method

The data collected in this thesis was part of a joint research project examining the influence of speech pause on listener perceptions of communicative effectiveness and personal attributes.

Speech Recordings

The segments of speech evaluated in this study were extracted from audio samples previously collected in a research project by Harmon (2018) evaluating the effect of partner attitudes, attention, and emotion on the communication of PWA. The segments acoustically analyzed consisted of samples of speech produced by 20 individuals diagnosed with aphasia, seven male, 13 female. The samples were approximately one to two minutes in length. As shown in Table 1, 11 of these individuals presented with mild or very mild aphasia and nine individuals presented with moderate aphasia as measured by scores on the Western Aphasia Battery Aphasia Quotient (WAB-AQ). The speech samples were elicited by asking the PWA to retell a story to a supportive communication partner. All participants signed a consent agreement approved by the Institutional Review Board at UNC-Chapel Hill (IRB Study #16-2544).

Acoustic Measurements

Using Praat acoustic analysis software (Boersma & Weenink, 2021), each sound segment was used to create a viewable acoustic signature, as shown in Figure 1. This display contained

two “text grids” that were used to mark the beginning and end of each utterance, as well as individual word segments and periods of pause. Instances of obvious

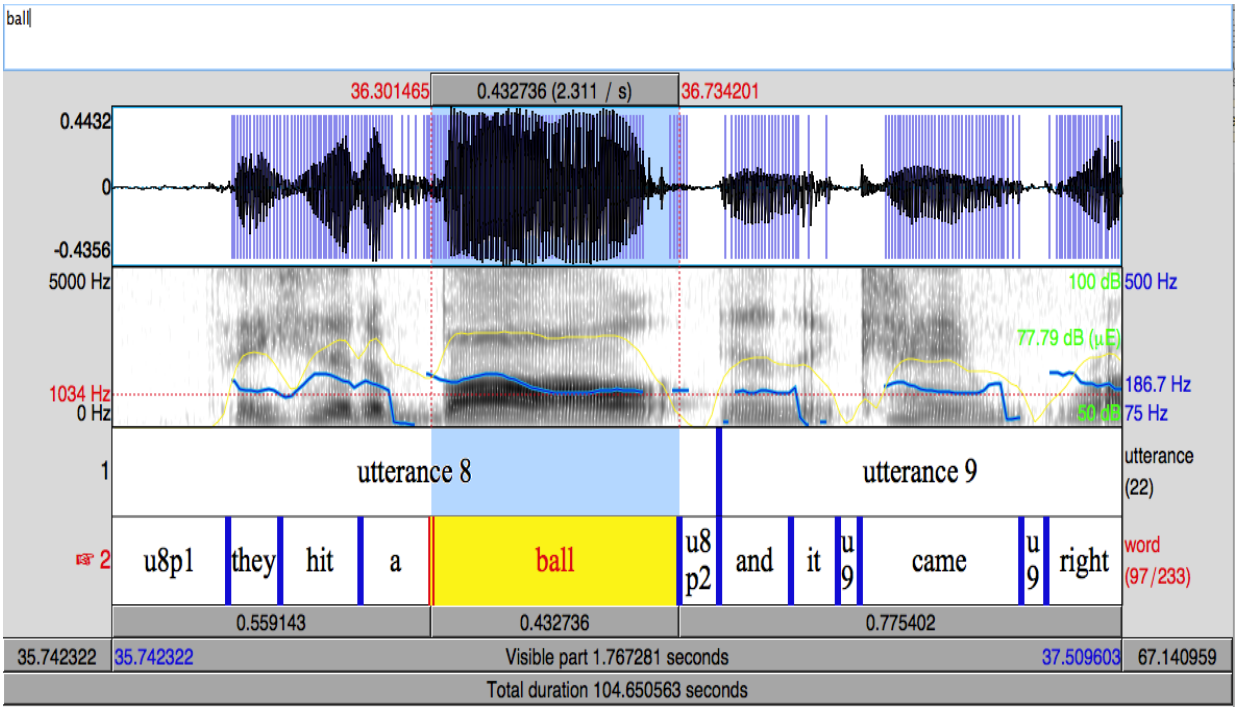
Table 1

Type, Subtype, and Severity of Aphasia for Each Subject and the Total Number of Utterances, Words, and Syllables in Their Samples

Demographic Data				Sample Data		
Subject	Type of Aphasia	Subtype	Severity	Total # Utterances	Total # Words	Total # Syllables
6	Nonfluent	TMA	Moderate	14	107	146
10	Nonfluent	Broca’s	Moderate	12	99	129
13	Nonfluent	Broca’s	Moderate	12	99	118
22	Nonfluent	Broca’s	Moderate	15	95	129
23	Nonfluent	Broca’s	Moderate	10	65	112
8	Fluent	Latent	Very Mild	13	121	162
16	Fluent	Latent	Very Mild	12	142	185
18	Fluent	Latent	Very Mild	12	145	183
19	Fluent	Latent	Very Mild	22	248	318
1	Fluent	Anomic	Mild	20	170	207
2	Fluent	Anomic	Mild	12	183	238
3	Fluent	Anomic	Mild	13	131	204
4	Fluent	Anomic	Mild	23	146	200
9	Fluent	Anomic	Mild	19	232	272
11	Fluent	Anomic	Mild	26	213	257
17	Fluent	Anomic	Mild	13	165	245
12	Fluent	Anomic	Moderate	18	238	370
20	Fluent	Anomic	Moderate	17	106	171
14	Fluent	Wernicke’s	Moderate	9	89	126
21	Fluent	Conduction	Moderate	5	56	74

Figure 1

Example of the Pitch (Blue Line) and Intensity (Yellow Line) Analysis Using Praat Software



artifacts in the speech signal (e.g., coughing, electronic static, environment noise) were disregarded. During the acoustic analysis evaluators used both visual cues from the speech signature and auditory cues from the recording playback.

The duration of each within utterance and between utterance pause was computed to the nearest millisecond. Pause boundaries were defined by a rapid decrease or increase in acoustic energy from baseline noise floor levels. Unintelligible sounds or syllables produced during a pause duration were considered part of the overall pause.

Mean Duration Measures

The pause duration was measured after every word in each speech sample, regardless of the duration, including sections where no pause between words was detected. For example, in

cases where words were temporally continuous, the value of the measured pause may be zero or a very small number, whereas extended pauses could be several thousand milliseconds.

Percentage of Extended Pause

Pauses were categorized according to five different duration intervals, including pauses < 250 ms, between 250–499 ms, 500–749 ms, 750–1,000 ms, or greater than 1,000 ms. The percentage of categorized pause was calculated as a proportion of the overall number of words within a speech sample.

Utterance Position

To calculate the duration values by sentence position, the overall number of words in each utterance was divided into three sections, thereby creating an initial, medial, and final interval. If a word fell on a position boundary, it was considered to be in the subsequent interval. For example, if there were eight words in an utterance, two were considered initial, three medial, and three final.

Results

This was a preliminary study to examine pause durations in the speech of PWA as part of a larger project investigating how pausing affects listener perceptions of PWA. Due to the significant differences in the speech patterns of people with nonfluent and fluent aphasia, the data are reported separately.

Nonfluent Aphasia

Between Utterance Pause

The mean between utterance pause durations, interquartile range, and standard deviation data are displayed in Table 2, along with the percentage of between utterance pauses greater than one second. The data show nearly half of between utterance pauses were one second or more in

duration. Figure 2 illustrates the means and standard error of measurement by aphasia subtype for both between and within utterance pause.

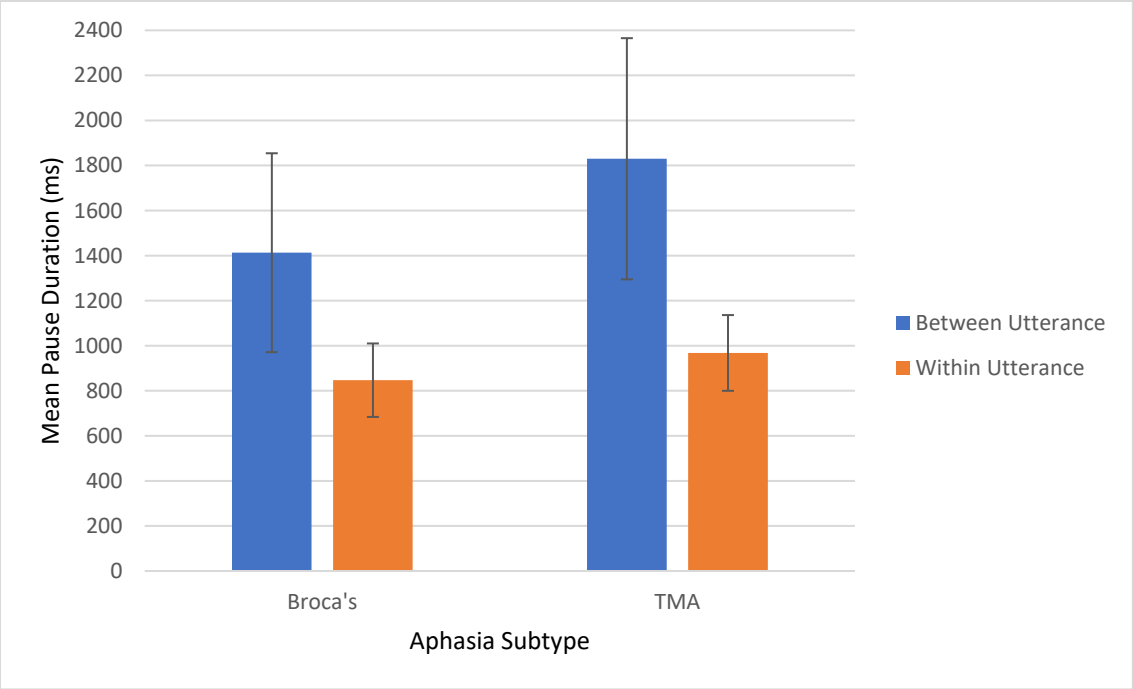
Table 2

Mean Between Utterance Pause Durations and Percentage of Between Utterance Pauses Greater Than One Second Produced by Speakers With Nonfluent Aphasia

Subject	Between Utterance Pause (ms)			Between utterance pauses > 1,000 ms
	M	*IQR*	*SD*	
6	1,830	785	2,003	57.1%
10	2,353	2,303	2,432	66.7%
13	903	939	715	33.3%
22	561	582	492	13.3%
23	1,836	1,836	2,308	60.0%

Figure 2

Mean Between and Within Utterance Pause by Nonfluent Aphasia Subtype



Within Utterance Pause

Figure 3 illustrates the means by aphasia subtype across utterance position. Table 3 displays the mean, interquartile ranges, and standard deviations of within utterance pauses broken down by their position in the utterance.

Table 4 shows the percentages of pauses produced by speakers with nonfluent aphasia across different pause lengths. The greatest proportion of pauses were more than one second in duration. Figure 4 compares the proportion of one second pauses between utterances and within utterances.

Figure 3

Mean Within Utterance Pause Duration Across Pause Position by Nonfluent Aphasia Subtype

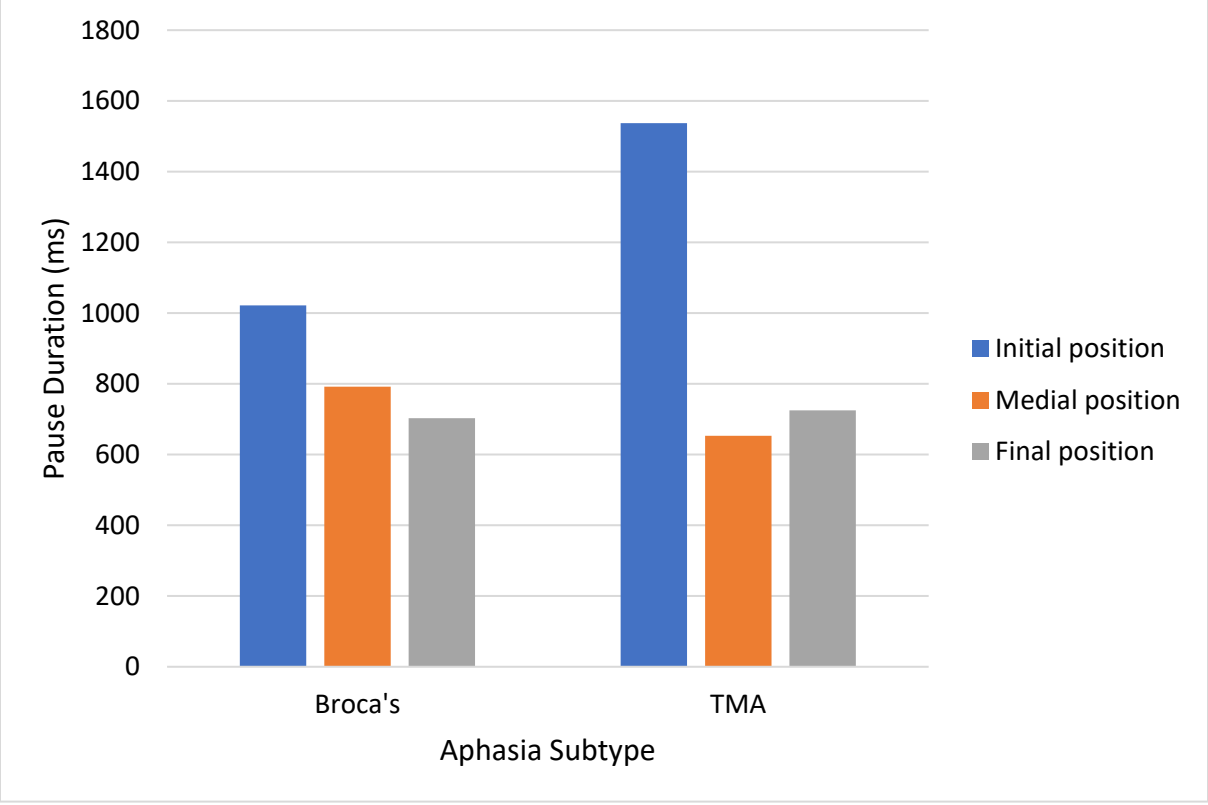


Table 3

Within Utterance Pause Durations (ms) of Utterances by Speakers With Nonfluent Aphasia Across Utterance Position

Subject	Overall Average			Initial Position			Medial Position			Final Position		
	M	*IQR*	*SD*	*M*	*IQR*	*SD*	*M*	*IQR*	*SD*	*M*	*IQR*	*SD*
6	968	1,277	1,739	1,537	1,826	2,253	653	771	971	725	404	1,679
10	1,335	1,282	3,333	2,041	1,352	5,082	1,180	1,803	1,573	695	669	1,849
13	405	577	719	424	670	571	364	515	604	433	353	964
22	508	824	920	583	718	1,231	543	991	753	352	625	555
23	1,135	1,300	1,774	1,036	1,255	1,464	1,078	1,548	1,309	1,331	1,159	2,494

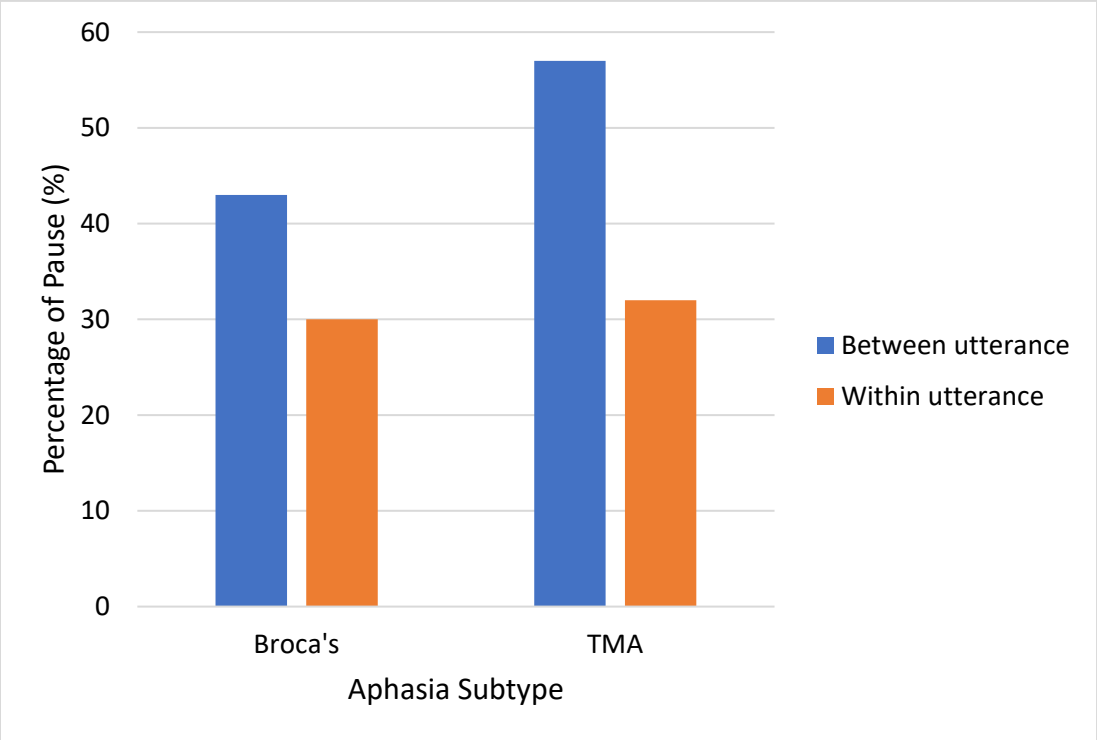
Table 4

Percent of Extended Pauses Produced by Speakers With Nonfluent Aphasia Across Differing Pause Lengths

Subject	Pause 250–499 ms	Pause 500–749 ms	Pause 750–999 ms	Pause >1,000 ms
6	4.7%	8.4%	9.4%	31.8%
10	10.1%	4.0%	9.1%	36.4%
13	5.1%	12.1%	4.0%	13.1%
22	5.3%	6.3%	8.4%	21.1%
23	12.3%	4.6%	9.2%	49.2%

Figure 4

Comparison of Percentage of Pauses Over 1,000 ms Between and Within Utterances Across Nonfluent Aphasia Subtype



Fluent Aphasia

Between Utterance Pause

The mean between utterance pause durations, interquartile range, and standard deviation data are displayed in Table 5, along with the percentage of between utterance pauses greater than one second. Figure 5 illustrates the means and standard error of measurement by aphasia subtype for both between and within utterance pause.

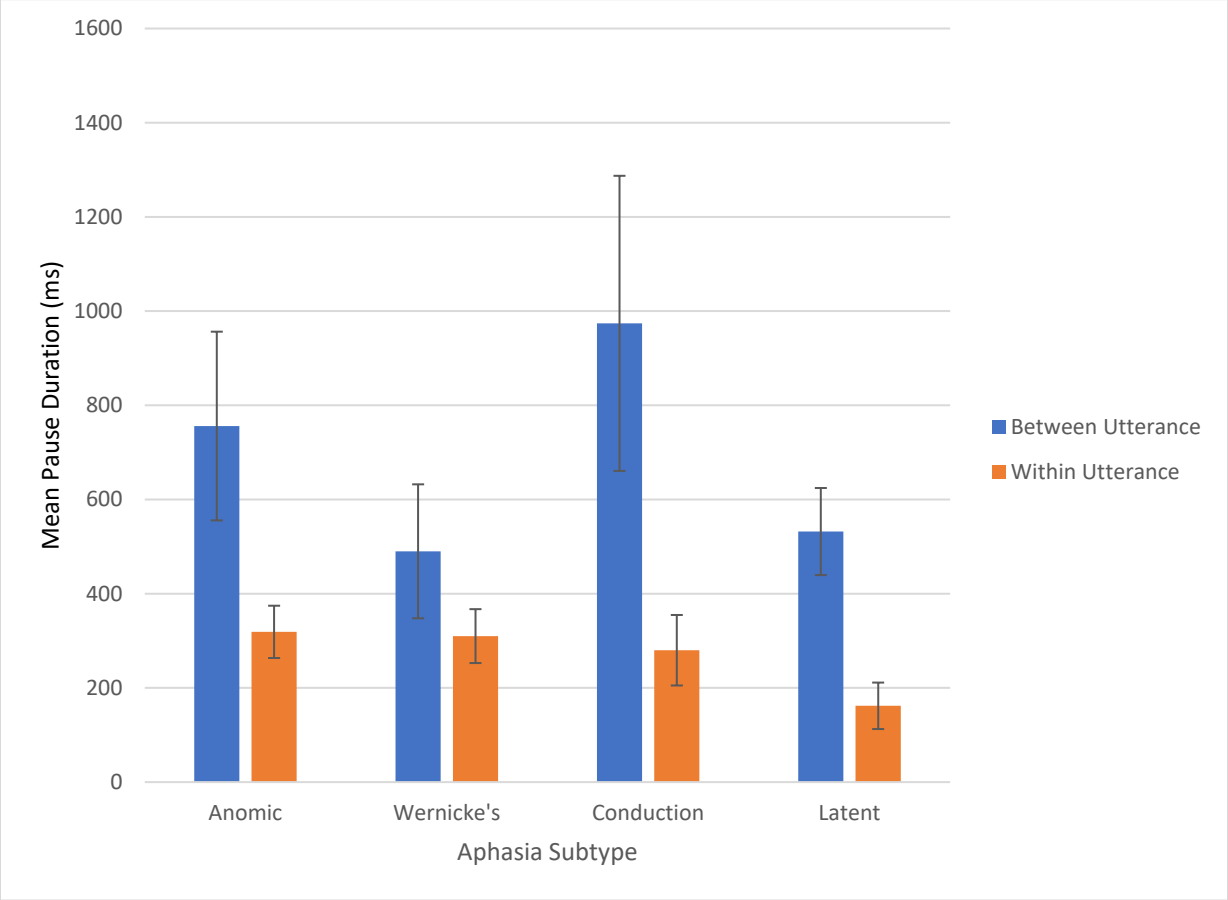
Table 5

Mean Between Utterance Pause Durations and Percentage of Between Utterance Pauses Greater Than One Second Produced by Speakers With Fluent Aphasia

Subject	Between Utterance Pause			Between utterance pauses > 1,000 ms
	M	*IQR*	*SD*	
1	354	692	447	15.0%
2	619	746	487	25.0%
3	494	245	425	15.4%
4	581	890	527	21.7%
8	413	760	412	7.7%
9	569	937	523	21.1%
11	990	613	1,178	23.1%
12	1,297	692	2,900	27.8%
14	489	980	426	0.0%
16	562	338	258	8.3%
17	779	778	621	38.5%
18	416	414	277	0.0%
19	735	703	471	36.4%
20	1,116	603	523	47.1%
21	974	1,283	700	60.0%

Figure 5

Mean Between and Within Utterance Pause Duration Across Fluent Aphasia Subtype



Within Utterance Pause

Table 6 displays the mean, interquartile ranges, and standard deviations of within utterance pauses broken down by their position in the utterance. Figure 6 illustrates the means by aphasia subtype across utterance position.

Table 7 shows the percentages of pauses produced by speakers with fluent aphasia across different pause lengths. Figure 7 compares the proportion of one second pauses between utterances and within utterances. Figure 8 compares the mean duration of pause between and within utterances across aphasia severity: very mild, mild, and moderate.

Table 6

Within Utterance Pause Durations of Utterances by Speakers With Fluent Aphasia Across Utterance Position

Subject	Overall Average			Initial Position			Medial Position			Final Position		
	M	*IQR*	*SD*	*M*	*IQR*	*SD*	*M*	*IQR*	*SD*	*M*	*IQR*	*SD*
1	193	36	702	261	0	1,018	162	28	536	153	72	348
2	167	135	400	186	269	338	129	36	386	190	128	467
3	522	678	737	667	715	927	528	931	694	352	446	461
4	101	0	291	168	177	383	110	0	290	8	0	27
8	291	24	1,303	533	201	1,685	300	89	1,369	1	0	10
9	151	0	452	184	0	583	138	0	304	131	0	437
11	473	497	917	425	307	953	534	769	905	448	357	881
12	377	475	452	349	389	340	421	551	540	355	523	441
14	309	343	591	263	212	501	214	262	441	468	756	772
16	77	0	179	106	83	208	91	23	192	28	0	97
17	222	365	294	289	456	341	208	333	231	168	288	289
18	66	0	198	109	0	278	42	0	132	46	0	137
19	211	296	359	196	207	355	257	316	435	172	273	238
20	663	879	919	702	879	997	628	853	720	666	957	1,044
21	280	0	774	332	378	734	178	0	572	344	0	975

Figure 6

Mean Within Utterance Pause Duration Across Pause Position by Fluent Aphasia Subtype

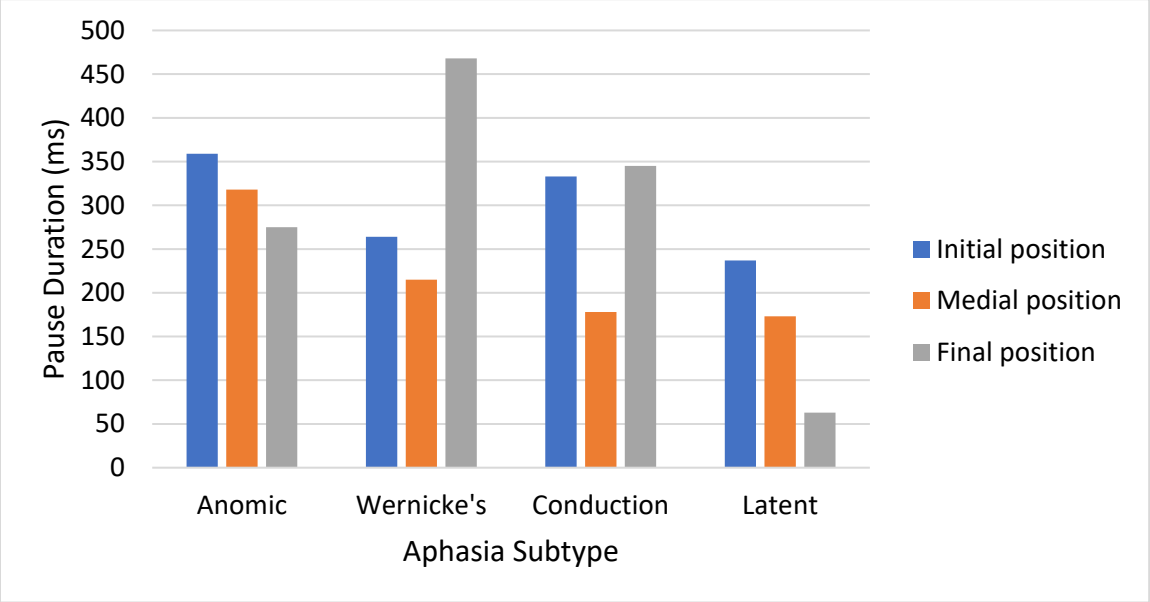


Figure 7

Comparison of Percentage of Pauses Over 1,000 ms Between and Within Utterances Across Fluent Aphasia Subtype

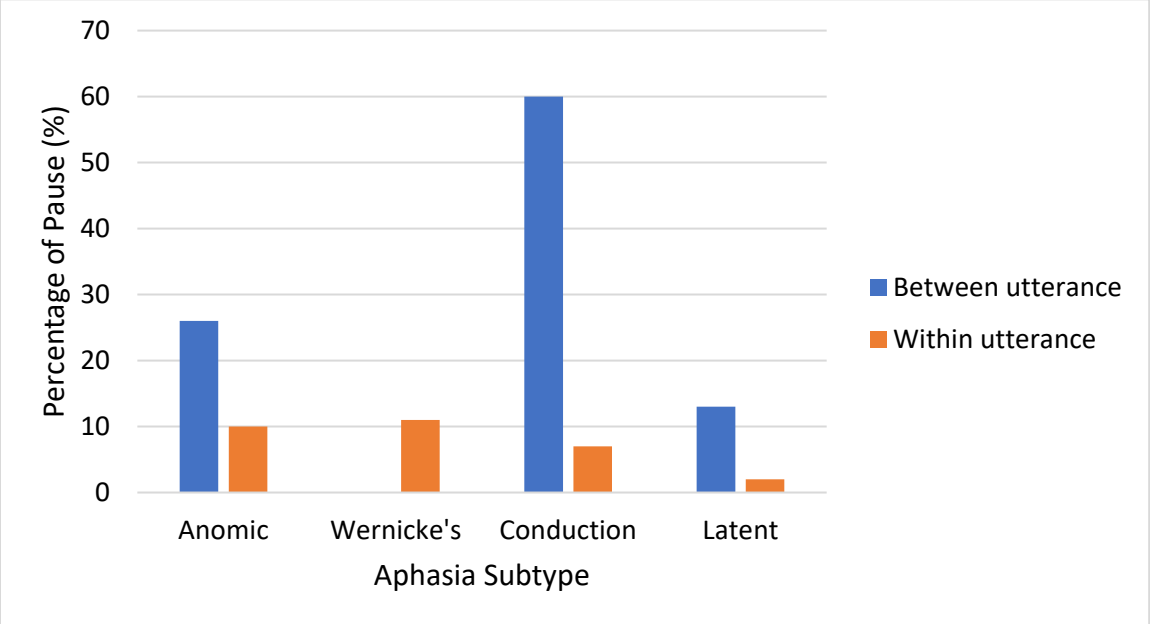


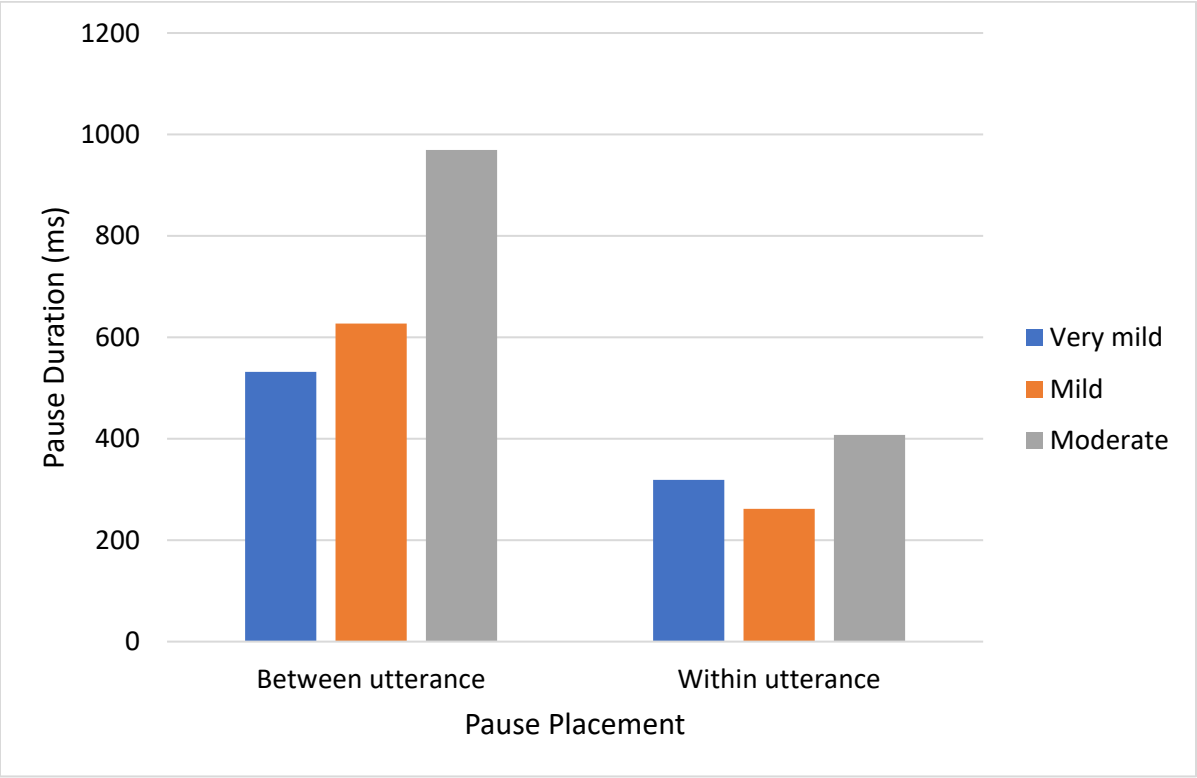
Table 7

Percent of Extended Pauses Produced by Speakers With Fluent Aphasia Across Differing Pause Lengths

Subject	Pause 250–499 ms	Pause 500–749 ms	Pause 750–999 ms	Pause >1,000 ms
1	3.5%	2.4%	1.2%	5.3%
2	8.7%	3.8%	1.1%	4.9%
3	22.9%	13.0%	3.1%	24.4%
4	6.2%	1.4%	2.1%	2.7%
8	4.1%	1.7%	2.4%	4.1%
9	3.9%	4.7%	3.0%	3.9%
11	6.6%	3.8%	5.2%	13.1%
12	29.4%	14.7%	8.8%	8.8%
14	7.9%	3.4%	10.1%	11.2%
16	9.9%	2.1%	1.4%	0.0%
17	29.7%	13.3%	4.2%	1.8%
18	5.5%	2.1%	2.1%	0.7%
19	10.1%	8.1%	4.8%	2.8%
20	15.1%	17.0%	12.3%	26.4%
21	5.4%	7.1%	3.6%	7.1%

Figure 8

Comparison of Mean Duration of Pause Between and Within Utterances Across Fluent Aphasia Severity



Discussion

This study set out to examine how pause is exhibited in the speech of people with different degrees and types of aphasia. As expected, nonfluent aphasia had higher mean durations of both between and within utterance pauses than fluent aphasia. When examining the varying pause lengths within utterances, the greatest proportion of pauses fell in the over 1,000 ms category for speakers with nonfluent aphasia, while speakers with fluent aphasia had the highest proportion of pauses under 250 ms. If we use the classifications provided by Campione and Véronis (2002), this means people with nonfluent aphasia most frequently used long pauses (>1,000 ms), while people with fluent aphasia used short or medium length pauses. Their

research found pauses of long and medium length in the spontaneous speech of typical speakers as well, so it would be interesting to compare the proportions typical speakers use with the current aphasia data. The differing methodology of the two studies, however, does not allow for direct comparison.

For both fluent and nonfluent aphasia subtypes, there was a larger proportion of pauses longer than one second between utterances than within them. This follows patterns found in typical speakers as described in the study by Yang (2004), which found 60–88% of pauses marked a boundary and longer pauses were more likely to mark the end of a phrase. Boundary pauses were frequently one second in duration in these typical speakers, so it is reasonable to expect that these aphasia samples would also see many pauses one second or greater serving as boundary markers at the end of an utterance.

If looking beyond the general division of fluent and nonfluent aphasia into specific aphasia subtypes, longer pause durations in conduction and anomic aphasia than in Wernicke's or latent aphasia were found. Latent aphasia is very mild aphasia, so it is not surprising to find shorter pause durations from this group. One possible explanation for Wernicke's aphasia having shorter pause durations than conduction or anomic aphasia is that Wernicke's is associated with an impairment in language comprehension and may be less aware of their own production errors, whereas people with conduction and anomic aphasia have comprehension that is typically less impaired than other aphasia subtypes. People with conduction and anomic aphasia may pause longer to find the words that correctly express their meaning, whereas people with Wernicke's aphasia might continue with a paraphasia or word repetition. However, it is important to note that this study only evaluated samples from one person with Wernicke's and one person with conduction aphasia, so it is difficult to draw definitive conclusions or generalize findings from

these two subtypes. Similarly, the nonfluent subtypes showed an increase of pause duration in transcortical motor aphasia over Broca's aphasia, but again, there was only one TMA sample, so caution must be taken in interpreting these results.

Given that all the nonfluent samples were moderate in degree of severity, only the differences in severity across the fluent aphasia samples, which were rated very mild, mild, or moderate, were examined. Between utterances, there was a positive correlation between increase in severity and increase in pause duration. Within utterances, there was less variation, but moderately severe aphasia had a longer mean duration than mild or very mild cases. This is encouraging data as today's speech-language pathologists use a variety of formal and informal assessments when diagnosing and treating aphasia, but no standardized assessment directly measures pause. Pause in aphasia is indirectly measured when looking at overall fluency and speech rate in samples of spontaneous speech. Speech language pathologists (SLPs) make perceptual judgments based on extended pauses, hesitations, and speech rate. These data show that these perceptual judgments are lining up with more precise measurements of pause duration.

The second question this study set out to address is if the frequency of longer pauses was tied to the position of the pause within an utterance. For the purposes of this study, these pauses were divided into initial, medial, and final positions. In four out of six of the represented subtypes, pauses were longest in the initial position. The two outliers were Wernicke's and conduction aphasia, in which the final position showed an increase in pause duration. It is important to note that these two subtypes of aphasia were represented by only one speaker each, so this may or may not hold with additional data. The overall pattern for both fluent and nonfluent aphasia is increased duration in the initial utterance position. This suggests a pattern of beginning to speak but requiring a pause before continuing, rather than pausing equally

throughout or having increased pauses as an utterance goes on, which is interesting to note. This particular view of pause has not been addressed in previous studies, and it would be informative to look at typical speakers to see if this pattern is unique to aphasia or common to all speakers.

As mentioned previously, one limitation to this study is the relatively small sample size of this study. While this is common among aphasia studies, it is limiting in the degree to which conclusions can be drawn from the data. Not all aphasia subtypes were represented in this sample, and several were only represented by one subject. As there was some variation within each group, it is likely that the data reported by aphasia subtype would change to some degree given additional subjects. This study also only allowed one sample per subject and in a story retell context, further limiting the conclusions that can be drawn from the data.

Future studies should include a larger sample with more subjects representing each aphasia subtype. Data from typical speakers without aphasia should also be collected to allow the comparison of pause patterns in speakers with and without aphasia. Additional acoustic data (such as the effect of fundamental frequency and intensity) may reveal patterns not explored in this study. Multiple speech samples in different contexts including conversation would provide opportunities to further understand the role of pause in the communicative effectiveness of people with aphasia. Additionally, future studies should investigate the listener's perception of pause and explore how pause in the speech of PWA affects their day-to-day living. A deeper exploration of these topics may inform the way SLPs provide aphasia treatment and education to PWA and their communication partners.

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APPENDIX A

Annotated Bibliography

Angelopoulou, G., Kasselimis, D., Makrydakis, G., Varkanitsa, M., Roussos, P., Goutsos, D., Evdokimidis, I, & Potagas, C. (2018). Silent pauses in aphasia. *Neuropsychologia, 114,* 41–49. https://doi.org/10.1016/j.neuropsychologia.2018.04.006

Objective: To determine whether people with aphasia use different patterns in the distribution of pause duration compared to neurologically healthy individuals and to assess the relationship between pause length and linguistic elements. *Method*: Eighteen patients with aphasia between 40 and 74 years old were selected and assessed with the Boston Diagnostic Aphasia Examination short form (BDAE-SF), adapted in Greek. They were also given the Boston Naming Test (BNT), standardized in Greek, and the Controlled Oral Word Fluency (COWF). CT or MRI scans were collected for each patient and the sites of the lesions were identified and coded. *Conclusions*: People with aphasia use more pauses and longer pauses between and within utterances. *Relevance to current study*: This study shows that people with aphasia use more pauses and longer pauses.

Baskett, G. D., & Freedle, R. O. (1974). Aspects of language pragmatics and the social perception of lying. *Journal of Psycholinguistic Research, 3*(2)*,* 117–131. https://doi: 10.1007/BF01067571.

Objective: To examine the influence of extralinguistic variables on lying. *Method:* Participants listened to a speaker say an adjective and a second speaker's self-evaluation of whether that attribute describes them, saying, "true" or "false." They were asked

whether they thought the second speaker was lying or telling the truth. *Conclusions:* A response that came too quickly or too slowly was viewed as a lie. *Relevance to current study:* This study shows that pausing can be seen as a negative and undermine the speaker's message.

Bosker, H. R., Pinget, A. F., Quené, H., Sanders, T., & de Jong, N. H. (2012). What makes speech sound fluent? The contributions of pauses, speed and repairs. *Language Testing, 30*(2)*,* 159–175. https://doi: 10.1177/0265532212455394

Objective: To investigate the contributions of pauses, speed, and repairs in perceived fluency. *Method*: Native Dutch speakers were played the speech recordings from native and non-native speakers of Dutch and were asked to rate overall fluency based on the use of silence and pauses, speed of speech, and hesitations and corrections. Three additional experiments involved the participants being instructed to rate one of the three components (pauses, speed, hesitations). The rating scale was composed of nine stars ranging from "not fluent at all" to "very fluent." Acoustic measures of the speech recordings were also taken. *Conclusions*: All three aspects of fluency played a role in fluency perception. Listeners were perceptually sensitive to pause and speed. L2 speakers that spoke relatively fast with few pauses were judged more fluent than those who speak accurately but more slowly and with more pauses. *Relevance to current study*: This study showed that people are perceptually sensitive to pauses in speech when judging fluency.

Croteau, C., & Le Dorze, G. (2001). Spouses' perceptions of persons with aphasia. *Aphasiology*, *15*, 811–825. https://doi:10.1080/02687040143000221

Objective: To determine how the speech of people with aphasia is perceived by their spouses compared to a typical speaking control group. *Method:* The Adjective Check List was administered to twenty-one spouses of people with aphasia and twenty-five control spouses. The spouses were asked to check which adjectives best described their spouse. *Conclusions:* People with aphasia were perceived differently, and often more negatively, than typical speakers. Women and men with aphasia were also perceived differently, men scoring lower on endurance and achievement scales. *Relevance to current study:* We know there are some negative perceptions associated with the speech of people with aphasia. We do not know how pause contributes to these perceptions.

DeDe, G., & Salis, C. (2020). Temporal and episodic analyses of the story of Cinderella in latent aphasia. *American Journal of Speech-Language Pathology, 29,* 449–462. https://doi.org/10.1044/2019_AJSLP-CAC48-18-0210

Objective: To examine the temporal and episodic organization of discourse of people with latent aphasia. *Method:* Cinderella narratives of 10 people with latent aphasia, 10 people with anomic aphasia, and 10 neurotypical controls were analyzed with Praat to look at duration of speech segments, dysfluencies including pause, and other behaviors. *Conclusions:* The latent and anomic aphasia groups had longer silent pause duration and slower speech rate than controls. *Relevance to current study:* We know that people with aphasia exhibit longer pause durations than typical speakers.

Groenewold, R., Bastiaanse, R., Nickels, L., & Huiskes, M. (2014). Perceived liveliness and speech comprehensibility in aphasia: The effects of direct speech in auditory narratives.

International Journal of Language & Communication Disorders, *49*(4), 486–497. https://doi: 10.1111/1460-6984.12080

Objective: To explore the perception of liveliness and comprehensibility in the direct speech of individuals with and without aphasia. *Method:* Thirty-seven listeners rated 30 speech samples with and without direct speech constructions, collected from semi-structured interviews from ten speakers with aphasia and ten without. The participants rated the perceived liveliness and comprehensibility of each sample. *Conclusions:* Communication including direct speech constructions from both speech groups were perceived as livelier, but not more comprehensible. *Relevance:* We know that including direct speech constructions can have a positive effect on listeners' perceptions of liveliness and can be a strategy for people with aphasia to improve their communication.

Harmon, T. G., Jacks, A., & Haley, K. L. (2019). Speech fluency in acquired apraxia of speech during narrative discourse: Group comparisons and dual-task effects. *American Journal of Speech-Language Pathology, 28,* 905–914. https://doi.org/10.1044/2018_AJSLP-MSC18-18-0107

Objective: To determine whether measures of fluency including pause differ between speakers with aphasia and apraxia of speech (AOS) and those with only aphasia and to determine if cognitive load reduces fluency for these groups. *Method:* Three groups (aphasia only, aphasia plus AOS, neurotypical control) of seven people each retold a short story in a single-task condition and then another in a dual-task condition (while discriminating between high and low tones). These narrative samples were analyzed for fluency measures including pause time. *Conclusions:* Both the aphasia only and aphasia

plus AOS groups had more pauses than neurotypical controls. All three groups had longer pauses during the dual-task condition. *Relevance to current study:* This study confirmed that speakers with aphasia had more pauses than neurotypical controls.

Harmon, T. G., Jacks, A., Haley, K. L., & Faldowski, A. (2015). Listener perceptions of simulated fluent speech in nonfluent aphasia. *Aphasiology*, *30*(8), 922–942. https://doi:10.1080/02687038.2015.1077925

Objective: To confirm whether listeners have negative perceptions of the speech of people with aphasia and determine the effects of simulated fluency on those perceptions. *Method:* Thirty-eight participants listened to speech samples of narrative monologues from speakers with nonfluent aphasia, simulated fluent samples from those speakers, and neurologically healthy speakers. Listeners then answered a questionnaire about their perceptions of speech output, attributes of the speaker, and the listener's feelings. *Conclusions:* The samples of simulated fluency improved listener perceptions compared to the original speech of the people with aphasia. Speech fluency may be a valid treatment strategy to target in therapy. *Relevance to current study:* This study confirmed that speakers with aphasia were viewed more negatively and that fluency contributed to listener perception.

Hird, K., & Kirsner, K. (2010). Objective measurement of fluency in natural language production: A dynamic systems approach. *Journal of Neurolinguistics, 23,* 518–530. https://doi:10.1016/j.jneuroling.2010.03.001

Objective: To determine the sensitivity of a fluency measure based on pauses and speech segment duration. *Method:* Three individuals with aphasia provided speech samples. Pauses were identified as long or short and described with a variety of measures. Control speakers' samples were likewise analyzed. *Conclusions:* The Fluency Profiling System is a sensitive measurement of fluency in individuals with aphasia and other groups. Pauses and speech segmentation without regard to meaning provide information about the speaker's fluency. *Relevance to current study:* This establishes that pauses are a key feature of aphasia.

Kraut, R. E. (1978). Verbal and nonverbal cues in the perception of lying. *Journal of Personality and Social Psychology, 36*(4)*,* 380–391.

Objective: To examine how observers judge if someone is lying and what cues they use to make that judgment. *Method*: Five male actors participated in a job interview setting and were signaled to lie or tell the truth on each question randomly. Observers were asked to identify whether the actor was telling the truth on each question, making their judgments as quickly and accurately as possible. The observer's judgment was compared with a number of verbal and nonverbal cues, including length of pause. A second experiment further investigated the role of pause. A female actor responded to an interview question about marijuana use with either a 1-second pause or 7-second pause. Subjects listened to the excerpt and estimated the job candidate's marijuana use and judged her honesty. *Conclusions*: In the initial experiment, observers were more likely to judge a response as truth when there was a shorter pause. The second experiment found that if the answer after a pause was self-serving, it was interpreted as a lie, while a self-

damaging answer after a pause was judged as truth. *Relevance to current study*: Pauses convey meaning, and listeners may judge a speaker's honesty based on the length and number of pauses.

Lee, J., Huber, J., Jenkins, J., & Fredrick, J. (2019). Language planning and pauses in story retell: Evidence from aging and Parkinson's disease. *Journal of Communication Disorders, 79,* 1–10. https://doi.org/10.1016/j.jcomdis.2019.02.004

Objective: To determine if and how pauses during connected speech reflect cognitive processes in typical aging and Parkinson's disease (PD). *Method:* Forty-nine participants retold the story of Cinderella and were recorded with Praat. Pauses were defined as no speech for 150 ms or longer and tallied based on their location in the utterance. *Conclusions:* Aging was found to lead to increased pausing in atypical places. *Relevance to current study:* Older adults tend to pause more in less natural locations. Many people with aphasia are older adults.

Mack, J. E., Chandler, S. D., Meltzer-Asscher, A., Rogalski, E., Weintraub, S., Mesulam, M. M., & Thompson, C. K. (2015). What do pauses in narrative production reveal about the nature of word retrieval deficits in PPA? *Neuropsychologia, 77,* 211–222. https://doi:10.1016/j.neuropsychologia.2015.08.019

Objective: To examine pause distribution across nouns and verbs in narrative speech of individuals with primary progressive aphasia and cognitively healthy controls. *Method:* Participants told the story of Cinderella and their samples were recorded, transcribed, and coded. Rate of pauses for verbs and nouns were calculated. MRI data was compared with

the narrative data. *Conclusions:* Individuals with PPA produced more pauses than the healthy controls, but greater difficulty with a naming task did not correlate with increased pause rates in narrative. *Relevance to current study:* We know that individuals with PPA produce more pauses, which could have an effect on how they are perceived.

O'Connell, D. C., Kowal, S., & Hörmann, H. (1969). Semantic determinants of pauses. *Psychologische Forschung, 33,* 50–67.

Objective: To determine if the semantic context affects the length of a pause. *Method:* The participants were asked to read and retell a story. The participants read either the normal or abnormal version, wherein the subject and object were reversed in one sentence. The total time was recorded, and length of pauses analyzed. *Conclusions:* The number and length of pauses increased when the semantic context was unusual. *Relevance to current study:* The number and duration of pauses are tied to semantic context in typical speakers.

Oomen, C. C., & Postma, A. (2001). Effects of divided attention on the production of filled pauses and repetitions. *Journal of Speech, Language, and Hearing Research, 44*(5), 997–1004. https://doi.org/10.1044/1092-4388(2001/078)

Objective: To examine the effect divided attention has on filled pauses. *Method:* Eighteen adults told a story based on pictures with and without simultaneously exploring sandpaper figures. *Conclusions:* The number of pauses and repetitions increased in the divided attention condition. *Relevance to current study:* If working on pause duration can

help with the perception of aphasic speech, it's important to remember that divided attention increases pause length.

Pistono, A., Parlente, J., Bezy, C., Lemesle, B., Le Men, J., & Jucla, M. (2019). What happens when nothing happens? An investigation of pauses as a compensatory mechanism in early Alzheimer's disease. *Neuropsychologia, 124,* 133–143. https://doi.org/10.1016/j.neuropsychologia.2018.12.018

Objective: To determine whether pauses in people with Alzheimer's disease (AD) show different processes depending on the type of discourse. *Method*: The pause frequency in picture-based narrative and memory-based narrative were analyzed in 17 patients with early AD and 17 matched controls. The relationship between pause frequency and cognitive processes were compared via a multiple regression model. *Conclusions*: Participants with AD produced more pauses with picture-based narrative, but not memory-based narrative. Patients may use pauses as compensatory mechanisms in the early stages of AD and may be considered a positive sign of awareness of their weak processing abilities. *Relevance to current study*: Pauses can be considered a positive compensatory strategy.

Reich, S. (1980). Significance of pauses for speech perception. *Journal of Psycholinguistic Research, 9*(4), 379–389.

Objective: To determine whether pause location effects sentence comprehension and recall. *Method*: Four undergraduate students were presented with 12 practice and 44 test sentences with a pause in either a structural/grammatical (between clauses) or

nonstructural (within a clause) location and instructed to recall the sentence as quickly as possible after the presentation. Response time, within-response pauses, and accuracy of content were assessed. *Conclusions*: Sentences with pauses at nongrammatical locations took the respondent longer to recall with more pauses and less accuracy. *Relevance to current study*: This study shows that placement of a pause has an effect on perception and comprehension of speech.

Roberts, F., & Francis, A. L. (2013). Identifying a temporal threshold of tolerance for silent gaps after requests. *The Journal of the Acoustical Society of America, 133*(6)*,* EL471-EL477. https://doi: 10.1121/1.4802900

Objective: To determine at what length a silent gap in turn transition is judged to be negative. *Method*: Three hundred and eighty undergraduate students listened to 15 simulated telephone conversations (11 distracters and 4 targets) of approximately 10 seconds in length, ending with a positive response to a request, invitation, or assessment. The participants answered a question on a six-point Likert-type scale to indicate their perception of the recipient's willingness or enthusiasm in their response. *Conclusions*: Pauses of 600 ms and longer were perceived as the responder being less willing. *Relevance to current study*: This study shows negative attributions occurring with pauses over 600 ms.

Rochford, I., Rapcan, V., D'Arcy, S., & Reilly, R. B. (2012). Dynamic minimum pause threshold estimation for speech analysis in studies of cognitive function in ageing. *34th Annual International Conference of the IEEE Engineering in Medicine and Biology Society,*

Engineering in Medicine and Biology Society. Annual International Conference, 2012, 3700–3703. https://doi.org/10.1109/EMBC.2012.6346770

Objective: To investigate the effect of pause duration in determining cognitive health in older adults. *Method:* Participants were assessed with the MMSE to determine cognitive health. Each participant was recorded reading a short text. Pause and utterance duration and distribution data were collected. Features that were statistically significant were used in classification of the participants. *Conclusions:* Pause mixing proportion and utterance mean data correctly classified the participants. *Relevance to current study:* Pause may be an earlier indicator of cognitive decline.

Scherer, K. R., London, H., & Wolf, J. J. (1973) The voice of confidence: Paralinguistic cues and audience evaluation. *Journal of Research in Personality, 7*(1)*,* 31–44. https://doi.org/10.1016/0092-6566(73)90030-5

Objective: To determine what paralinguistic cues mark confident speech. *Method*: Recordings of confident and doubtful speech were analyzed to record any silent interval longer than .4 seconds. The means of within-sentence pauses, between-sentence pauses, and duration of within-sentence pauses were calculated. Participants listened to the recordings and were asked to rate the speaker's confidence from 0 to 100%. *Conclusions*: Speakers with a confident voice used shorter and less frequent pauses. The listeners perceived pause, pitch, and volume differences to identify confidence in the speaker. *Relevance to current study*: Speakers using more pauses may be viewed as less confident or knowledgeable.

Yang, L. (2004). Duration and pauses as cues to discourse boundaries in speech. In *Proceedings of Speech Prosody- SP-2004* (pp. 267–270). Department of Foreign Languages and Literature, Tunghai University, Taiwan.

Objective: To determine the role of pause duration in marking phrase boundaries. *Method*: The researchers compiled corpora comprised of broadcast speech from television and radio, with several measures including pause duration. *Conclusions*: Over 60% of pauses indicated a boundary. The longer the pause was, the more likely it was to be a boundary pause. The type of discourse (narrative, news, etc.) had an effect on the boundary marking strength of the pause. *Relevance to current study*: This study showed that longer pauses are typically correlated with the end of a phrase.

APPENDIX B

Informed Consent

University of North Carolina at Chapel Hill
Consent to Participate in a Research Study
Participants with Aphasia

Consent Form Version Date: 17 February, 2017
IRB Study # 16-2544
Title of Study: Speech production by people with aphasia during story retell
Principal Investigator: Tyson Harmon
Principal Investigator Department: Allied Health Sciences
Principal Investigator Phone number: 919-500-6233
Principal Investigator Email Address: tyson_harmon@med.unc.edu
Co-Investigators: Katarina Haley

Faculty Advisor: Adam Jacks
Faculty Advisor Contact Information: (919) 966-9464

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may choose not to participate, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The general purpose of this study is to compare different ways of assessing story telling ability of people with aphasia. Systematic measures of language and speech production are traditionally used in research but communication partners are the ones who judge performance during everyday interactions. We will compare traditional measures with listener judgements. We hope to use the knowledge we gain to improve assessment of people with aphasia's running speech. We are asking you to be in this study because you had a stroke or other brain injury that affected your ability to talk.

Are there any reasons you should not be in this study?
You should not be in this study if you had a communication disorder prior to your onset of aphasia, are not a native speaker of English, or if you are unable to verbally retell a story.

How many people will take part in this study?

There will be approximately 40 people in this research study.

How long will your part in this study last?
Your participation in this study will involve two sessions of 1-2 hours, including an initial session to evaluate speech and language abilities and a second session to test how different communication scenarios affect your speech. The initial session can take place in your home, UNC-CH campus, or Triangle Aphasia Project's central office. The second session will take place at UNC-CH.

What will happen if you take part in the study?
Session 1: Evaluation
In our first meeting you will complete a series of tests and questionnaires designed to help us assess how your neurological injury affected your speech, language, short-term memory, and mood. This session will take approximately 2 hours.

Session 2: Story Retell Tasks
During this session we will ask you to retell three short stories. You will retell a story to two different listener judges and once while at the same time pressing a button every time you hear a tone.

We will audio and video record every time you tell the story so that we can view and listen to the recordings later to measure your performance and compare these measures to the listener judgments. We will also conduct a short focus group interview after you have completed the experiment to learn more about your experience. This session will be video recorded and will take approximately 90 minutes.

What are the possible benefits from being in this study?
Research is designed to benefit society by gaining new knowledge. You will not benefit personally from being in this research study.

What are the possible risks or discomforts involved from being in this study?
You will be telling a story to people that you don't know, which may be somewhat uncomfortable and embarrassing. Telling a story while listening for tones may also cause some uneasiness. There may also be uncommon or previously unknown risks. You should report any problems to the researcher.

What if we learn about new findings or information during the study?
You will be given any new information gained during the course of the study that might affect your willingness to continue your participation.

How will information about you be protected?
As part of this study, you will be asked to provide some personal information such as your name, address, phone number, date of birth, and date of aphasia onset. All data collected during the study (e.g., test scores, audio/video recordings) will be identified by an assigned participant number, so it will not have your name, initials, date of birth, or any other identifying information attached to it. Your data will be secured in the following ways:

1. Video cameras and/or audio recording devices with your recordings as well as written materials with your information will be kept in locked offices and/or file cabinets.
2. Video and audio recordings will be secured on laptop computers with full-disk encryption.
3. Digital files with the above information will be maintained on a password-protected file server maintained at UNC and accessible only to the study staff.

An electronic password-protected code sheet will be maintained that links participant codes and names. This will be stored in a separate folder from both the personal information and data files.

Participants will not be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (for example, the FDA) for purposes such as quality control or safety.

Please indicate below if you allow us to audio and video record you for data analysis by check marking only one of the options.

___ I give my permission for audio and/or video recordings to be made of me during my participation in this research study.

___ I do NOT give my permission for audio/video recordings to be made of me during my participation in this research study.

If you indicated that you WILL allow us to audio and video record you during the study, please provide a response below. It is sometimes helpful to show examples to scientific audiences at conferences, to clinicians in training, and to the general public to raise awareness. If you check any of these boxes, we may retain the recordings and scans until you request that they be destroyed. Please place a check mark by one or more of the options below to indicate if you allow us to use your audio and video recordings for the following purposes.

___ I give the study investigators permission to use my audio/video recordings in **scientific journals or presentations.**

___ I give the study investigators permission to use my audio/video recordings in **classroom teaching.**

___ I give the study investigators permission to use my audio/video recordings in **outreach or community presentation sessions.**

___ I do NOT want my recordings to be used for any other purpose than data analysis. If you check this box, your recordings and scans will be destroyed 7 years after the final publication of the study.

What will happen if you are injured by this research?

All research involves a chance that something bad might happen to you. This may include the risk of personal injury. In spite of all safety measures, you might develop a reaction or injury from being in this study. If such problems occur, the researchers will help you get medical care, but any costs for the medical care will be billed to you and/or your insurance company. The University of North Carolina at Chapel Hill has not set aside funds to pay you for any such reactions or injuries, or for the related medical care. You do not give up any of your legal rights by signing this form.

What if you want to stop before your part in the study is complete?
You can withdraw from this study at any time, without penalty. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped.

Will you receive anything for being in this study?
There is no payment to you as a participant in this study.

Will it cost you anything to be in this study?
It will not cost you anything to be in this study.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research participant?
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

Participant's Agreement:
I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

_____ _____
Signature of Research Participant Date

_____
Printed Name of Research Participant

_____ _____
Signature of Research Team Member Obtaining Consent Date

_____
Printed Name of Research Team Member Obtaining Consent