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Speech Prosody in People With Non-fluent Aphasia: A Descriptive Study of Between and Within Utterance Pause

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Speech Prosody in People With Nonfluent Aphasia and Apraxia:

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A thesis submitted to the faculty of
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ABSTRACT

Speech Prosody in People With Nonfluent Aphasia and Apraxia:
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The purpose of this study was to examine patterns of pause duration and frequency in speakers with moderate nonfluent aphasia and apraxia. The speech recordings analyzed in this study were produced by 16 adult speakers of American English (8 males and 8 females). Speech samples were provided by the AphasiaBank database (i.e., narrative samples from the Cinderella Story). Praat acoustic analysis software was used to code the speech samples for utterance boundaries and durations, as well as between and within filled and silent pause durations and frequencies. Results found a difference in silent versus filled pause durations, with silent pauses that were longer in duration than their filled pause counterparts. Differences in pause durations as a function of pause location were not found to be statistically significant. The majority of correlations between pause patterns and AQ rating were found to be insignificant, with just three measures that were statistically, but not clinically, significant. Gender differences in filled and silent pause durations and frequencies were not found to be significant. There was also a strong positive correlation between utterance duration and within utterance pause rate. Further research on speech pause in people with nonfluent aphasia and apraxia of speech with larger sample sizes, a variety of language contexts, and linguistic analyses is needed in order to better understand expected pause patterns in this population. Despite these limitations, this study provides further information on typical and atypical patterns of pause for clinicians who are assessing people with aphasia and apraxia.

Keywords: aphasia, pause, Broca's aphasia

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DESCRIPTION OF THESIS STRUCTURE AND CONTENT

This thesis, *Speech Prosody in People with Nonfluent Aphasia and Apraxia: A Descriptive Study of Between and Within Utterance Pause,* is part of a larger study exploring the impact of pause on speech communication in people with aphasia and apraxia. 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

Speech and its suprasegmental characteristics play a tremendous role in communication between conversational partners. However, the ease with which this communicative process occurs is increasingly difficult for people with aphasia (PWA). Aphasia is an acquired language disorder caused by damage to the language centers of the brain and is often the result of stroke or head injury, though it may also be caused by other neurological damage or disease (National Institute on Deafness and Other Communication Disorders, 2017). At present, one in 272 individuals in the United States suffer from aphasia, with an incidence rate of about 180,000 new aphasia cases each year (Le & Lui, 2022). Although aphasia affects expressive and receptive language, the types and severities of aphasia and its associated language deficits vary and are closely tied to the amount and location of damage.

Aphasia greatly impacts individuals' ability to produce verbal and written language in a coherent and efficient manner and with the appropriate emotion. It may also impact their perception of these aforementioned language elements (Le & Lui, 2022; Leung et al., 2017), creating barriers to communication.

These deficits in communication not only negatively affect the effectiveness with which PWA can express themselves, but their overall emotional wellbeing and quality of life. Many PWA experience "linguistic anxiety" as their deficits may result in more frequent conversational breakdowns, requiring greater efforts in communication and possible increased self-consciousness (Cahana-Amitay et al., 2011). PWA may also experience frustration, denial, anger, and possibly symptoms of depression as a result of their disorder.

Additionally, PWA may exhibit decreased levels of social participation and interpersonal interactions as a result of these associated communication and emotional challenges, affecting not only the individuals themselves, but family members and friends as well. According to Dalemans et al. (2010), PWA may be less involved in social activities and may feel as though they are a burden because while they want to participate in certain activities, they feel they will be a hindrance to the group as they are unable to communicate or contribute as well as they used to. The authors also reported that PWA feel they are not fully respected or seen as a "whole person" and that unfamiliar listeners and many others in society are not always accommodating to the PWA's needs in conversation. Strains in relationships may occur as a result of the difficulties associated with aphasia. It thus becomes crucial to find successful means to effectively diagnose and treat aphasia in order to support aphasic individuals' communication, relationships, and overall quality of life.

Aphasia Subtypes

Aphasia can be divided into two main subtypes: fluent and nonfluent aphasia. Fluent aphasia is characterized by speech that exhibits minimal impairment of prosody and articulation. However, productions of those with fluent aphasia are often meaningless, with the presence of anomia (Fraser et al., 2014) and phonemic and semantic paraphasias in which the PWA produces a different word than what was intended, altering the meaning of their production (Le & Lui, 2022). Those with fluent aphasia may also present with logorrhea, or long runs of speech with few breaks. Nonfluent aphasia on the other hand, involves nonfluent, effortful productions containing elements of impaired prosody (dysprosody), word-finding deficits, and agrammatism (Dahmani et al., 2008; Fraser et al., 2014). Nonfluent aphasia is also characterized by decreased phrase length and mean length of utterance (MLU), as well as reduced word usage (Fraser et al., 2014). The dysprosody present in nonfluent aphasia is particularly troublesome in that it has a significant impact on the ease and flow of the production of speech and language for communication.

Individuals with nonfluent aphasia also commonly present with the concomitant condition of apraxia of speech (AOS). AOS differs from aphasia in that it primarily involves a disruption in the motor planning of the sequence of muscle movements necessary for speech and does not involve other modalities of language such as auditory comprehension or language formulation. Due to the nature of the two diagnoses and their associated occurrence as a result of brain injury, it is often very difficult to distinguish if an individual's speech disruptions are due to the motoric challenges of apraxia or impaired language abilities due to aphasia.

Prosodic Patterns in Nonfluent Aphasia

Universally across languages, prosody aids communication effectiveness by contributing to the "lexical identity" and the "general affect" of an individual's speech (Hirst, 2005). The methods in which one uses prosody to convey meaning varies from one speaker to another, and the same prosodic feature can be used for a variety of meanings (Hirschberg, 2002).

Prosody refers to the suprasegmental components of speech that add linguistic and nonlinguistic meaning to verbal communication (Walker et al., 2009). Prosodic elements of speech include tempo, pitch/intonation, emphasis, and speech pause. Tempo refers to the rate and rhythm of speech. Sentence-level pitch, or intonation, "conveys verbal information at the sentence or phrase level" (Seddoh, 2000) and can signal the function of a person's utterance. Stress, or emphasis, functions in a sentence by adding prominence to particular words, therefore affecting the overall meaning of an utterance (Lass, 1976). Stress can be marked by the duration, amplitude, and fundamental frequency of segments of a person's speech (Walker et al., 2009). Speech pauses contribute to the rhythm of speech and occur within and at the boundaries of utterances, adding information and meaning by indicating emotion, hesitation, emphasis, and signaling word and phrase boundaries.

Speech Pause

While all prosodic elements provide depth to verbal communication and expression, speech pause is of particular interest as it occupies nearly 40–50% of an individual's utterance time (Goldman-Eisler, 1964) and is essential to speech. Additionally, pause is integral to temporal patterning and speech perception (Nooteboom, 1997) and serves both cognitive and linguistic functions.

Seeing as pause is a prominent factor in determining speech rate and subsequent measures of speech fluency, measuring speech pause may offer a window into the cognitive processes involved in speech production, including verbal planning and selection (Goldman-Eisler, 1964). Moreover, the patterns of pauses in one's speech may be indicative of varying cognitive and internal processing loads (Angelopoulou et al., 2018) as hesitations may reflect word retrieval or utterance planning (Shriberg & Kent, 2012). For example, Goldman-Eisler (1964) found that in tested subjects, speech pause was related to the information content of the words bordering the pause, and that the durations of speech pause observed were longer with more complex tasks. Of particular note, excessive or inappropriate use of speech pause is considered a disfluency as it affects a listener's understanding of an utterance (Shriberg & Kent, 2012), and may be representative of increased processing demands within the brain of a speaker.

Speech pause is also used to signal linguistic context and contrastive stress. For example, syllable duration and pause insertion are used by typical speakers to delineate syntactic boundaries (Walker et al., 2009), as well as to flexibly and intentionally emphasize particular words or phrases within an utterance for a desired listener effect (Shriberg & Kent, 2012).

Additionally, the locations of inserted pauses in a speaker's utterance can affect the meaning and point of emphasis of the utterance (Edwards, 2002). Moreover, a study performed by Dahmani et al. (2008), with nine Algerian adults with Broca's aphasia, found that speech pause and subsequent intonation and speaking rate, may be useful qualitative measures for distinguishing between speech in PWA and healthy individuals. Inappropriate speech pause can therefore blur syntactic boundaries and points of contrastive stress, making it difficult for communication partners to segment out words and sentences, and for speakers to effectively express their intended meaning.

Disordered Speech Pause in Nonfluent Aphasia

As mentioned previously, inappropriate use of speech pause contributes to disruptions in speech and language production, and these patterns have been found in PWA (DeDe & Salis, 2020). People with aphasia tend to produce more pauses overall and within utterances as compared to individuals without aphasia (Angelopoulou et al., 2018). This may be partially influenced by the notion that in general, individuals with aphasia experience decreased neurological processing speeds which can impact language processes and which may be reflected in the form of speech pause.

While both fluent and nonfluent aphasia subtypes may involve difficulties with speech pause, individuals with nonfluent aphasia typically have more frequent pauses with higher durations (Kirsner et al., 2002). For example, Mack et al. (2015) found that subjects with an agrammatic variant of primary progressive aphasia (PPA-G) had reduced speech rates, decreased MLU, fewer grammatical sentences, possible verb-lemma retrieval impairment and higher pause rates when compared to controls and those with semantic and logopenic variants of PPA. Fraser et al. (2014) also found reduced speed/speech rates in those with nonfluent aphasia. The aforementioned observations of increased pausing in nonfluent aphasia subtypes may be the result of increased word-finding difficulty in these individuals (Kim et al., 2021).

Persons with nonfluent aphasia exhibit pause errors in the form of silent and filled pauses, and prolongations. Silent pauses can be considered "empty gaps" (Angelopoulou et al., 2018) or silent abnormal hesitations in speech production that vary from one person to another (Maclay & Osgood, 1959). Unusual "non-phonemic lengthening of phonemes" may also be considered a type of silent pause (Maclay & Osgood, 1959). Additionally, silent pauses may "relate to lexicosemantic and syntactic aspects of planning" (DeDe & Salis, 2020) and may occur more frequently at word boundaries and before lexical words (Maclay & Osgood, 1959). Filled pauses differ from silent pauses in that they are hesitations with verbal fillers (i.e., er, um, uh, eh, mm; DeDe & Salis, 2020; Henderson et al., 1966; Mack et al., 2015) and may occur more frequently at phrase boundaries and before function words (Maclay & Osgood, 1959).

Research has shown that the productions of filled and unfilled pauses in PWA may vary according to location. In one study, researchers investigated left hemisphere (LHD) contribution to prosody in which three subjects had Broca's aphasia. They found that individuals with LHD struggled with pre-boundary syllable lengthening and insertions of pauses at nonsyntactic junctures and non-boundary positions (Walker et al., 2009). This research encourages further examination and study in relation to pause location in the speech of people with nonfluent aphasia, as well as the words and phrases that border them at these boundaries.

In addition to inappropriate use of filled and unfilled pausing, individuals with nonfluent aphasia, especially those with comorbid AOS, may also demonstrate prolongation errors in their speech. People with nonfluent aphasia and AOS may inappropriately prolong "segment and intersegment durations" (Bislick et al., 2017, p. 611) and syllables, which adds to the hesitation in their utterances and results in less fluent speech production. Due to the high frequency and duration of speech pause and prolongations in nonfluent aphasia speakers, it is of interest to further study, examine, and analyze speech pause in order to better understand, treat, and diagnose people with nonfluent aphasia and AOS.

Purpose of this Study

Previous research has aimed to investigate various elements of speech pause in connected speech, particularly pause duration and rates of pause. These studies and others have clearly documented that people with nonfluent aphasia have increased rates and duration of speech pause. However, while some studies have delved into the research of speech pause location in connected speech, clear explanations as to when and why these extended pauses occur is generally less clear. Thus, the specific aims of this study are as follows:

1. Describe the duration and frequency of extended silent and filled pauses produced by people with nonfluent aphasia and AOS during narrative discourse. Considering the research on nonfluent aphasia, it is predicted that the duration and frequency of extended silent pauses will be greater than those of extended filled pauses during narrative discourse. Filled pauses are generally the length of a syllable, where silent pauses can be prolonged for much longer.
2. Describe the patterns of between and within utterance pauses produced by people with nonfluent aphasia and AOS during narrative discourse. Based on previous research in typical speakers, between utterance pauses are longer than those of within utterance pauses. It is predicted that the same will be true of our nonfluent aphasia and apraxia speakers, even with likely pause duration and frequency abnormalities.

3. Examine possible correlations between patterns of pause as a function of pause type, pause location, and speaker aphasia rating during narrative discourse. Considering the characteristics of nonfluent aphasia and AOS, as well as the Western Aphasia Battery (WAB; Kertesz, 1982) severity ratings associated with moderate aphasia, it is predicted that WAB aphasia quotient (AQ) scores will be negatively correlated with an increased frequency and duration of pause.

Methods

Speech Recordings

Speech samples from 16 individuals with nonfluent aphasia were downloaded from the AphasiaBank database (MacWhinney et al., 2011) and analyzed in this study. The AphasiaBank (MacWhinney et al., 2011) database consists of hundreds of recorded speech samples of both PWA and control populations, across a wide variety of different speech task types, speaker demographics, as well as aphasia subtypes and severities. As shown in Table 1, the 16 recordings evaluated in the current study were produced by an equal number of individuals identifying as male and female, all of which were diagnosed with the nonfluent subtype of Broca's aphasia of moderate severity as classified by the WAB (Kertesz, 1982). The WAB aphasia quotient (AQ; Kertesz, 1982) scores ranged from 52.5 to 72.8 (M = 60.99) and speakers ranged from 31.8 to 78.3 years of age (M = 55.06). Additionally, all subjects were identified as having apraxia of speech (AOS).

The speech samples were all collected under a similar protocol as outlined by AphasiaBank (MacWhinney et al., 2011). The recordings were contributed by several different research groups, including Gretchen Szabo of Adler Aphasia Center, Denise McCall of Snyder Center for Aphasia Life Enhancement, Maura Silverman of Triangle Aphasia Project, Janet

Whiteside of the University of Central Florida, Julius Fridriksson of the University of South Carolina, Roberta Elman of the Aphasia Center of California, and Heather Wright of Arizona State University. The specific speech data examined in this study were elicited via a narrative retell of the Cinderella story. Speakers were first asked to read a short picture book detailing the story of Cinderella in order to familiarize themselves with the basic setting, characters, and premise of the story. The book was then removed with instructions to "tell as much of the story as you can remember" (MacWhinney et al., 2011). The speech samples were coded after the familiarization portion of the sample and at the start of the retell. The 16 speech samples evaluated in the current study ranged from 0:56 to 9:55 minutes in duration (M = 2:42).

Acoustic Analysis

Prior to acoustic analysis, transcripts of the speech recordings were created by downloading CHAT (Codes for the Human Analysis of Transcripts; MacWhinney, 2000) formatted descriptions of the samples from the AphasiaBank database. With the support of CHAT transcripts, the speech recording samples were acoustically analyzed and coded using Praat software (Boersma & Weenink, 2023). As shown in Figure 1, tiered boundaries of the within and between utterance silent and filled pauses were marked using a visual display of the acoustic waveform and the intensity track, as well as listening to an audio playback of the speech samples through closed-ear headphones (Sennheiser HD 650).

Between and within utterance filled pauses in the recordings were determined by laughter, humming, and by "pseudo-words that do not affect sentence meaning" (Igras-Cybulska et al., 2016; e.g., er, um, uh, eh, mm, like) and were labeled with a "BFP" (between utterance filled pause) or "WFP" (within utterance filled pause) using the text grid feature. Sighing, exhaling, audible breathing, etc., were not considered filled pauses, but were instead considered silent pauses as there was no vocalization. Between utterance unfilled/silent pauses (BSP) were identified as any silent pause between two consecutive participant (PAR) utterances on the sample transcript. Within utterance unfilled/silent pauses (WSP) were identified as silent durations of 250 ms or longer (Goldman-Eisler, 1968) in which the intensity waveform contacted the noise floor and were also labeled using the text grid. Prolongations of syllables and phonemes in various word positions within and between utterances, as well as false starts before and after words and utterances, were not included or analyzed in this study.

Reliability

In order to ensure that samples were reliably analyzed, the acoustic measures of 10% of the samples were randomly assigned and measured by a second researcher. The first- and second-rater measurements of the time boundaries of each identified speech pause had a Pearson correlation of $r = .93$, $p < .001$ with a mean absolute different between the two raters' values of approximately 4 ms per boundary.

Statistical Analysis

Descriptive statistics were used to report the silent and filled pause duration mean and standard deviations produced by speakers between utterances. Extended within utterance pause durations longer than 250 ms were also calculated and descriptively reported. It is important to note that the pause before the first utterance of each subject sample was not analyzed since these pauses were just the beginning of the recording and were therefore unable to be measured accurately. Possible differences in speaker gender were evaluated using a between subjects Analysis of Variance (ANOVA).

Results

Speech Sample Utterance Frequency and Duration

The number of utterances in each sample varied widely across speakers, ranging from eight to 105 utterances per sample. Overall utterance durations also varied widely across speaker samples, with utterance duration ranging from as short as 1.444 second (s) to as long as 7.421 s ($M = 4.05$ s). When comparing utterance frequency and mean utterance durations between genders, it was observed that female speaker samples had a greater average number of utterances (female = 40.25; male = 37.38), containing utterances with longer mean durations (female = 4.42 s; male = 3.68 s). Descriptive statistics describing the number of utterances per sample, mean utterance durations per sample, and mean pause-to-speech ratios per sample are displayed in Table 2.

Pause Frequency

The rate of between utterance pausing was determined by the number and length of utterances within each speaker's recording. However, the rate of within utterance pauses were found to differ significantly as a function of the pause type, $F(1,14) = 8.55$, $p = .01$. As shown in Figure 2, WSP rates per utterance ($M = 1.476$ s) were higher than WFP rates per utterance ($M = 0.784$ s), with no significant differences found between speakers across reported gender. We also found a significant positive correlation between the overall utterance duration and the WFP ($r = .71$, $p = .002$) and WSP rates ($r = .89$, $p < .001$). Thus, as the overall duration of utterances increased, within utterance pause rates also increased. Within utterance pause rate means across each speaker and gender are reported in Table 3.

Pause Durations

The repeated measures ANOVA indicated that the speakers' pause durations varied as a function of the pause type, $F(1,4) = 12.02$, $p = .03$. As illustrated in Figure 3, speakers' silent pauses ($M = 1.308$ s) were longer than the filled pauses ($M = .517$). In the aphasic speaker recordings, no significant differences were found across pause location (between versus within utterance), nor were there any significant interactions between the duration of the different pause types and the gender of the speaker, or the pause location. As expected, the variability of the pause durations was much greater for the silent pauses ($SD = 1.082$ s), compared to the filled pauses ($SD = .246$ s). Duration means and standard deviations for each speaker across the pause type and pause location are reported in Tables 4 and 5.

Adjusted Calculations of Pause Data Considering Combined Types

During data analyses it was noted that on a number of occasions, speakers would produce adjacent silent and filled pauses. Although these pauses could be considered separate types, the overall pause in communication was a combination of these different pauses. Thus, the data was reevaluated considering this third type of "combination" pause, namely between combined pause (BCP) and within combined pause (WCP). These adjusted frequency and duration values across individual speaker, pause type, and pause location are reported in Tables 6 and 7.

As shown in Figure 4, the most common type of within utterance pauses were silent (58.7 %), followed by combined pauses (33.7 %), and then filled pauses (7.6%). For the adjusted pause data, an ANOVA indicated a significant difference in the different pause types, $F(2,4) = 11.46$, $p = .02$. As expected, the BCPs ($M = 5.234$ s) were much longer than the BSPs ($M = 1.208$ s) or BFPs ($M = 0.717$ s), as illustrated in Figure 5. The within utterance pause durations followed a similar pattern, with the WCPs ($M = 2.835$ s) being longer than the WSPs ($M = 0.924$ s) and

WFPs (*M* = 0.587 s). These differences are shown in Figure 6. No other significant differences or interactions were found in the adjusted data as a function of the reported speaker gender.

Pause Patterns' Association with Speaker AQ

The majority of correlations between pause frequency and durations and a speaker's AQ were not positively or negatively significant. Only three pause measures were found to be positively correlated with the AQ: (a) the unadjusted WSPs (r = .56, p = .02), (b) BCPs (r = .78, p = .004), and (c) the WCPs (r = .75, p =.001).

Discussion

Previous research conducted by Mitchell (2022) and Thomas (2021) examined the durations and locations of BSPs and WSPs in individuals with fluent and nonfluent aphasia. This study aimed to expand upon their findings by describing patterns of pause as a function of pause type (filled and silent) and location (between and within) in subjects with a nonfluent aphasia subtype.

Pause Patterns Across Pause Type

The first aim of our study was to describe the patterns of pause in terms of filled versus silent pauses. Our data showed that silent pauses comprised the greatest proportion of overall pause time compared to filled pauses. This was true for both adjusted and unadjusted pause data. These findings are understandable, given that filled pauses are generally one syllable interjections, while silent pauses are naturally longer in duration and can last several seconds. These findings may explain why research has focused so heavily on silent pauses in PWA as compared to filled pauses. Abnormally frequent and long silent pauses tend to be more apparent to the listener and may contribute to why a person with nonfluent aphasia is perceived as more dysfluent than a typical speaker or an individual with fluent aphasia.

It is also important to discuss how our pause data from nonfluent aphasia speakers compares to filled and silent pause data of typical speakers. In our study, we observed average adjusted BFP and WFP durations of 135 ms and 430 ms respectively, and BSP and WSP durations of 1,208 ms and 924 ms, respectively. This stands in significant contrast to pause durations found in typical speakers by Hoffer (2023), who observed average BFP durations of 85 ms, and BSP durations of 80 ms. Though research by Hoffer (2023) focused on between utterance pauses, the large gaps between typical pause durations and nonfluent pause durations are significant. The utterances of individuals with nonfluent aphasia are often extremely disjointed and listeners may experience great difficulty in following the conversation and flow of ideas. This is relevant clinically in that professionals may need to emphasize teaching patients how to reduce pause time and/or advocate for themselves while conversing with a variety of listeners.

Additionally, the data from this study can aid clinicians in educating family members and friends of those with nonfluent aphasia and AOS on expected pause patterns in their speech. Thorough caregiver education on typical versus atypical pause patterns is important in order to facilitate greater caregiver patience, responsiveness, and compassion. Our data can therefore be used as a means to better support PWA and AOS improve their quality of life.

Another conclusion that may be drawn from our findings is the need for further research on the potential relationships between long pause durations in nonfluent aphasia, and underlying factors such as linguistic context.

Pause Patterns Across Pause Location

Our second aim was to describe pause patterns in terms of between versus within utterance pauses. Though not statistically significant, subjects demonstrated a greater overall occurrence of within utterance pauses compared to between utterance pauses. This difference in occurrence encourages discussion of the perceptual impacts of these findings.

Between utterance pauses certainly disturb conversational fluency, however, they tend to be perceived on a different scale than within utterance pause durations. This is because between utterance pauses are more natural than abnormal and extended pauses within utterances. As found by Lyman (2023), within utterance pause durations were rated consistently and significantly lower in both likeability and communicative effectiveness than between utterance pause counterparts across all duration intervals (3, 5 and 7 seconds). Therefore, a greater frequency of within utterance pausing will significantly impact an individual with nonfluent aphasia's overall communication, as it affects their conversational fluency, as well as the listener's overall perception of their speech. The majority of participants in our study displayed average WCP durations between 2 s and 6 s long. This suggests that if included in the current study, perceptual ratings of likeability and communicative effectiveness would likely be quite low due to the significant impact that within utterance pauses have on perceived conversational ease and fluency.

Some of our participants also displayed between utterance pause durations that would lower perceptual ratings. Though short between utterance pauses would not impact perceived conversational ease and fluency, between utterance pauses of 4 to 5 seconds or more most certainly would. In the present study, nearly half of the subjects displayed BCP durations that ranged from 4 to 12 s in duration. This would likely yield negative ratings of likeability and communicative effectiveness comparable to ratings for 2 to 6 s within utterance pauses. Based on these results and our discussion, perceptual ratings of between and within utterance pauses may therefore offer important information for clinicians to consider when assessing typical versus atypical pausing in individuals with moderate nonfluent aphasia.

Our results support the suggestion made by Lyman (2023) that perhaps clinicians should be more concerned about assessing and treating within utterance pauses to further boost positive listener perceptions. They also encourage questions examined by Mitchell (2022) of the roles that cognitive processes such as lexical and syntactic planning have on pause location and duration within utterances. Expanding her findings to both WFPs and WSPs in individuals with moderate nonfluent aphasia would allow for better treatment planning and a greater understanding of why these observed patterns of pause in our study occurred and continue to occur. It would also provide needed information as to what is typical and what is atypical amongst this population in order to better assess pause patterns.

In addition to differences in pause type frequencies, we also examined differences in between and within utterance pause durations. As stated previously, we did not find statistically significant differences in pause duration as a factor of pause location for either adjusted or unadjusted pause data. This is likely due to the fact that in typical speakers, between utterance pause durations tend to be much longer than within utterance pauses (Krivokapi, 2007; Thomas, 2021) because they signal the end of an utterance. In contrast to the literature, our nonfluent aphasia speakers displayed atypically long within utterance pause durations that were more comparable to their between utterance pause durations. Because of this, participants' between and within utterance pause durations were more balanced and lacked significant differences.

Another interesting observation from the current study was that between utterance pause variability surpassed that of within utterance pause. This stands in contrast to the literature, which has previously found that in typical speakers, greater variability in duration occurs within utterances across speakers (Krivokapi, 2007). One reason for the between utterance duration variability in our subjects may have been due to fewer subjects who exhibited BFPs and BCPs, therefore increasing the likelihood of variability of between utterance pauses. Further research with larger sample sizes is warranted in order to determine if the observed variability among our subjects mirrors that of larger populations of individuals with nonfluent aphasia. If consistent with larger populations, this may indicate that while pause patterns in typical speakers are more predictable and uniform, patterns in those with nonfluent aphasia are greatly individualized, making it difficult to develop unified assessment procedures and treatment protocols for this population.

Pause Patterns Across Speaker Gender and AQ Rating

The third aim of our study was to examine correlations in pause data as a function of speaker gender and speaker AQ rating. No significant differences were found between genders.

Correlations Between Patterns of Pause as a Function of AQ

As mentioned previously, there were no significant correlations between pause patterns and AQ, aside from the three measures: unadjusted WSPs, BCPs, and WCPs. The relative lack of significant correlations may have been due to the fact that only participants with moderate AQs were selected, therefore restricting the AQ range and making it harder for correlations to reach significance. Furthermore, AQ measures are calculated based on WAB subtests, which assess a variety of communication areas including language content, fluency, auditory comprehension, repetition and naming, and reading. While fluency is included in the WAB assessment, it is mainly a perceptual measurement and looks at utterance length and apparent effort of speech, rather than qualitative or quantitative pause data. Though three of our pause measures were statistically significant in terms of correlation with AQ ratings, the correlations lack clinical significance due to the fact that WAB measures do not specifically assess patterns of pause in PWA.

Correlations Between Patterns of Pause and Utterance Duration

While the correlation between pause patterns and AQ was not clinically significant, there was a statistically and clinically significant positive correlation between utterance duration and within utterance pause rates. The fact that within utterance pause rates increased with utterance duration makes sense seeing as subjects would have greater opportunities for pause errors with longer utterances. Shorter utterance durations with fewer words leaves less room for error and therefore fewer opportunities for atypical pause. These results are significant, particularly when discussing individuals with more mild or moderate forms of aphasia. Those with mild or mild-moderate aphasia often produce longer utterances with more words and content words, therefore increasing their likelihood of producing utterances with increased rates of within utterance pauses. This is of significant interest clinically as speech-language pathologists (SLPs) and other professionals evaluate individuals with aphasia. It also brings up the question of whether pause measures should be added to fluency and aphasia ratings on the WAB and other assessment tools.

Limitations/Future Directions

While this study offered further discussion regarding patterns of pause, there were a few limitations present. One limitation of this project was that pauses were analyzed only from narrative retell segments of each subject's interview. While this allowed for uniformity, it did limit the extent to which we could analyze patterns of speech pause in those with nonfluent aphasia in more conversational contexts. Research has shown that pause frequencies and durations may vary from well-learned material (such as the Cinderella story) to open-ended interview questions or conversations (Krivokapi, 2007). Thus, further research is needed to examine patterns of between and within filled and silent pauses in a larger variety of contexts in order to better conceptualize pause data in people with nonfluent aphasia.

Another limitation to this study was that we only examined pause patterns in those with nonfluent aphasia of moderate severity. Therefore, data collected in this study offers insights into patterns of pause in those with this particular severity of nonfluent aphasia, though it does not expand research to those with mild or severe aphasia. Moreover, examining only those with moderate nonfluent aphasia limited the AQ range and may have impacted correlations between pause data and AQ ratings. Further studies comparing data across severities would be beneficial in contributing additional information to this area of research.

A third limitation of this project was the variability in pause data across subjects. With such variability and a small sample size (16), it is difficult to generalize pause data to all nonfluent aphasia speakers. Additional research with a much larger sample size is encouraged.

A fourth limitation of our study was our inability to examine observed pause patterns in the context of lexical and syntactical data. This was due to unexpected complexities of identifying intended content words in the speech of our subjects. Future research should aim to expand the findings of our study and Mitchell's (2022) research by further analyzing our data in the context of linguistic factors.

Conclusion

People with nonfluent aphasia exhibit hallmark symptoms of increased pause frequency and durations within their speech. This study aimed to further describe patterns of pause in these individuals, specifically in the areas of pause type (filled and unfilled) and pause location (between and within utterances). Despite the limitations of our research, this project adds to the literature by offering clinicians further information on typical versus atypical types and locations of pause in the speech of people with nonfluent aphasia and AOS, which can help in treatment and assessment planning. It also opens the door for an expansion of our research that could include an examination of how lexical and syntactical context and planning may influence pause data, as well as how these cognitive processes more generally impact the speech of all those with nonfluent aphasia and AOS.

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Tables

Table 1

Demographic Information for Participants with Nonfluent Aphasia

Study	Subject	Gender	Age	WAB-AQ	Aphasia Subtype	Aphasia Severity	Apraxia	Dysarthria
Adler	13a	Male	52.4	55.8	Broca	Moderate	Yes	Yes
	16a	Male	63.5	57.2	Broca	Moderate	Yes	Yes
Elman	09a	Female	58.8	57.8	Broca	Moderate	Yes	No
Fridriksson	12a	Female	47.9	57.5	Broca	Moderate	Yes	Yes
Scale	01a	Male	78.3	52.5	Broca	Moderate	Yes	No
	10a	Male	44.7	63.5	Broca	Moderate	Yes	Yes
	26a	Male	58.8	64.8	Broca	Moderate	Yes	No
	36a	Male	55.2	66.3	Broca	Moderate	Yes	No
Tap	11a	Female	62.7	58.1	Broca	Moderate	Yes	No
	14a	Male	44.9	60.2	Broca	Moderate	Yes	No
	16a	Male	42.9	56.7	Broca	Moderate	Yes	Yes
	17a	Female	65.5	59.5	Broca	Moderate	Yes	No
	19a	Female	54.7	59.4	Broca	Moderate	Yes	No
Whiteside	11a	Female	31.8	72.8	Broca	Moderate	Yes	No
	15a	Female	54.9	72.2	Broca	Moderate	Yes	No
Wright	207a	Female	63.9	61.5	Broca	Moderate	Yes	No

Note. Data collected from AphasiaBank.

Table 2

Speech Sample Utterance Frequency and Duration

Study[a]	Speaker Identifier	Number of Utterances	Utterance Duration (s)	
			M	*SD*
Adler	13a	105	2.376	2.443
	16a	15	7.421	6.026
Elman	09a	14	5.493	3.013
Fridriksson	12a	45	1.628	1.253
Scale	01a	38	4.158	4.085
	10a	36	3.767	4.14
	26a	18	5.189	3.822
	36a	59	2.808	2.727
Tap	11a	14	6.731	5.31
	14a	8	2.269	2.454
	16a	20	1.444	1.21
	17a	16	2.515	2.123
	19a	59	5.130	6.239
Whiteside	11a	13	4.071	3.487
	15a	80	5.594	6.112
Wright	207a	81	4.201	4.109
		Gender		
Male		299	3.68	3.363
Female		322	4.42	3.956
Total		621	4.05	3.660

Note. [a] The speech recordings were drawn from several previous studies all using the same elicitation protocol outlined by the Aphasiabank database administrators.

Table 3

Within Utterance Filled and Silent Pause Rates as a Function of Individual Speaker and Speaker Gender

Study	Sample	Within Filled Pause Rate	Within Silent Pause Rate
Adler	13a	0.34	0.85
	16a	1.6	3.93
Elman	09a	2.29	1.21
Fridriksson	12a	0.24	0.24
Scale	01a	1.18	1.58
	10a	1.11	1.47
	26a	1.17	1.67
	36a	0.36	0.98
Tap	11a	0.86	3.21
	14a	0.00	0.75
	16a	0.15	0.25
	17a	0.38	0.63
	19a	1.05	2.90
Whiteside	11a	0.85	1.08
	15a	0.48	2.14
Wright	207a	0.48	0.73
	Gender Average Rate		
Male		0.739	1.435
Female		0.829	1.518
Total Average Rate		0.784	1.476

Table 4

Between Utterance Filled and Silent Pause Durations as a Function of Individual Speaker and Speaker Gender

Study	Sample	Between Filled Pause (s)		*N*	Between Silent Pause (s)		*N*
		M	*SD*		*M*	*SD*	
Adler	13a	0.593	0.325	30	1.503	1.325	107
	16a			0	0.860	0.278	7
Elman	09a			0	0.496	0.225	12
Fridriksson	12a			0	0.694	0.642	30
Scale	01a			0	0.529	0.212	24
	10a	0.113	N/A	1	1.631	1.291	15
	26a			0	0.732	0.334	15
	36a	0.507	0.195	10	0.978	1.379	54
Tap	11a			0	0.691	0.583	12
	14a			0	3.580	1.199	3
	16a			0	1.914	1.984	10
	17a			0	2.373	2.504	12
	19a	0.474	N/A	1	0.966	0.835	34
Whiteside	11a	0.379	0.091	3	3.328	3.305	12
	15a	0.978	N/A	1	2.129	2.765	66
Wright	207a			0	0.836	0.429	23
		Gender					
Male		0.404	0.26	5.125	1.466	1.000	29.375
Female		0.610	N/A	0.625	1.439	1.411	25.125
Total		0.507	0.204	2.875	1.453	1.206	27.25

Table 5

Within Utterance Filled and Silent Pause Durations as a Function of Individual Speaker and Speaker Gender

Study	Sample	Within Filled Pause (s)		*N*	Within Silent Pause (s)		*N*
		M	*SD*		*M*	*SD*	
Adler	13a	0.464	0.230	36	1.247	1.243	89
	16a	0.518	0.356	24	0.746	0.513	59
Elman	09a	0.797	0.821	33	0.609	0.379	17
Fridriksson	12a	0.548	0.220	11	1.003	0.899	11
Scale	01a	0.538	0.494	45	0.765	0.505	60
	10a	0.306	0.161	40	1.380	1.083	53
	26a	0.509	0.107	21	1.701	1.460	30
	36a	0.464	0.284	21	1.150	0.971	58
Tap	11a	0.577	0.289	12	1.067	0.753	45
	14a			0	1.643	2.206	6
	16a	0.756	0.488	3	0.505	0.167	5
	17a	0.502	0.045	6	1.908	1.077	10
	19a	0.609	0.180	62	0.711	0.504	172
Whiteside	11a	0.585	0.258	11	1.920	1.522	14
	15a	0.523	0.245	38	1.256	1.407	171
Wright	207a	0.234	0.132	39	1.018	0.626	59
		Gender					
Male		0.508	0.303	23.75	1.142	1.019	45
Female		0.547	0.274	26.5	1.187	0.896	62.375
Total		0.528	0.289	25.125	1.164	0.958	53.688

Table 6

Adjusted Between Utterance Filled, Silent, and Combined Pause Durations as a Function of Individual Speaker and Speaker Gender

Study	Sample	Between Filled Pause Duration (s)		*N*	Between Silent Pause Duration (s)		*N*	Between Combined Pause Duration (s)		*N*
		M	*SD*		*M*	*SD*		*M*	*SD*	
Adler	13a	1.252	0.504	2	1.152	0.939	58	4.681	3.215	25
	16a			0	0.860	0.278	7			0
Elman	09a			0	0.462	0.214	10	1.744	0.503	2
Fridriksson	12a			0	0.618	0.608	27	2.023	0.643	2
Scale	01a			0	0.538	0.212	24			0
	10a			0	1.517	1.297	11	4.141	3.594	4
	26a			0	0.732	0.334	15			0
	36a	0.426	N/A	1	0.681	0.978	42	6.881	5.424	4
Tap	11a			0	0.535	0.228	11	3.718	N/A	1
	14a			0	3.580	1.199	3			0
	16a			0	2.072	1.984	10			0
	17a			0	1.328	1.076	9	8.277	1.040	2
	19a	0.474	N/A	1	0.923	0.846	31	2.499	1.047	3
Whiteside	11a			0	2.172	2.825	6	12.907	N/A	1
	15a			0	1.346	1.403	58	9.479	3.598	6
Wright	207a			0	0.806	0.384	19	1.222	N/A	1
					Gender					
Male		0.839	N/A	0.375	1.392	0.903	21.25	5.234	4.078	4.125
Female		N/A	N/A	0.125	1.024	0.948	21.375	5.234	1.366	2.25
Total		0.717	N/A	0.25	1.208	0.926	21.313	5.234	2.722	3.188

Table 7

Adjusted Within Utterance Filled, Silent, and Combined Pause Durations as a Function of Individual Speaker and Speaker Gender

Study	Sample	Within Filled Pause Duration (s)		*N*	Within Silent Pause Duration (s)		*N*	Within Combined Pause Duration (s)		*N*
		M	*SD*		*M*	*SD*		*M*	*SD*	
Adler	13a	0.390	0.115	5	1.096	1.186	53	2.997	2.484	20
	16a	0.478	0.371	6	0.665	0.534	35	1.891	0.920	16
Elman	09a	0.663	0.609	17	0.754	0.657	5	2.160	1.432	9
Fridriksson	12a	0.689	0.348	3	0.549	0.122	5	2.053	0.939	6
Scale	01a	0.638	0.588	13	0.660	0.555	29	1.779	1.015	24
	10a	0.391	0.279	6	1.417	1.082	20	2.092	1.537	22
	26a	0.420	0.081	2	0.704	0.448	9	4.544	2.283	12
	36a	0.603	0.243	2	0.781	0.629	37	2.889	1.696	17
Tap	11a			0	0.865	0.515	27	3.028	1.869	10
	14a			0	1.643	2.206	6			0
	16a	0.635	N/A	1	0.508	0.194	3	1.317	0.482	2
	17a			0	2.020	1.169	5	3.988	2.029	3
	19a	0.816	0.319	2	0.661	0.486	88	1.664	0.681	55
Whiteside	11a	0.884	0.587	2	0.709	0.431	5	6.162	3.550	7
	15a			0	0.909	0.695	115	4.559	4.808	32
Wright	207a	0.275	N/A	1	0.847	0.471	21	1.737	0.982	31
		Gender								
Male		0.508	0.280	4.375	0.934	0.854	24	2.501	1.488	14.125
Female		0.665	0.466	3.125	0.914	0.568	33.875	3.169	2.036	19.125
Total		0.587	0.373	3.75	0.924	0.711	28.938	2.835	1.762	16.625

Figures

Figure 1

Within and Between Utterance Pause Boundaries Using Acoustic Analysis Software

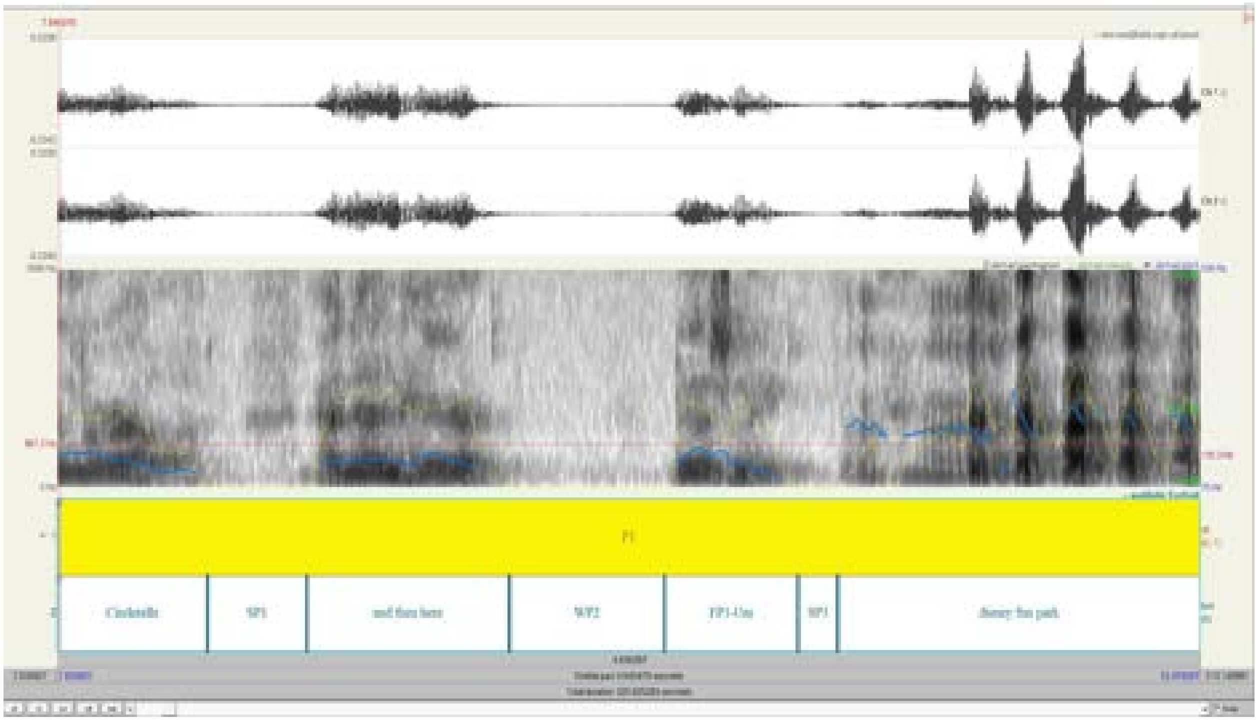


Figure 2

Within Utterance Pause Rate of Occurrence Across Pause Type and Speaker Gender

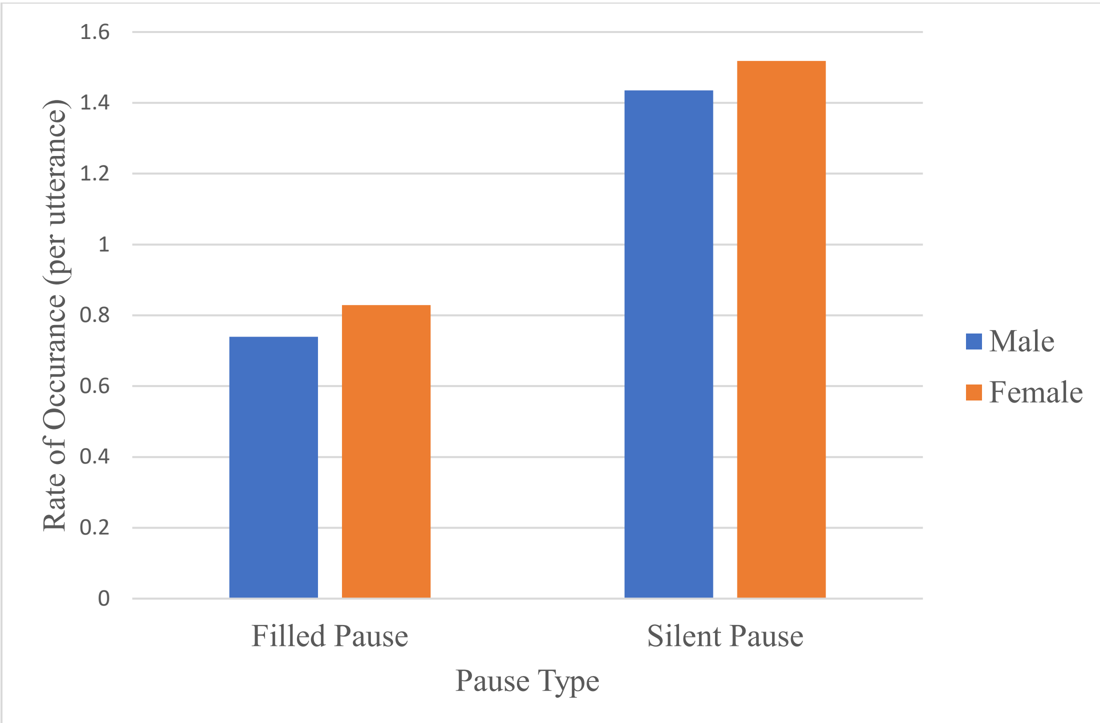


Figure 3

Pause Duration Across Pause Type and Pause Location

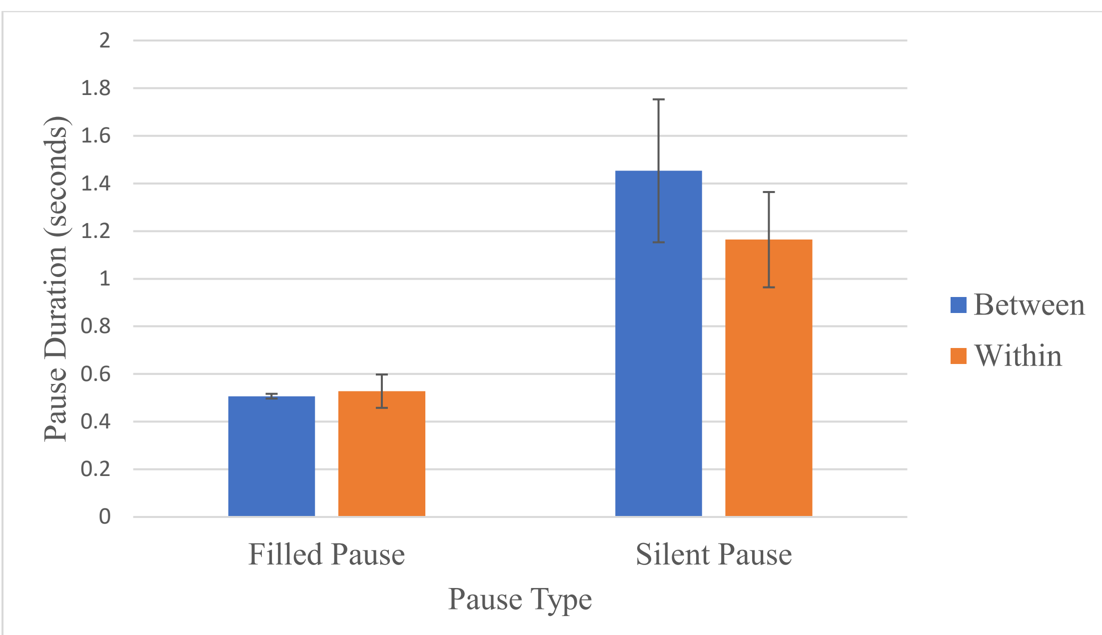


Figure 4

Percentage of Pauses by Type in Adjusted Data Analysis

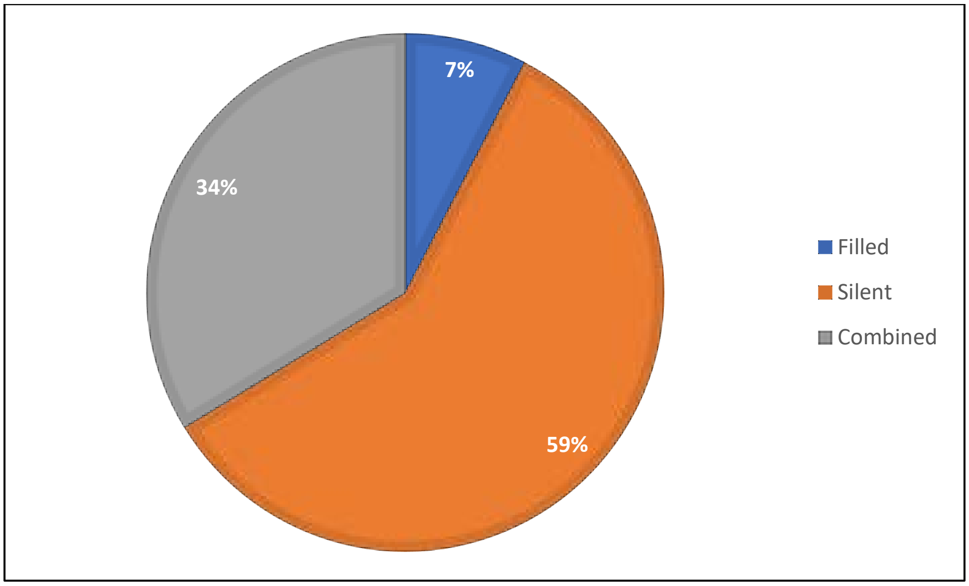


Figure 5

Adjusted Between Utterance Pause Duration Across Pause Type and Speaker Gender

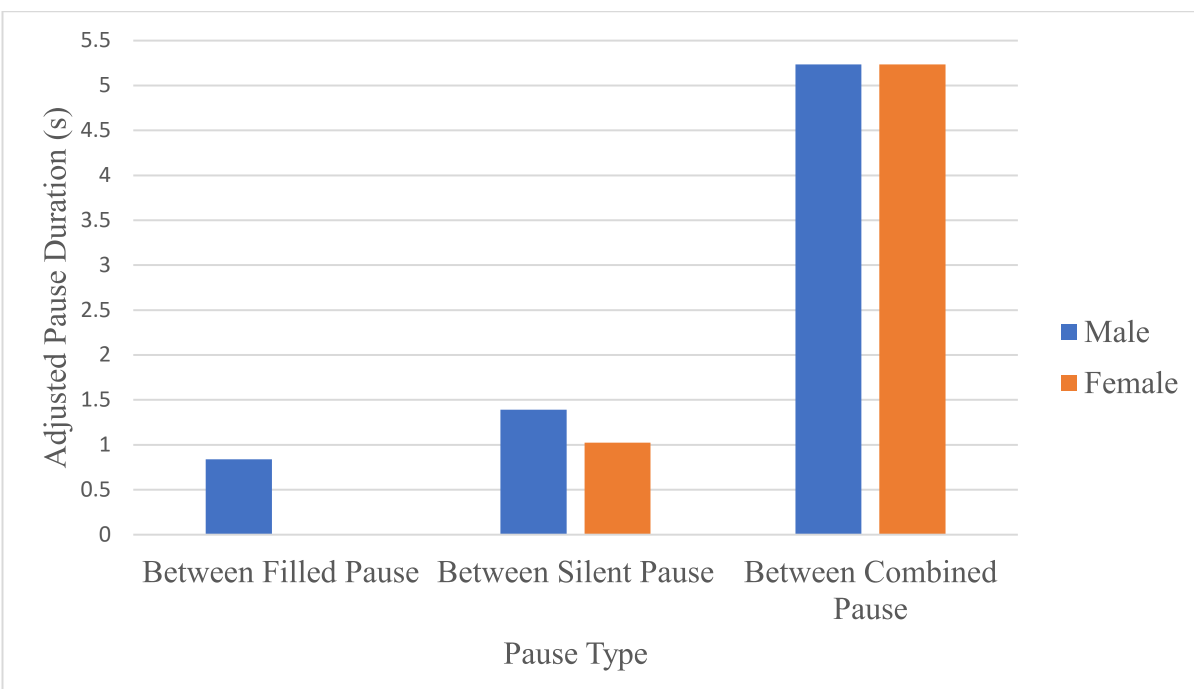
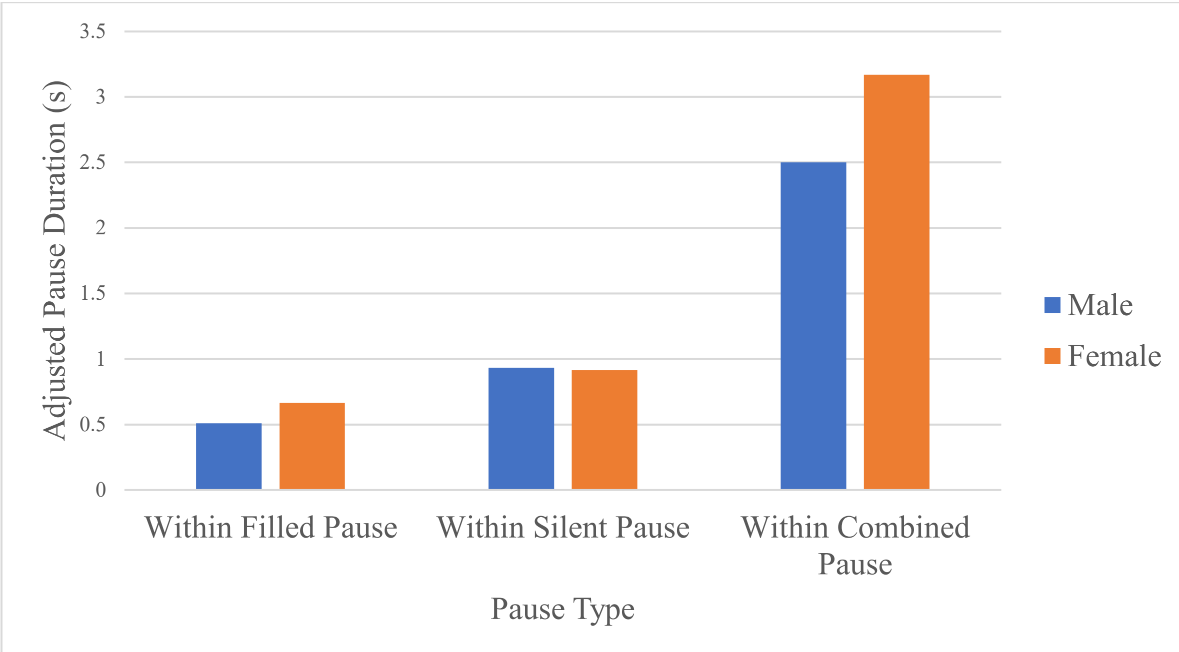


Figure 6

Adjusted Within Utterance Pause Duration Across Pause Type and Speaker Gender



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: This study aimed to compare silent pause duration distributions of patients with aphasia and neurologically intact speakers, as well as investigate the relationships between short and long pauses and linguistic elements. *Method*: Narrative speech samples from 18 adult patients with chronic aphasia due to left hemisphere stroke and 19 healthy adult control patients were taken and silent pauses in their samples were annotated (using ELAN). They also annotated verbs, nouns, paraphasias, and segmented/annotated utterances. Pause annotation involved location of the pause, as well as what followed the pauses using lexical categories. Bimodal distributions were then created as well as boundary thresholds. Finally, analyses were performed including correlations between lesion score and pause rate, spearman correlation analyses between rates, naming, fluency, and MLU, and comparisons between short and long pause rates in individuals with aphasia and controls. *Results*: The combination of short and long pauses in utterances can be represented by bimodal distribution models for individuals with aphasia (IWA) and healthy individuals. Threshold values between pause types were higher in IWA than in the healthy controls. Researchers also found that IWA had shorter pauses and less long pauses than controls. They also found a positive correlation between lesion score and long pause rate. Inferior frontal gyrus lesions were correlated with increased long pause rates. In controls and IWA, long pause rates were associated with speech rate,

but IWA's long pause rates were also associated with MLU. Authors also found that short pauses were mostly found before nouns and noun phrases, but that long pauses were typically found before verbs. IWA produced a greater number of pauses within utterances compared to controls and produced more pauses in general. Finally, IWA produced more short pauses as well as more "long pauses between and within utterances." *Conclusions*: Research on speech pause and aphasia is limited and is mainly restricted to pause frequency and location. Pauses in aphasic's connected speech have high ecological validity and may offer new insights into connected speech in aphasia. Pause distributions between healthy and aphasic individuals are similar, but boundary thresholds and pause durations and rates differ. *Relevance to the current study*: Few studies have investigated pause duration and how this is affected by word and utterance boundaries. People with aphasia tend to produce more pauses (and more short pauses) overall and within utterances. A study with a larger sample size should be used to expand upon this study.

Cahana-Amitay, D., Albert, M. L., Pyun, S. B., Westwood, A., Jenkins, T., Wolford, S., & Finley, M. (2011). Language as a stressor in aphasia. *Aphasiology, 25*(5), 593–614. https://doi.org/10.1080/02687038.2010.541469

Objective: This article aimed to review the literature regarding language as a stressor in aphasia, as well as to identify issues and gaps in the literature in order to stress the importance of the emotional toll that results from aphasia. *Conclusions*: Physiologic stress responses can be used to determine linguistic stress in a PWA. Additionally, these responses can be used as an unbiased measure to determine language anxiety in a patient and how to help mitigate that anxiety. Few clinicians currently address emotions such as anxiety in therapy. *Relevance to current study*: An aphasia diagnosis carries emotional baggage for the client and can be anxiety-inducing when conversing with others. This would contribute to a description of the many effects that aphasia has on those diagnosed with it.

Dahmani, H., Selouani, S. A., Chetouani, M., & Doghmane, N. (2008). Prosody modelling of speech aphasia: Case study of Algerian patients. *2008 3rd International Conference on Information and Communication Technologies: From Theory to Applications*, 1–6. https://doi.org/10.1109/ICTTA.2008.4530030

Objective: This article aimed to propose an acoustic-prosodic characterization tool for prosody data analysis in people with aphasia. *Methods*: Nine Algerian adults (all male) with Broca's aphasia participated in the study. Speech samples for CV and VC syllable/sub-word repetition, simple words, complex words, and complicated sentences were collected and analyzed for aphasia examination, and prosody modelling. Acoustic measurements were taken/analyzed for fundamental frequency, intensity, duration, speaking rate, and intonation. *Conclusions*: Researchers found that intonation and speaking rate may be useful qualitative measures for distinguishing between speech in PWA and healthy individuals. *Relevance to Current Study*: Rhythm/speaking rate is an important characteristic of the speech of those with Broca's aphasia. The current study will aim to examine speech pause, an element of rhythm, in individuals with nonfluent aphasia. Nonfluent aphasia is characterized by dysprosody and involves frequent pauses, and difficulties with inflection and melodious speech.

Dalemans, R. J. P., Witte, L., Wade, D., & Heuvel, W. (2010). Social participation through the eyes of people with aphasia. *International Journal of Language and Communication Disorders, 45*(5), 537–550. https://doi.org/10.3109/13682820903223633

Objective: This article investigated the ways in which PWA perceive their participation in society as well as factors behind their perceived participation. *Method*: Researchers used a qualitative study design in which participants kept a diary regarding their social participation perceptions and were later interviewed. Twenty participants were recruited by rehab practitioners, SLPs and the chairman of the Regional Aphasia Association and had to have an aphasia etiology of stroke and had to be 6 months post-onset. They also had to be living at home, have a central caregiver, and be at least 20 years old. Researchers also tried to survey people with varying aphasia severity. Thirteen PWA and 12 central caregivers were included in the final sample. Aphasia severity was determined by the FAST (Frenchay Aphasia Screening Test). PWA kept a diary for 2 weeks regarding their social participation perceptions across domains with the help of their caregiver. An interview picked up the diary after that 2-week period and then returned again 2 weeks later for a semi-structured interview. *Conclusions*: PWA and caregivers all stated that social participation was often difficult and that PWA tend to feel excluded or burdensome if they are participating or doing something. Most PWA want to be included and feel useful but perceptions of this can depend on a variety of personal, social, and environmental factors. *Relevance to current study*: PWA's social participation is greatly impacted as a result of their diagnosis. This can be used to demonstrate the negative effects that aphasia has on the relationships and participation in those with the disorder.

Davies, M. (2008–2022). The corpus of contemporary American English (COCA) [Data set]. https://www.english-corpora.org/coca/

Relevance to current work: This website offers a comprehensive description of the COCA database and what is included within it. The COCA database is what will be used in the current work to analyze the speech samples and words at pause boundaries.

DeDe, G., & Salis, C. (2020). Temporal and episodic analyses of the story of Cinderella in latent aphasia. *American Journal of Speech-Language Pathology, 29*(1S), 449–462. https://doi.org/10.1044/2019_AJSLP-CAC48-18-0210

Objective: This study examined a few different questions: First, authors explored the temporal aspects (silent pause duration, speech rate, articulation rate, and pure word rate) of the speech of individuals with latent aphasia, anomic aphasia, and neurotypical controls to see if these elements would differ across groups. Second, researchers investigated if formulated utterance processing demands increase as a result of the introduction of a novel episode to a narrative. Third, this study asked whether aphasia type (latent, anomic, neurotypical) will influence the "episodic structure of Cinderella narratives." *Method*: Thirty participants were divided into three groups (latent aphasia, anomic aphasia, and neurotypical), with audio and orthographic data collected from the AphasiaBank. Latent aphasia and anomic aphasia groups were determined based on the WAB-R Aphasia Quotient. Initial coding of the 30 samples was completed using PRAAT before coding for base and rate measures (pauses, speech rate, articulation rate, word rate) and discourse organization. *Results*: There was a significant difference in the number of words across all three groups, distinguishing between each of them. Rate measures also yielded significant results in that speech rate distinguished between controls and the overall clinical group (didn't distinguish between each of the aphasia groups) and articulation rate differed between controls and the anomic group (but not between the latent and control groups). Pure word rate differed significantly between the anomic and control groups (not between latent and control groups) and approached significance between aphasia groups. Concerning narrative discourse, controls and latent aphasics demonstrated formulation time differences between utterances with and without novel episodes while anomic aphasics displayed no differences in formulation time. Percentage of formulation time for new utterances was lower for the control group in comparison to the aphasic groups. The percentage of formulation time for continued utterances was different across all subject groups and distinguished between them. Finally, there were no significant differences across groups for episode recurrence but there were for episode omissions between aphasia groups. *Conclusions*: Certain temporal measurements can assist in distinguishing between latent aphasics and controls and introducing novel episodes in a narrative utterance may increase processing demands. *Relevance to current work*: This article discusses differences between filled and silent pauses and outlines how presence of aphasia or differing aphasia types may have varying impacts on prosody. The article also discusses the impact that certain words or phrases may have on formulating utterances, contributing helpful information to a new study involving effects word type and frequency on prosody in individuals with aphasia.

Fraser, K. C., Meltzer, J. A., Graham, N. L., Leonard, C., Hirst, G., Black, S. E., & Rochon, E. (2014). Automated classification of primary progressive aphasia subtypes from narrative speech transcripts. *Cortex, 55*, 43–60. https://doi.org/10.1016/j.cortex.2012.12.006 *Objective*: Develop a computational method for analyzing and classifying speech samples, as well as determine which features aid in classifying controls, progressive nonfluent aphasia (PNFA), and semantic dementia (SD) and compare the automated

features with manual analyses. *Method*: Twenty-four patients with SD or PNFA and 16 age-matched controls participated in neuropsychological and linguistic tests for a longitudinal primary progressive aphasia (PPA) study. Speech samples of a retelling of the Cinderella story from each participant were collected. Analyses for syntactic complexity, parts of speech (POS) categories and frequencies, and fluency and vocabulary richness were performed as well as for speech rate and filled pauses. Machine learning classifiers were used to predict diagnoses based on certain speech features. *Results*: The features that were considered significant between the SD and control transcripts, and therefore used in that classification task, were: number of clauses, mean length of sentence, mean length of clause, T-units per sentence, total Yngve depth, mean Yngve depth, nouns, noun-verb ratio, noun ratio, demonstratives, adverbs, pronoun ratio, frequency, noun frequency, verb frequency, verb imageability, familiarity, noun familiarity, mean word length, and speech rate. For the task of classifying PNFA versus controls, the significant features were number of words, T-units per sentence, demonstratives, frequency, verb frequency, age of acquisition, noun age of acquisition, mean word length, and speech rate. In the case of SD versus PNFA, only five features were significant: dependent clauses per clause, noun frequency, familiarity, noun familiarity, and occurrence of "um". *Conclusions*: Automated quantitative analysis of speech samples can yield good classification accuracy between controls and aphasic groups. Word familiarity/frequency, adverb and demonstrative production, shorter clauses, and reduced word length and speech rate all helped classify SD subjects from controls. Reduced speed rate and word length, and higher word/verb frequency helped distinguish PNFAs from controls. SD subjects tended to rely on high

familiarity/frequency words (especially with nouns) and PNFA subjects demonstrated reduced speech rate and word length and used high frequency words (especially with verbs). *Relevance to the current study*: People with nonfluent aphasia have reduced speech rate and word lengths. Also, word length, speech rate, word familiarity and word frequency may help distinguish between aphasia subtypes and healthy individuals. Filled pauses may be helpful in analyzing speech samples.

Goldman-Eisler, F. (1964). Hesitation, information, and levels of speech production. In A. Reuck & M. O'Connor (Eds.), *Disorders of Language* (pp. 96–111). Churchill Livingstone. *Objective*: This article explored the underlying/internal processing that goes into speech generation by observing external factors of subject's spontaneous speech. This included and highlighted speech pause/hesitation and their lengths under various conditions. *Methods*: This article reviewed and reported previous experiments regarding the internal processes of spontaneous speech. In the second experiment, subjects had to read and fill in the blanks for incomplete sentences. In the third experiment, subjects described a picture sequence from a wordless cartoon, and then described the overall meaning of the cartoon. In another experiment, breath rates were measured during interviews. *Results*: In experiment one, they found that pauses were related to information content of words bordering the pause. In a second experiment, it was found that pauses in filling in the blanks were proportional to the pauses from the original speaker's completed sentences. In the third experiment, they found that the amount of pausing in the meaning description task was over twice as long as in the sequencing task. Pausing was also independent of degree of spontaneity. In the fourth experiment, it was found that higher breathing rates were associated with more emotional topics, and more restrained breathing rates were associated with intellectual and guarded content. *Conclusions*: Pausing can indicate verbal planning and selection, and operations of two different levels may go into speech. Additionally, breathing rate can signal emotional states of speakers. *Relevance to current study*: Those with nonfluent aphasia may display inappropriate pauses based on the level of verbal planning and selection difficulty. Is different planning required for different lexical categories, lengths, and frequency and are pause durations affected by these differences?

Henderson, A., Goldman-Eisler, F., & Skarbek, A. (1966). Sequential temporal patterns in spontaneous speech. *Language and Speech, 9*(4), 207–216. https://doi.org/10.1177/002383096600900402

Objective: This article examined various temporal aspects of graphs of collected speech samples including hesitations/pauses and when they occurred and with what characteristics. In analyzing their collected data, the authors raised three questions/hypotheses including: a) Was the incidence of filler words associated with steeper slopes? b) Do false starts and repetitions occur more frequently on the steeper slopes? And c) Speech gaps occurring at syntactic junctions will be higher in fluent speech versus hesitant speech. *Method*: Five subjects were interviewed in a question-answer format using objective questions and transcripts were recorded. Using a pen-oscillograph, these recorded passages from the interviews were turned into graphs as a visual representation of pause as a function of speech time. Subjects also read aloud a passage of prose which was recorded and graphed in the same manner as the spontaneous speech interviews. *Results*: The graphs recorded from the interviews resulted in alternating steep and shallow slopes (alternations of relatively long pauses and short

utterances and short pauses and long utterances), which fed into the hypotheses formed. In response to hypothesis number one, the authors found that the incidence of fillers was indeed higher on the steeper slopes in comparison to the shallow slopes. They drew this conclusion by calculating the number of words produced per filler and found the numbers to be overall lower in the steeper slopes. Regarding hypothesis two, researchers found that the incidence of false starts was higher for the steeper slopes as supported by data that there were fewer words per false start in comparison to the shallow slopes. For hypothesis three, it was found that "a steep slope and its succeeding shallower slope form a single unit." *Conclusions*: Researchers concluded that "the present data suggest a functional unit based upon what might be called cognitive rhythm or cognitive stride." Their data also supported the idea that the amount of planning and structure for an utterance can affect the composition of that utterance in terms of pause and other elements. *Relevance to current work*: While this experiment did not involve individuals with aphasia, it discussed the role that planning and organizing an utterance has on pause duration and fillers. The influence of word type, length, and frequency (all elements of utterance planning and organization) and their possible impact on filled pause durations will be examined in the present study.

Hirschberg, J. (2002). Communication and prosody: Functional aspects of prosody. *Speech Communication, 36*(2002), 31–43. https://doi.org/10.1016/S0167-6393(01)00024-3 *Objective*: This article aimed to identify areas of prosodic variation and functions and to review current literature on prosody and future directions/actions to take. *Method*: The article extensively describes functions of prosodic variation and intonational variation in spoken dialogue systems. *Conclusion*: Component technology should be improved to

better prosodic variation production and recognition capabilities. *Relevance to current work*: Prosody adds to human interactions and varies slightly from one speaker to another. One can use certain prosodic features for a variety of meanings. If prosody is impaired, individuals have a difficult time expressing ideas and forming connections with others.

Hirst, D. J. (2005). Form and function in the representation of speech prosody. *Speech Communication, 46*(2005), 334–347. https://doi.org/10.1016/j.specom.2005.02.020 *Objective*: This article aimed to examine prosodic annotation and to distinguish between prosodic function and form and that the two should be separated. *Method*: The author describes prosodic function and form in detail as well as the MOMEL algorithm and INTSINT coding scheme used for annotation of prosodic form. *Conclusion*: Distinctions and separation between prosodic function and form should be emphasized. *Relevance to current study*: Prosody contributes to "lexical identity" and "general affect" in speech and is universally used across languages. Prosodic function and form varies across languages and within languages.

Kim, H., Kintz, S., & Wright, H. H. (2021). Development of a measure of function word use in narrative discourse: Core lexicon analysis in aphasia. *International Journal of Language & Communication Disorders*, *56*(1), 6–19. https://doi.org/10.1111/1460-6984.12567 *Objective*: The purpose of this article was to develop core function word lists for function word evaluation in discourse, and to examine its effectiveness in classifying PWA and distinguishing between aphasia types. *Method*: The study included 470 cognitively healthy adults divided into seven groups based on age (ranging from 20s to 80s) and the 25 most commonly used function words were taken from their narrative language samples. Percent agreement of core function words were compared between PWA groups (nonfluent and fluent) and controls. *Results*: PWA produced fewer function words than controls in narratives, and nonaphasics produced fewer core function words than fluent aphasics. *Conclusions*: Presence/absence of core function words may help classify aphasia types. *Relevance to current study*: Core function word production may be more difficult for individuals with nonfluent aphasia. Could this influence pause duration in samples from this population?

Kirsner, K., Dunn, J., Hird, K., Parkin, T., & Clark, C. (2002). Time for a pause. In *Proceedings of the Ninth Australian International Conference on Speech Science and Technology* (pp. 52–57). https://assta.org/proceedings/sst/sst2002/Papers/kirsner050.pdf

Objective: This article discusses pause types and aims to answer questions about pause analyses and how to look at pause with a new and improved perspective. *Method*: Authors used sample data from a memory experiment involving story generation and then analyzed the sample using PRAAT and SOLVER. There were 20 participants, and each had a 2–5-minute sample. Short pause and long pause distributions were made and analyzed. *Results*: The higher the pause threshold, the higher the proportion of misclassifications. Also, thresholds vary from person to person. No relationship was found between long pause duration and speech segment duration under conditions of story generation and recall. *Conclusions*: Threshold procedures should be implemented in speech analysis and recognition. *Relevance to current study*: This article discusses many elements of speech pausing including its role in classifying aphasia. It also references other articles that are to be included in the current work and that are important regarding pausing in aphasia. The role of pause analysis in research is also discussed in detail, lending itself well to the current work aimed at analyzing pause data from nonfluent aphasics.

Lass, N. (1976). *Contemporary issues in experimental phonetics*. Academic Press. https://doi.org/10.1016/B978-0-12-437150-7.X5001-5

Objective: Chapter 7 of this book outlines and describes suprasegmental elements of speech production in detail. *Relevance to current study*: Stress adds prominence to certain words within a sentence to provide meaning. Intonation signals the function of an utterance/statement.

Le, H., & Lui, M. Y. (2022). *Aphasia*. StatPearls.

Objective: This book article aims to describe the pathophysiology of aphasia as well as the symptoms of each type. It also aims to describe aphasia treatment options as well as suggestions for interprofessional collaboration and practice for aphasia treatment. *Conclusions*: This article provides a detailed explanation of each aphasia subtype, as well as which category they fall under (fluent or nonfluent). It also explains prognostic factors and ideas for aphasia treatment, as well as how to enhance aphasia treatment. *Relevance to current study*: This article lists four different subtypes of nonfluent aphasia, all of which should be accounted for in the sample in my study. Those with Broca's aphasia display difficulty with forming grammatically correct sentences (such as withholding prepositions and articles) and tend to use excessive pauses as a result of this syntactical difficulty. Those with fluent aphasia such as Wernicke's aphasia produce fluent utterances but display errors such as phonemic and semantic paraphasias.

Leung, J. H., Purdy, S. C., Tippett, L. J., & Leao, S. H. S. (2017). Affective speech prosody perception and production in stroke patients with left-hemispheric damage and healthy

controls. *Brain & Language, 166*(2017), 19–28.

https://doi.org/10.1016/j.bandl.2016.12.001

Objective: This article aimed to demonstrate that in addition to those with RHD, those with left-hemisphere damage also present with affective prosody deficits. It also aimed to evaluate current methods for analyzing affective prosody production and perception. *Method*: Participants included 11 people with LHD post-stroke (6 males, 5 females) and 15 controls (4 males, 11 females). Criteria for participation included an age between 30–80, as well as the absence of additional medical/neurological diagnoses. All of the LHD patients completed the WAB-R to assess severity. To assess affective prosody perception, subjects completed the Advanced Clinical Solutions (ACS) Social Perception Subtests in which participants had to listen to an audio recording of a statement and conversation and then matched the audio to the face/picture that best represented it. To assess affective prosody production, subjects completed the aprosodic battery for a repetitive monosyllabic task, and then a spontaneous monosyllabic task in which they either repeated or spontaneously produced "babababa" using six different emotional tones. The participants also produced a phrase for a spontaneous word task in six emotional tones as well. Each of the samples was recorded, analyzed, and used to generate acoustic values. Three second-year speech and language therapy masters students listened to the recordings (the tracks were randomized and renamed) and rated them based on their perception of which emotion was used and how well it was used. Quality-of-life questionnaires were also given to participants. *Results*: Prosodic perception differed significantly between the LHD and control groups, with the controls obtaining higher scores. For prosody production acoustic analysis, they found significant differences

between groups on angry utterances and surprised utterances in the word task. Significant differences in pitch range were found for neutral utterances, semitones, and happy utterances for combined monosyllabic tasks. For prosody production rater judgements, they found raters less likely to identify angry, disinterested neutral, and surprised emotions between groups. LHD patients were better at conveying sadness in words, happiness was similar between groups, and raters had significantly greater difficulty with perceiving all of the emotions from LHD patients in the combined monosyllabic task. LHD patients had a significantly lower degree of emotional expression for sad emotions. Significant quality-of-life differences were found between the two groups. Finally, researchers found significant positive relationships between aphasia severity and physical health, social relationships, and disability subscales on the questionnaire. *Conclusion*: Significant differences in affective prosody perception were found between the LHD and control groups. Differences in prosody production were also found between the groups, with deficits in the LHD group for those with and without aphasia. Poorer quality of life was also found in the LHD group. *Relevance to current study*: PWA may experience difficulties with prosody, including affective prosody. This would make communication difficult and would affect PWA's overall quality of life. Aphasia can affect prosody production, impacting communicative effectiveness.

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.org/10.1016/j.neuropsychologia.2015.08.019

Objective: To examine the effects of word class, frequency, and length on pause rate and pause distribution in individuals with PPA (primary progressive aphasia). *Method*: Three groups of individuals with PPA, divided based on type: PPA-L (logopenic variant), PPA-S (semantic variant), and PPA-G (agrammatic variant). Also, a group of age/education-matched controls. Subjects participated in a retell of the Cinderella story and their response samples were transcribed and coded. Various analyses were completed on the samples, as well as pause analyses. Pauses preceding nouns and verbs (both filled and unfilled) were tallied and timed, then those nouns and verbs were coded according to frequency and length. Researchers also obtained words per minute (WPM) measurements and MRI scans. *Results*: Reduced speech rate, decreased mean length of utterance (MLU), and fewer grammatical sentences were found in the PPA-G group. PPA-S individuals exhibited reduced open-class word production in comparison to PPA-Gs and controls. PPA-Ls demonstrated less noun production than controls. No significant verb differences were found across groups. Higher noun word frequency was found in PPA-S when compared to other groups. Higher pause rate in PPAs than in controls. Higher pause rates for slower speech rates and low-frequency words. PPA-Ls had higher pause rates before nouns than PPA-Gs and controls. *Conclusions*: PPAs had greater pauses in production when compared to controls. Pauses in individuals with PPA-L "may stem from lemma-level noun retrieval deficits." There is also a suggested verb-lemma retrieval impairment and high pause rate in PPA-G. Lemma-level noun-retrieval deficits suggested in PPA-S. Pause distributions may offer neural process understanding. *Relevance to current work*: This study focused on PPA which is a nonfluent aphasia type. The current work will focus on pause durations and lexical analyses in subjects with nonfluent aphasia and therefore this study's pause findings based on lexical variables may offer valuable perspective and background information as to the importance and relevance of a new aphasia pause study.

Maclay, H., & Osgood, C. E. (1959). Hesitation phenomena in spontaneous English speech. *Word, 15*(1), 19–44. https://doi.org/10.1080/00437956.1959.11659682

Objective: This article explores hesitation phenomena in spontaneous speech in terms of analysis of hesitation differences and linguistic distribution. *Method*: Researchers collected, recorded, and transcribed 163 utterances (all greater than 80 words in length) by 13 professional male speakers from samples from a conference at the University of Illinois. These transcriptions were scored/coded according to hesitation type (repeats, false starts, filled pauses, and unfilled pauses) and location. *Results*: The majority of filled and unfilled pauses occurred at word boundaries. Also, overall, filled and unfilled pauses were found to more often occur before lexical words in comparison to function words. More specifically, filled pauses were relatively more likely to occur before functional words, and unfilled before lexical words. It was also found that 47% of overall pauses occurred within phrases. In addition, filled pauses were found to occur more frequently at phrase boundaries and unfilled at word boundaries. Repeats were found to most frequently involve subject personal pronouns, articles, possessive pronouns, numbers, prepositions, and words uniting phrases. False starts most frequently involved nouns, verbs, adjectives, and adverbs. Additionally, false starts tended to occur with lexical words while repeats correlated with function words. Researchers found that overall, pauses tended to occur more frequently than repeats and false starts. It was also noted that hesitancy preferences varied across individuals. *Conclusions*: The types of hesitation phenomena are uncorrelated across speaker and speaker utterances. False starts involve lexical words while repeats “involve function words and occur antecedent to lexical items” and are typically found in similar locations as pauses. Filled and unfilled pauses are “not free variants with respect to positions of occurrence.” Implied levels of encoding organization (lexical and grammatical) and possible differences in pause types based on non-speech interval duration. *Relevance to current work*: While this study does not involve aphasic subjects, it offers important information regarding location of both filled and unfilled pauses as well as false starts/incomplete words. These are all elements that will be analyzed in the current work. This information on syntactic categories, pauses and their relation to prosody can lend perspectives that could potentially transfer over to nonfluent aphasia speakers.

MacWhinney, B., Fromm, D., Forbes, M., & Holland, A. (2011). AphasiaBank: Methods for studying discourse. *Aphasiology, 25*(11), 1286–1307. https://doi.org/10.1080/02687038.2011.589893

Objective: The purpose of this article was to outline the AphasiaBank protocol and to describe various analyses that can be done using the samples stored in the bank. *Method*: The article first describes the background and protocol of the AphasiaBank. It then describes sample analyses of AphasiaBank Cinderella story transcriptions. *Conclusion*: AphasiaBank samples support a wide variety of analyses that can be included in various studies of aphasia. *Relevance to current work*: All nonfluent aphasia samples will come from this database. Therefore, the description of AphasiaBank protocols and collection of samples should be included in the introduction of the current work.

Mitchell, L. (2022). Speech pause in people with aphasia across word length, frequency, and syntactic category (9536) [Master's thesis, Brigham Young University]. *Theses and Dissertations*. https://scholarsarchive.byu.edu/etd/9536/

Objective: The purpose of this study was to examine if silent extended pause durations in people with aphasia are influenced by the word length, word frequency, and syntactic category around pause boundaries. *Method*: Speech samples taken from 21 aphasic speakers aged 32–81 with varying types and severities of aphasia were analyzed. These samples were gathered using a narrative discourse task and pauses between and within utterances were recorded. Pause durations within these samples were measured in a previous study, while the current study coded the words at aforementioned silent pause boundaries according to word length, word frequency, and syntactic category. Results were divided and discussed according to aphasia type (fluent vs. nonfluent). *Results*: It was found that there was no significant correlation between silent pause duration and word length both in nonfluent and fluent aphasia speakers. Additionally, there was no significant relationship found between pause duration and word frequency in either group. Concerning syntactic category, researchers found that there were no significant differences in pause durations between content and function words at utterance boundaries in both nonfluent and fluent groups. But significant differences of pause duration were seen for both groups in that within an utterance, pause durations were shorter before a content word versus a function word. *Conclusions*: Word length and frequency appeared to have no significant impact on silent pause durations, although syntactic category may influence pause duration more significantly within utterances when comparing pauses preceding content and function words. It was noted that there

were limitations to this study in that the ratio of fluent to nonfluent aphasia speakers was uneven. Also, only silent pauses were analyzed, opening the door for more research including filled pause analyzation. *Relevance to current work*: The limitations of this study open the door for a study that extends pause analysis by incorporating a greater number of nonfluent aphasic subjects as well as the use of filled pause data. Data collected in an extension study with these new elements can allow for comparisons to be drawn and for further analysis of prosody in persons with aphasia.

Nooteboom, S. (1997). The prosody of speech: Melody and rhythm. *The Handbook of Phonetic Sciences* (pp. 1–48). https://www.researchgate.net/publication/46675980

Objective: This chapter provides in-depth and thorough descriptions of the suprasegmental properties of melody and rhythm as well as the components that make up each of them. *Relevance to current work*: Speech pause is integral to temporal patterning and speech perception. Because speech pause is impaired and abnormal in those with nonfluent aphasia, this temporal patterning in their expressive language may be impacted. How is this temporal patterning affected by linguistic and contextual factors?

Schlenck, K. J., Huber, W., & Willmes, K. (1987). “Prepairs” and repairs: Different monitoring functions in aphasic language production. *Brain and Language, 30*(2), 226–244. https://doi.org/10.1016/0093-934x(89)90030-8

Objective: Number and type of linguistic repairs and “prepairs” (hesitation prior to a paraphasia) were analyzed using picture description samples from people with varying types of aphasia (Broca’s, Wernicke’s, and amnesic) or no aphasia to better understand linguistic processing difficulties across groups. *Method*: The study included 60 participants total, with 10 per group according to aphasia type or control type. Aphasia

groups were classified based on the Aechen aphasia test (AAT). Participants were recorded as they described pictures in one sentence and then pause durations and linguistic performances were analyzed. *Results*: Nonaphasics and Broca's aphasics used fewer clauses in the picture description task while Wernicke's aphasics used more. Prepairs dominated in left-hemisphere groups while repairs were minimal across all subjects. Relative frequency of prepairs was not significantly different across aphasia groups. In Broca's and Wernicke's aphasics, positive correlation was found between comprehension and prepairs while negative correlation was found between production score and prepairs. Researchers found that prepairs were higher before a finite verb and between syntactic constituents versus after finite verbs and within syntactic constituents. There was also a high amount of unfilled pausing recorded across aphasia groups. *Conclusions*: Prepairs can occur in individuals with production and/or comprehension difficulties and they mostly occurred at clause boundaries in this study. *Relevance to current work*: Prepairs offer a greater perspective into hesitation and speech planning in those with aphasia. This study also offers the idea that syntactic elements may result in pause differences, especially in between utterance pauses versus within utterance pauses The location of prepairs in these samples made it difficult to determine what particular elements influence these prepair locations and therefore further studies can expand upon this question.

Seddoh, S. A. (2000). Basis of intonation disturbance in aphasia: Production. *Aphasiology, 14*(11), 1105–1126. https://doi.org/10.1080/02687030050174656

Objective: This article aimed to examine abnormalities in the intonation PWA and their origins (linguistic or nonlinguistic). *Method*: This study involved 31 subjects total: 15 (7

male, 8 female) PWA with LHD (6 w/conduction, 4 w/Wernicke's, 5 w/Broca's) who were at least 3 months post-onset, and 16 controls (8 male, 8 female). Each PWA was classified as fluent or nonfluent (10 fluent, 5 nonfluent) and were presented with 20 matched echo/intonation questions and statements of varying length (long or short). Each subject was given a card with questions and statements and was required to produce the sentences in a natural way. Each utterance was recorded and filtered with a low-pass filter. *Results*: Terminal frequency change (F-delta) was 2x higher for questions versus statements across groups. PWA's terminal frequency change was significantly lower than controls. Terminal final frequency (TFF) was lower for PWA in comparison with controls. Performance was otherwise comparable between groups. *Conclusions*: fundamental frequency as a function of intonation is impaired in PWA. As sentence/syntactical complexity increases, the more fundamental frequency is disturbed in PWA. *Relevance to current study*: Intonation is correlated to fundamental frequency and "conveys verbal information at the sentence or phrase level." PWA exhibit impaired intonation across sentences.

Walker, J. P., Joseph, L., & Goodman, J. (2009). The production of linguistic prosody in subjects with aphasia. *Clinical Linguistics & Phonetics, 23*(7), 529–549. https://doi.org/10.1080/02699200902946944

Objective: The purpose of this study was to investigate left hemisphere contribution to prosody in three linguistic conditions (three experiments) and evaluate them according to fundamental frequency, duration, and amplitude. *Method*: In experiment 1, lexical stress differences were emphasized and assessed using nine left hemisphere-damaged (LHD) individuals and ten controls. LHD language abilities were assessed and they had to meet

a cutoff score. Subjects participated in OPEs and speech tasks, and intelligibility ratings. Subjects were given paired words and the three acoustic measures were analyzed for each pair. Ten listeners listened to the lexical stress productions and followed directions for identifying the pictures for what they heard. In experiment 2, prosodic structures “that determined the location of syntactic boundaries” was emphasized. Subjects read paired sentences out loud and naïve listeners selected the picture that depicted the sentence. In experiment 3, prosodic elements for questions and statements were emphasized. Subjects read paired sentences as either a question or a statement and then naïve listeners selected whether they heard a question or statement. *Results*: Experiment 1 found that first syllable durations depended on word type. They also found effects of word type on ssecond syllable durations. Second syllable amplitudes were also affected by word type. Fundamental frequencies also varied depending on group assignment. In experiment 2, they found that first syllable durations were affected by word type, but there was no significance in the relationship between word type and second syllable durations. Experiment 3 found that controls produced longer final syllables than LHDs. Amplitude in final syllables of questions was higher than in statements. Fundamental frequency peak in final syllables of controls was higher than in LHD group. *Conclusions*: Experiment 1 found that acoustic features of stressed syllables differed between control and LHD groups. Experiment 2 found that LHD and control groups differed in acoustic features when marking syntactic boundaries. They found that individuals with LHD struggled with pre-boundary syllable lengthening and insertions of pauses at nonsyntactic junctures and non-boundary positions. Finally, experiment 3 found that prosodic cues conveying questions and statements differed between groups. *Relevance to current study*: Prosody involves interactions of fundamental frequency, intensity, and duration. These all contribute to the meaning of a sentence. Individuals with aphasia had greater amounts of pausing as well as inappropriate uses of pausing.

APPENDIX B

IRB Approval Protocols

TalkBank | IRB Approval

This page explains the principles involved in securing IRB permission for data sharing. If you already have IRB clearance and are ready to contribute your data to TalkBank (CHILDES, AphasiaBank, SLABank, etc.), you should follow these ***instructions*** on how to actually submit your data.

1. IRB Principles

TalkBank members who are interested in contributing their data need to make sure that they obtain IRB approval for their study, along with informed consent from individual participants. There are no standard forms for IRB applications, since every university or institute creates their own forms, procedures, and templates. For the purposes of contributing to TalkBank, the important thing is to select the appropriate level of access to the data that participants are being asked to grant. To help you determine this, we have created an ***OPTIONS summary*** for the 9 options that are available. We would recommend that you ask participants to permit unrestricted access with pseudonymization of the transcripts (Options 1 and 2). You should include on your form the fact that participants always have the right to request that parts or all of the data in which they participate be removed from TalkBank at any time.

2. Contributions of Archival Data

Often researchers will wish to contribute data collected in projects that have already been completed. In such cases, it may be difficult or impossible to contact participants to obtain a new consent form. However, IRBs are allowed to permit including these data in TalkBank, if certain conditions are met.

1. The original consent forms should not have exclusionary language such as "These data will only be made available to Professor XYZ and her laboratory". If the consent forms says something like "These data will only be made available to qualified researchers," then inclusion in TalkBank should be allowed, as long as only qualified researchers are given the necessary password. If the consent form is still more general, then passwords may not be necessary.
2. Data should be anonymized.
3. Additional protection is possible, as described on the ***options summary page*** .

4. It is important to emphasize that granting agencies stipulate that data collected with federal funds should be made available to researchers, as long as anonymity is preserved.

3. GDPR Compliance

The General Data Protection Regulation (GDPR) establishes rules for personal data on the web. The EU web site for GDPR issues is https://gdpr-info.eu/. In regards to TalkBank, there are five core GDPR issues

1. Commercial purposes issue: GDPR is designed to apply to data transferred for commercial purposes. TalkBank has no commercial purposes. However, it could still apply if TalkBank were to collect emails and addresses, which it does not do.
2. The scientific data issue: A good summary of these issues can be found in ***this Nature article*** which notes that, consent is given "to certain areas of scientific research when in keeping with recognised ethical standards for scientific research." Article 89 of the GDPR states that, "Where personal data are processed for scientific or historical research purposes or statistical purposes, Union or Member State law may provide for derogations from the rights referred to in Articles 15, 16, 18 and 21 subject to the conditions and safeguards referred to in paragraph 1 of this Article in so far as such rights are likely to render impossible or seriously impair the achievement of the specific purposes, and such derogations are necessary for the fulfilment of those purposes." In other words, data-sharing is allowed for research purposes. In addition, Recital 113 allows for transfers of data from a limited number of data subjects for scientific purposes for an increase of knowledge.
3. The informed consent Issue: NIH IRB informed consent guidelines are in accord with the GDPR Consent rules. Given this, if participants give consent for making data available to qualified researchers, then this should be approved. GDPR emphasizes also that this consent must be revocable and that there should be methods for allowing participants to revoke consent.
4. The deidentification issue: If data are deidentified, then they are not personal data and are not covered by GDPR and IRB. Data are not be anonymous or deidentified if they have: name plus surname, credit card, telephone, address, or number plate. First name alone is not identifying. It has to be Name plus Surname. Anonymization must be irreversible. This means that contributors should destroy participant names. This holds in both EU and USA. However, the GDPR catch-22 here is that a link to the data needs to be maintained to allow for data removal. The solution for this is to make the information linking to a person only available to a third party "honest broker". See below for a discussion of identification based on voice samples.
5. The Code of Conduct issue: Article 40 allows for development of a Code of Conduct to facilitate data transfer to non-EU countries. In the case that an institution prefers to have identifiable media stored on servers in the EU, it is possible to implement CORS (cross origin resource sharing) from a CHAT file at

CMU to a media server in the EU. This is done by allowing access from https://*.talkbank.org.

4. Deidentification

In order to deidentify transcripts, it is important to replace any last names with the word "Lastname" with a capital L. Also addresses or local city names should be replaced with "Addressname" with a capital A. Other forms include "Cityname", "Schoolname", "Hospitalname" and so on. These same English words should be used even in other languages. It is not crucial to replace children's first names unless they are very unique.

The EU Amnesia project at https://amnesia.openaire.eu provides software for deidentification of spreadsheet data.

The Canadian CONP Ethics and Governance Committee has a series of ***recommendations for deidentification of neuroimaging data*** .

For audio deidentfication, we can then use the occurrences of the terms Lastname and Address in the transcripts to guide the removal of the names and addresses from the corresponding segment in the audio track. You can follow the suggestions in the section of the CLAN manual on "Audio Anonymization" which are also available ***here*** Once this is done, children and others can only be identified by people who already know them. Because of this, contribution of audio is equivalent in IRB terms to contribution of transcripts.

You can also save yourself a lot of trouble if you avoid using idetifying information when making recordings.

Voiceprints

Researchers often ask about whether they need to request additional IRB approval for contributing audio data. The concern is that audio data may be less confidential than transcript data. However, as long as identifying material is removed from both transcripts and audio, they do not present additional confidentiality issues.

Some reviewers and IRB committees believe that spoken data is identifiable through voice recognition technology. However, this judgment is based on a confusion between closed-set identification and open-set identification. Closed-set identification relies on a pre-existing pool of voiceprints from a given group, such as members of a company or subscribers to a service. Open-set identification does not rely on this pre-existing pool of voiceprints. As noted by Togneri and Pullella (2011), "in open-set identification the unknown individual can come from the general population. However as identification is always carried out against a finite, known pool of individuals it is not possible to identify arbitrary people."

Togneri, R., & Pullella, D. (2011). An overview of speaker identification: Accuracy and robustness issues. IEEE circuits and systems magazine, 11(2), 23-61. ***pdf***

As Yuan and Liberman (2008) discovered, speaker identification in even a closed group of Supreme Court judges in TalkBank's SCOTUS corpus is still very difficult.

Yuan, J., & Liberman, M. (2008). Speaker identification on the SCOTUS corpus. Journal of the Acoustical Society of America, 123(5), 3878. ***pdf***

5. Contributions to CHILDES and PhonBank

Although each University and project will have different requirements, contributors often ask for a generic contribution template form, so here is a ***sample CHILDES/PhonBank consent form*** based roughly on the local format at CMU.

6. Contributions to AphasiaBank/DementiaBank/TBIBank/RHDBank:

Research with subjects with disabilities requires additional access restriction, such as password protection. It may also require more complete IRB documentation. In this regard, researchers working with the AphasiaBank protocol will find these additional IRB-approved materials useful:

- A ***generic informed consent*** form in the CMU format.
- Consent form from ***CMU***
- Consent form from ***Emerson***.
- Consent form for ***Mandarin***.
- Consent forms from Indiana University - 2020
  - ***Consent form for PWA***
  - ***Consent form for Control***
  - ***Verbal script for consent***
- Consent forms from Nazareth College
  - ***Consent form for Control***
  - ***Consent form for RHD participant***
  - ***Consent form for student participant***
- Consent forms from Duke University
  - ***Consent form for RHD participant***
  - ***e-consent form for RHD participant***
  - ***Consent form for volunteer participant***
  - ***e-consent form for volunteer participant***
- Full IRB application from ***University of South Florida***.
- Full IRB application from ***Kansas*** with these related documents:
  - ***Consent form for surrogate***
  - ***Consent form for PWA***
  - ***Assent form for PWA***
  - ***Recruitment poster***

- Four picture-based consent forms for people with aphasia:
    - a very ***simple*** one
    - one from ***USF***
    - one from the ***Adler Center***,
    - form for the ***Famous People Protocol***

Contributions to the other three clinical databanks -- DementiaBank, RHDBank, and TBIBank can follow formats similar those given above for AphasiaBank. The issues involved are generally similar.

7. Contributions to FluencyBank

To protect subject confidentiality, all research contributions to FluencyBank are restricted and require password to access. We suggest that new projects use a ***graduated consent form*** developed at the University of Maryland, that allows participants to specify use of video, audio-only, or transcript-only in contributed data.

When communicating with your IRB, you may find the suggestions in this ***briefing sheet*** helpful.

For projects underway, or recently completed, or longitudinal projects in which PIs would like to have an ongoing relationship before making a contribution request of subjects, we have a ***sample post-hoc consent form*** from the University of Maryland.

For completed projects that have used video without permission to share the video, we will work with you to extract the audio tracks from your video files. (Please see Contributing audio, above, for reasons why this may not require additional IRB consideration). Please contact Brian MacWhinney or Nan Bernstein Ratner to determine how best to handle your data.

8. Contributions to HomeBank

Please consult the ***HomeBank guidelines.***

APPENDIX C

Consent Form

Adler Aphasia Center
Where people touched by Aphasia can comfortably communicate

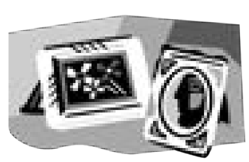
RESEARCH PARTICIPANT INFORMATION AND CONSENT FORM
AphasiaBank

PURPOSE

We want to collect data for the study of language and communication in people with aphasia.

TASKS

You will be asked to:



- Describe pictures
- Discuss events in your life
- Tell a story
- Complete aphasia tests

RECORDING

You will be:

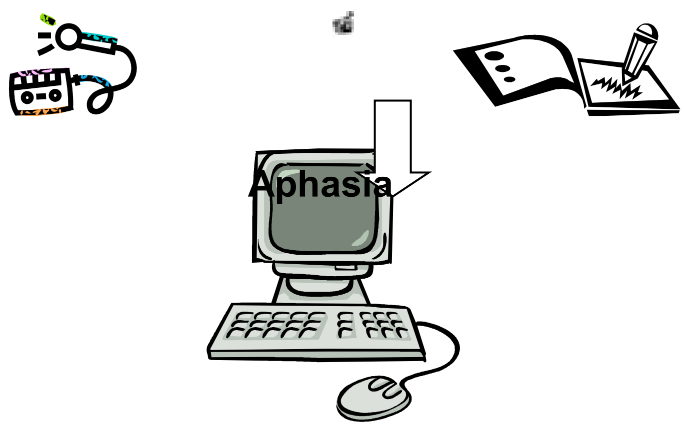
- Audio taped
- Videotaped

Your responses will be written out.

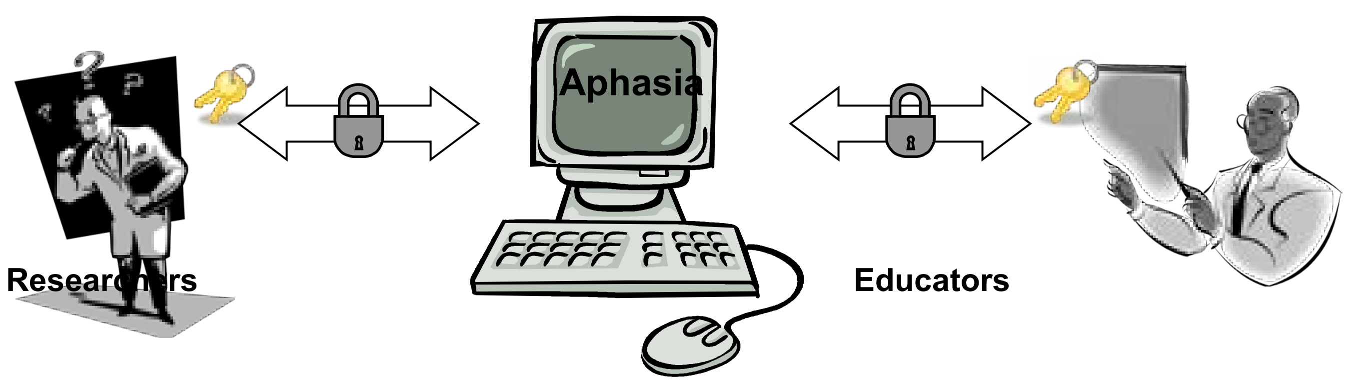
Your name and address will not be recorded.

USE

The data from the study will go on an internet database called AphasiaBank.



Researchers and educators with a password will have access the data.



Researchers or educators may use the videos in classes or presentations about aphasia.

RISKS

There are NO **known** risks or discomforts associated with this study.

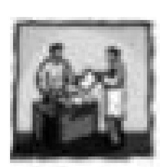
COMPENSATION

There is no monetary compensation for participating.

BENEFITS

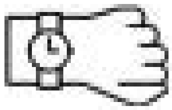
You will help us improve our understanding of aphasia.

We can give you your test results for your files.



TIME

It will take 2 to 3 hours.



If you get tired, we can stop and finish another day.

RIGHTS

Your participation is voluntary.

??

??

Yes? ☑ No? ☒

You can stop at any time.

Questions about the study:

Contact
Gretchen Szabo
at
201-368-8585
or
gszabo@adleraphasiacenter.org

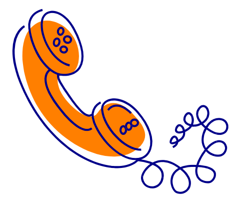
Questions about your rights:

Contact

IRB Chair

at

201-368-8585



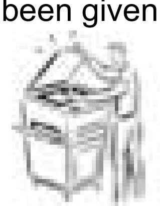
CONSENT TO PARTICIPATE

The information on the previous pages has been explained to me

☐ YES  ☐ NO 

____

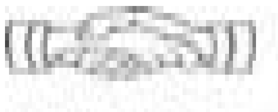
I have been given a copy of this form.

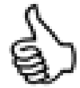


☐ YES  ☐ NO 

____

I agree to participate in the research project.



☐ YES 

☐ NO 

_______________________________ ________________

PARTICIPANT SIGNATURE DATE

___________________________________ __________________

WITNESS SIGNATURE DATE