2025-05-06

Pausing Patterns Across Speech Tasks in Individuals Diagnosed With Broca's Aphasia

Kate Low
Brigham Young University

Pausing Patterns Across Speech Tasks in Individuals

Diagnosed With Broca's Aphasia

Kate Low

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

Shawn L. Nissen, Chair
Tyson Harmon
Christopher Dromey

Department of Communication Disorders

Brigham Young University

ABSTRACT

Pausing Patterns Across Speech Tasks in Individuals
Diagnosed With Broca's Aphasia

Kate Low
Department of Communication Disorders, BYU
Master of Science

The purpose of this study was to investigate whether individuals with moderate Broca's aphasia exhibit different pause duration and frequency patterns compared to individuals without neurological disorders, as well as to explore how speech task type influences pause patterns. A total of 16 participants (eight male and eight female) previously diagnosed with moderate Broca's aphasia and apraxia were included in this study, along with 16 age- and gender-matched control participants. Speech recordings from the 16 participants were sourced from the AphasiaBank database. Speech samples from four different task types (i.e., interview, personal narrative, picture description, and story retell) were analyzed and coded using Praat software to identify the boundaries of between and within-utterance pauses, as well as identify pause type (filled, silent, and combination). Results found a significant difference in the pause durations in people with aphasia (PWA; $M = 1.405$ sec) compared to neurologically healthy individuals ($M = .744$ sec), but no significant difference in frequency of pausing per utterance between the two groups. There were no significant differences in pause duration or frequency across speech task type. A significant interaction was found between pause frequency and pause type, with silent pauses being the most frequent. A significant main effect was found for pause type, with combination pauses being the longest in duration. Additionally, a significant interaction between neurological status and pause type was found, with combination pauses being significantly longer in PWA. No other significant main effects or interactions were found. The findings of this study suggest that pause duration, rather than frequency may be a more reliable diagnostic indicator. Additionally, consistency of pause patterns across task types has important clinical implications for assessment and treatment efficiency. Further research is warranted in order to establish more precise definitions of atypical pausing and expand these findings to more diverse aphasia populations.

Keywords: aphasia, prosody, pause, Broca's aphasia, nonfluent aphasia

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to all who contributed to this research study. I am thankful for my advisor, Dr. Shawn Nissen, who graciously shared his invalulable knowledge, dedicated countless hours, and gave expert guidance throughout this whole process. I am also grateful for my thesis committee members, Dr. Tyson Harmon and Dr. Christopher Dromey, for their expert insights and perspectives. I would also like to thank the undergraduate research team for their dedicated time and talents in order to supply the data needed to complete this work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DESCRIPTION OF THESIS STRUCTURE AND CONTENT

This thesis, *Pausing Across Speech Tasks in Individuals Diagnosed With Broca's Aphasia,* is part of a larger study exploring the impact of pause on speech communication in people with aphasia. These data are an extension to previous research conducted by Newcombe (2024). 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, Institutional Review Board approved protocols in Appendix B, and consent forms in Appendix C.

Introduction

Individuals who sustain damage to the language centers of the brain often manifest symptoms of aphasia, characterized by difficulties in their ability to communicate effectively. While aphasia can stem from various etiologies such as traumatic brain injury, tumors, or neurological diseases, the most common cause is cerebrovascular accident (CVA; Le & Lui, 2023). Across the United States, aphasia is a prevalent and far-reaching disorder, with an estimated 180,000 new cases annually, as reported by the National Institute on Deafness and Other Communication Disorders (NIDCD; 2017). The symptoms and severity of aphasia can vary based on the location and size of an individual's brain injury, which highlights the necessity for specific assessment and treatment by speech-language pathologists.

Breakdowns in communication due to aphasia extend beyond mere linguistic challenges, often resulting in feelings of frustration, depression, and social isolation. Studies, such as the one conducted by Leung et al. (2017), have highlighted the impact of aphasia on an individual's quality of life, revealing heightened levels of anxiety surrounding interpersonal communication and language production (Cahana-Amitay et al., 2011). These feelings of anxiety have been found to affect the recovery prognosis of a person with aphasia (PWA). Additionally, research by Dalemans et al. (2010) illuminates the broader societal implications of communication difficulties in PWA, revealing diminished participation in society due to comprehension difficulties, social marginalization, feeling burdensome to others, and limited occupational opportunities.

Aphasia can manifest in varied forms, categorized broadly into fluent and nonfluent types. Those with fluent aphasia are able to speak in full sentences; however, they are often filled with nonwords or semantically empty utterances. Subtypes of fluent aphasia include Wernicke's, transcortical sensory, conduction, and anomic. In contrast, nonfluent aphasia is often characterized by slow and labored speech. Those diagnosed with nonfluent aphasia commonly have difficulty formulating grammatically correct sentences and typically speak in very short words or phrases. Subtypes of nonfluent aphasias include Broca's, transcortical motor, mixed transcortical, and global. This study will be specifically focused on individuals diagnosed with Broca's aphasia.

Broca's Aphasia

Individuals diagnosed with Broca's aphasia commonly have a lesion located in Broca's area, the cortical area located in the frontal lobe primarily responsible for speech production (Le & Lui, 2023). Damage to this region of the brain often leads individuals with Broca's aphasia to exhibit "telegraphic speech," marked by agrammatisms, or the omission of articles, prepositions, and other grammatical elements. Additionally, they often encounter difficulties in word retrieval, leading to halting, effortful speech characterized by frequent and long hesitations (Angelopoulou et al., 2018). Due to the location of damage in the motor cortex, acquired apraxia of speech (AOS) often accompanies Broca's aphasia, resulting in misarticulation of individual sounds and words. In fact, 81% of individuals with Broca's aphasia are also diagnosed with co-occurring AOS (Duffy, 2012). Due to the common co-occurring nature of Broca's aphasia and AOS, they are often not differentiated in treatment. Phonemic paraphasias can be typical of individuals with Broca's aphasia, whereas semantic and neologistic paraphasias are more common in fluent subtypes (Helm-Estabrooks et al., 2014). Generally, individuals with Broca's aphasia tend to have difficulty with expressive language, while their receptive language is relatively intact compared to other aphasia subtypes. Another common symptom of Broca's aphasia is impaired prosody, which is often a characteristic that is overlooked during diagnosis and treatment of aphasia.

Prosodic deficits in communication significantly impact a person's communicative effectiveness and quality of life (Baylor et al., 2011). Research indicates that neurologically healthy individuals demonstrate more accurate perception and production of affective prosody compared to those with left-hemisphere damage, leading to increased communication challenges and diminished quality of life among individuals with aphasia (Leung et al., 2017). Difficulties with the ability to perceive and produce prosody hinder the ability to establish and maintain relationships, express thoughts and emotions effectively, and may foster feelings of social isolation. Gavarró and Salmons (2013) found that individuals with Broca's aphasia could identify prosody with 89.1% accuracy, which is lower than the 95.6% accuracy demonstrated by neurologically healthy individuals. Despite some retained prosody comprehension in individuals with Broca's aphasia, their susceptibility to communication breakdowns due to impaired prosody results in a poorer quality of life compared to neurologically healthy individuals.

Prosody

Prosody is a paralinguistic feature of communication that enriches spoken language by conveying additional meaning and emotion (Behrman & Finan, 2016). It encompasses various elements of speech such as intonation, loudness, and timing features (Bauman-Wängler, 2009). The acoustic correlates of intonation are conveyed through pitch or fundamental frequency changes across an utterance. One of the roles of intonation is to assist a listener in determining the type of utterance being expressed by the speaker. For example, when asking a question, the pitch tends to rise at the end of the utterance. Speech loudness is one of the mechanisms often used to place stress or emphasis on a particular syllable, word, or phrase, altering the meaning of words such as "contest" based on which syllable is emphasized (e.g., *con*test vs. con*test*; Gussenhoven & Chen, 2020). Speakers may also use stress to indicate new information or provide clarification; for example, a speaker might emphasize an adjective to specify the object to which they are referring (e.g., "No, I meant the *blue* one"). The timing of speech for typical speakers includes the use of junctures or pauses at phrase, clause, or sentence boundaries (Shriberg & Kent, 2013). Duration can also be used as a stress cue, with stressed words or syllables being slightly prolonged. Due to the nuanced nature of spoken communication, the use of prosodic elements is crucial in conveying a message from one individual to another.

Speech Pause

By defining boundaries between words and phrases, pausing contributes to the temporal organization of speech, which aids listener comprehension (Reich, 1980). Moreover, the timing and duration of pauses offer valuable insights into the speaker's cognitive processes, highlighting the amount of effort required to perform tasks such as planning articulatory movements, speech monitoring, memory, and word access, selection, and retrieval. (Angelopoulou et al., 2018). It has been found that the frequency and length of pauses also contributes to perceived fluency of the speaker. For instance, research by Bosker et al. (2012) revealed that second language speakers who maintained a relatively faster speech pace with fewer pauses were perceived as more fluent compared to those who spoke at a slower speech rate and with more pauses, even if their accuracy was higher.

Pausing is a prosodic element that is used in everyday speech. A study conducted by Corley et al. (2007) revealed that neurologically healthy individuals often pause before encountering unpredictable or less frequently used words. Interestingly, these pauses or disfluencies influence how the brain processes language (Corley et al., 2007). Speakers often place emphasis on unfamiliar or low frequency words by inserting a speech pause immediately prior to the word, which increases memorability for listeners. However, a listener's comprehension of a speaker's message may be hindered if a pause is produced at ungrammatical or nonstructural locations (Reich, 1980).

Speech hesitations manifest in various forms, including silent and filled pauses. Silent pauses can be defined as a prolonged silence, while filled pauses are instances of a lengthening of phonemes or verbal hesitation markers (Maclay & Osgood, 1959). These hesitation devices include verbal fillers such as "er," "uh," and "um." Research by Maclay and Osgood (1959) indicated that silent pauses often occur before lexical words and within phrases, whereas filled pauses typically occur before function words and between phrase boundaries.

Speech Pause in Broca's Aphasia

Pausing is a crucial aspect of communication that is frequently problematic for individuals diagnosed with nonfluent forms of aphasia. Research by Angelopoulou et al. (2018) indicated that individuals with aphasia tend to incorporate more frequent and extended pauses both between and within their spoken expressions. This phenomenon may be attributed to the additional linguistic processing time required by individuals with damage to the language centers of the brain. Specifically, individuals with Broca's aphasia not only experience challenges with pausing, but also encounter difficulties in maintaining speech rhythm. Studies by Dahmani et al. (2008) and Fraser et al. (2014) have identified impaired rhythm, including pausing and speech rate, as a defining characteristic of Broca's aphasia. Given the word-finding difficulties experienced by individuals with Broca's aphasia, the increased number and duration of pauses may also reflect the inefficient use of cognitive resources during word retrieval tasks following an individual's brain injury.

A study performed by Newcombe (2024) gives further insight into pause patterns in individuals diagnosed with nonfluent aphasia. It was discovered that the individuals with aphasia had a greater proportion of silent pauses compared to filled pauses in their utterances. However, a relatively high degree of pauses were combination pauses, composed of two silent pauses with a filled pause in between. The duration of filled pauses in individuals with nonfluent aphasia varied from 135 to 430 ms, markedly longer than the average 85 ms observed in typical speakers (Bóna, 2016). Silent pauses within an utterance in those with nonfluent aphasia ranged from 924 to 1208 ms, durations that are much longer than those of typical speakers of under 250 ms (Bóna, 2016; Hoffer, 2023). Additionally, the study explored the frequency of pauses occurring within utterances, finding an average of approximately 1.5 extended pauses per utterance.

Speech Communication and Prosodic Patterns Across Task Type

A speaker's speech communication patterns can change as a function of the task type and linguistic complexity of the message they are communicating. Previous research with second language learners has found that the task structure of a speaker's communication may influence their speech fluency (Skehan & Foster, 1999). For example, structured narratives, with predictable plots and events, resulted in higher speech fluency compared to unstructured narratives. This is likely attributable to the lower cognitive load association with well-organized and prepared tasks, enabling more cognitive resources to be allocated to speech production. Tavakoli and Foster (2008) conducted a study that yielded comparable results. Their findings indicated that during the retelling of structured narratives, individuals exhibited greater fluency in speech, with fewer instances of reformulation, false starts, and pauses compared to unstructured narratives. Different tasks require different levels of linguistic processing, depending on the complexity of the task.

Predictability and structure reduce the cognitive load on the speaker, which allows more attention to be dedicated to speech, resulting in greater fluency (Robinson, 2001). Considering that an individual's perceived speech fluency is highly correlated with prosodic elements of speech (Bosker et al., 2012), it is of interest to examine the degree to which factors such as stress, emphasis, and pausing are affected by the structure and cognitive load of the speech task type.

Changing the type and complexity of speech tasks not only influences task difficulty in terms of cognitive load, but also affects an individual's speech pausing patterns from a motor planning and production perspective. Even in neurologically healthy speakers, research conducted by Howell and Kadi-Hanifi (1991) revealed that spontaneous speech exhibits longer and more frequent pauses compared to read speech. Laan (1997) noted a slower speech rate in read speech compared to spontaneous speech. Read speech tends to be more precisely articulated with fewer hesitations and false starts, due to reduced cognitive demand as readers are relieved of generating the words spontaneously. Additionally, Hoffer (2023) explored pausing patterns among neurologically healthy speakers during a picture description task, revealing mean durations of 70–90 ms for silent pauses and 80–90 ms for filled pauses. Bóna (2016) also investigated pause patterns in neurologically healthy speakers, but in spontaneous narratives. The results of this study found an average duration of 590 ms for silent pauses and 336 ms for filled pauses. The difference in pause durations between picture description and spontaneous narrative tasks likely arises from the greater cognitive demands inherent in spontaneously recounting a narrative, as opposed to the structured support provided by using a picture to guide task performance.

The research regarding how different task types influence speech production in individuals with aphasia has been growing in recent years. A study performed by Leaman and Edmonds (2023) evaluated the speech of individuals with aphasia when performing two tasks: picture description and unstructured conversation. The study revealed significant language differences between the two task types, including variability in overall success of communication, morphological errors, sentence structure, number of informative words, and coherence. These discrepancies emphasize the importance of not relying solely on one task type to inform intervention needs across all contexts of life. Additionally, it was noted by the authors that it is not appropriate to determine type and severity of aphasia based on a single task type language sample. Similarly, research by Stark and Fukuyama (2021) found that when comparing speech production across four different task types, notable differences in language usage were evident among them. For example, procedural discourse yielded the lowest number of overall words, whereas single-picture descriptions elicited the highest noun-verb ratio. These findings underscore the importance of intentionally selecting a broad range of task types that reflect an individual's real world communicative environment when assessing the language abilities in individuals with aphasia, recognizing that performance can vary depending on context.

Specific to prosody, Deloche et al. (1979) conducted a revealing study comparing speech pauses across different task types among individuals with aphasia. The control participants in the study exhibited a longer mean duration in pauses, reduced speaking rate, and an increased number of pauses during a picture description task compared to an interview task. Conversely, participants with aphasia displayed greater changes in speech rates during picture description, due to decreased pause durations and faster speech rates in this particular task. The researchers theorized that PWA may have spoken more efficiently in the picture description task because they had the picture to depend on for context. The results of this study show that people with aphasia may produce less frequent and shorter speech pauses when given extra context, which is similar to the findings in second language learners, due to the lightened cognitive load. Although the study by Deloche et al. (1979) provides valuable insights, further research is needed to understand the relationship between task type and pausing in individuals with aphasia.

Review of Prosodic Measurements in Common Aphasia Batteries

A review of commonly used aphasia assessments, such as the Revised Western Aphasia Battery (WAB-R; Kertesz, 2006), the Quick Aphasia Battery (QAB; Wilson et al., 2018), the Boston Diagnostic Aphasia Examination, Third Edition (BDAE-3; Goodglass et al., 2001), and the Ross Information Processing Assessment, Second Edition (RIPA-2; Ross-Swain, 1996), found a lack of comprehensive assessment materials for evaluating prosody, especially across different task types. While some assessments, such as the WAB-R and the BDAE-3, briefly mention pitch in their criteria for evaluating speech fluency, it is not objectively measured or standardized. For instance, the WAB-R considers aspects like varied intonation in its fluency rating but lacks a detailed assessment of typical pitch contours. Similarly, although the BDAE-3 assessment includes a rating for "melodic line," it lacks a standardized measure for intonation. Additionally, current aphasia batteries overlook the role of speech pause in determining aphasia type and severity. While assessments like the QAB and the BDAE-3 measure speech rate of spontaneous speech, they fail to provide specific measures for pausing. Although the QAB, BDAE-3, and RIPA-2 penalize prolonged hesitations of more than 3 seconds during language comprehension tasks, this does not directly assess speech pauses, but rather measures language comprehension.

Purpose of this Study

The absence of a normative sample for speech prosody in current assessments hinders objective comparisons and measurements. Since dysprosody is a key characteristic of nonfluent aphasia, identifying dysprosody could significantly contribute to diagnosing aphasia type and severity. However, the current assessments lack adequate measures for evaluating prosody, let alone prosody across task type. Understanding dysprosody is crucial for effectively evaluating prosodic aspects and guiding clinical assessments and interventions for individuals with aphasia. Furthermore, comprehending how prosody varies across task type is essential, as research suggests that prosodic features adapt based on situational demands. Given that individuals with aphasia encounter diverse communication scenarios, or “task types,” in their daily lives, it is imperative to develop treatment approaches that equip them to navigate these varied contexts successfully, ensuring their overall communication efficacy.

Given the lack of evidence concerning how speech pausing behavior changes in individuals with nonfluent aphasia in relation to task type, this study aims to address the following questions:

1. How do within-utterance pause durations and frequencies vary depending on neurological status? It is expected that aphasic individuals will exhibit longer pause durations and a higher frequency of pausing compared to neurologically healthy age and gender-matched controls due to damage to the language centers of the brain.
2. How does the type of speech task influence the duration and frequency of within-utterance pauses among individuals with Broca’s aphasia and neurologically healthy individuals? After reviewing the literature, it is expected that pause durations will be shorter in tasks that have more context, such as the picture description task. Tasks that

have less context and require greater cognitive effort will likely have longer pause durations, such as the personal narrative. Similar to pause duration, it is also expected that pause frequency will be influenced by the level of context and cognitive effort required to perform a task, with tasks requiring a greater level of cognitive effort and having a lower level of context yielding the highest frequency of pausing.

Methods

Participants

This study builds upon the research conducted by Newcombe (2024) and thus employs similar methodologies. The participants selected for this investigation, as shown in Table 1, were 16 individuals previously diagnosed with moderate nonfluent Broca's aphasia, as well as apraxia of speech. For the purposes of this study, when referring to individuals with nonfluent Broca's aphasia, it will be assumed that apraxia of speech is also co-occurring, as with most diagnoses of Broca's aphasia. Each participant's aphasia diagnosis was previously determined by the Western Aphasia Battery (WAB; Kertesz, 1982), with WAB Aphasia Quotient (AQ) scores ranging from 52.5 to 72.8 (M = 61.58). Participant ages spanned from 31.8−78.3 years (M = 55.5), with an even number of individuals who identified as male or female. Additionally, a control group of 16 age- and gender-matched individuals were also selected for this study.

Speech Recordings

Speech recordings from the 32 participants were sourced from the AphasiaBank database (MacWhinney et al., 2011), a publicly available archive containing diverse speech samples from PWA and control groups of neurologically healthy speakers. These speech recordings encompass a wide range of speech task types, speaker demographics, and aphasia severities and subtypes. All recordings analyzed in this study were collected according to the ethical research protocols outlined by AphasiaBank (MacWhinney et al., 2011). Speech samples were contributed by multiple research groups, including Adler Aphasia Center, Snyder Center for Aphasia Life Enhancement, Triangle Aphasia Project, and the University of Central Florida.

Table 1

Demographic Information for Participants With Moderate Broca's Aphasia

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

Note. Data collected from AphasiaBank.

Speech Task Types

This study examines speech samples across four distinct speech task types: interview, personal narrative, picture description, and story retell.

- **interview:** The interview involved posing four open-ended questions to participants, such as “How do you think your speech is these days?” and “Do you remember when you had your stroke? Can you tell me about it?”
- **personal narrative:** Participants were prompted to provide a personal narrative by asking the question, “Can you tell me a story about something important that happened to you?”
- **picture description:** In the picture description task, the participants were presented with a scene set in a park. The image featured several activities: a man trapped in a tree with a ladder fallen below, a girl attempting to retrieve her cat also caught in the tree, and two firefighters arriving to assist with a second ladder. The participants were instructed to narrate a story with a clear beginning, middle, and end, based on the picture.
- **story retell:** Participants were given a wordless picture book outlining the story of Cinderella for the story retell task. After reviewing the images, the book was removed, and participants were asked to “Tell me as much of the story as you can and you can use anything you know about Cinderella besides what you saw in these pictures.”

The length and number of utterances included in the speech samples vary across individual participant and speech task type, as demonstrated in Tables 2 and 3.

Table 2

Speech Sample Number of Utterances for Participants With Broca's Aphasia Across Task Type

Study	Subject	Number of Utterance Productions Per Task Type			
		Interview	Picture Description	Story Retell[a]	Personal Narrative
Adler	13	47	31	105	20
	16	14	16	15	13
Elman	09	33	15	14	21
Fridriksson	12	123	22	45	34
Scale	01	39	11	338	28
	10	12	6	36	19
	26	40	11	18	36
	36	28	32	59	22
Tap	11	32	6	14	11
	14	34	23	8	45
	16	20	14	20	27
	17	21	5	16	6
	19	27	48	59	17
Whiteside	11	21	7	13	21
	15	42	29	80	13
Wright	207	28	20	81	22

Note. [a]Data analyzed in Newcombe (2024).

Table 3

Speech Sample Number of Utterances for Neurologically Healthy Participants Across Task Type

Study	Subject	Number of Utterance Productions Per Task Type			
		Interview	Picture Description	Story Retell	Personal Narrative
Baycrest	12269	10	5	59	8
Capilouto	12	36	7	54	16
	18	17	6	35	4
	39	26	14	63	55
MSUC	6	25	9	56	25
UMD	22	6	9	27	6
Wright	22	11	4	20	15
	26	6	7	337	22
	28	13	8	55	21
	36	49	22	49	30
	57	17	7	66	16
	67	41	19	130	26
	86	6	3	14	20
	89	26	14	178	22
	96	28	11	49	35
	207	28	20	81	22

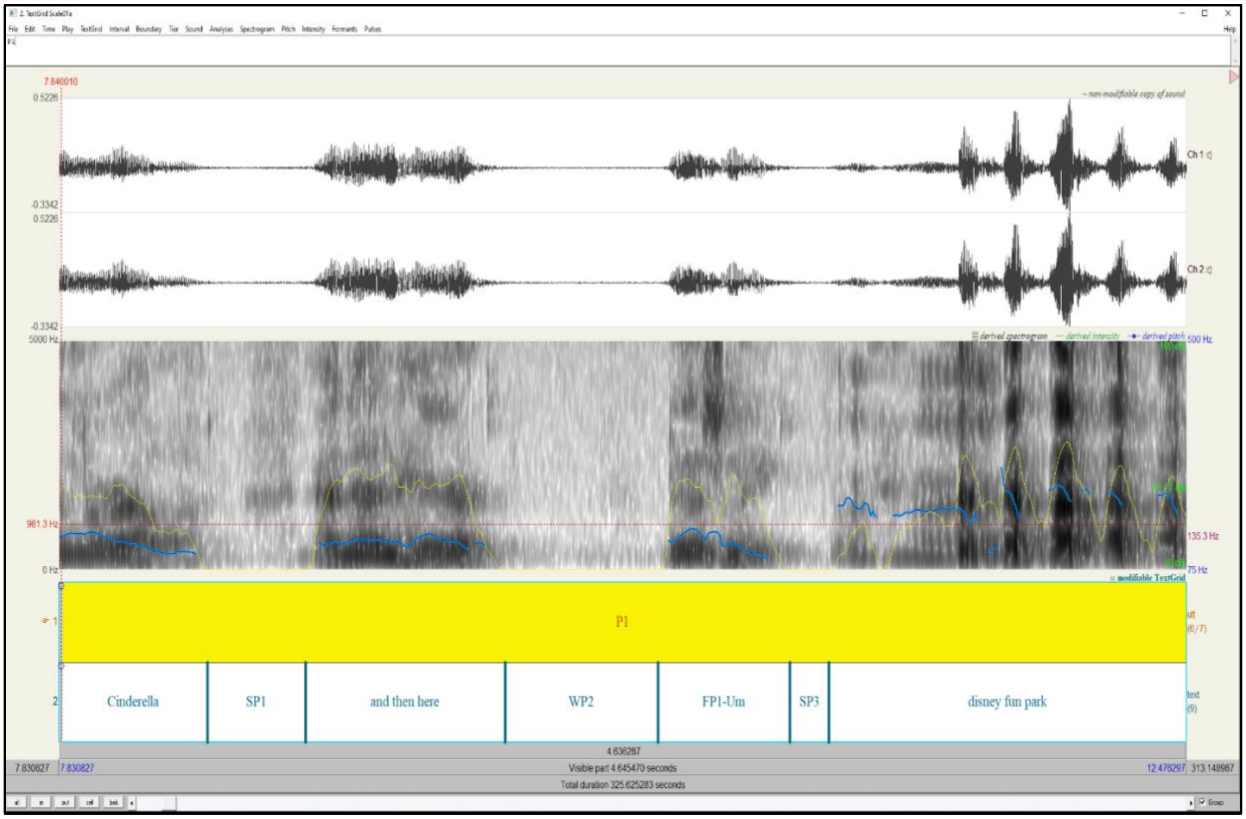
Acoustic Analysis

CHAT (Codes for the Human Analysis of Transcripts; MacWhinney, 2000) formatted transcriptions of each task type from each of the 32 participants were acquired through the AphasiaBank database. The speech samples were acoustically analyzed to identify the boundaries of the between and within-utterance pauses using Praat software (Boersma & Weenink, 2023). For the purpose of this study, we will focus only on the within-utterance pauses. The pauses were also coded to indicate the type of pause, namely silent, filled, or a combination of both silent and filled pauses. As seen in Figure 1, a combination of the intensity track, acoustic waveform, and auditory perception through listening to each utterance in the speech sample were used to locate and code the boundaries of each extended speech pause. Utterance boundaries were determined by the CHAT formatted transcripts created by the original researchers who contributed the speech recordings to the AphasiaBank database.

In this study, filled pauses were defined as filler words or voiced segments that do not add any meaning to the utterance, such as hesitation words (e.g., “um, mm, hmm, er”), as well as laughter or humming. During the coding process, filled pauses were indicated by writing the filler word and/or vocalization the participant produced within the pause boundary. Silent pauses were defined as segments within the recording that are longer than 250 ms in which there is an absence of vocalization within or between the participant utterances. Visual identification of a sharp break in intensity and pitch contours was also used to identify the boundaries of the silent pauses. These silent pauses also include non-vocalic respiratory sounds such as exhaling and audible breathing. Pause time boundaries were then converted from the Praat text grids and exported to an Excel spreadsheet for subsequent statistical analysis.

Figure 1

Within and Between Utterance Pause Boundaries Using Acoustic Analysis Software



Reliability

To evaluate the reliability of the pause measurements collected in this study, a second researcher reanalyzed 10% of the speech recordings. The utterances to be reanalyzed were randomly selected from the 32 participant recordings, irrespective of task type, aphasia severity, or gender of the speaker. The first- and second-rater measurements of the initial and ending time values for each pause had a Pearson correlation of $r = .93$, $p < .001$ with a mean absolute difference between the two raters' pause boundary values of 4 ms per boundary.

Statistical Analysis

Statistical measures of central tendency and variation were used to descriptively report the frequencies and durations of the pause data. A mixed analysis of variance (ANOVA) with a between subjects' factor of neurological status and within factors of speech task type, pause location (between- versus within-utterance), and pause type (silent, filled, or combination) was used to determine differences in the data collected. These statistical analyses were computed using IBM SPSS Statistics (Version 29.0.2.0).

Results

Pause Durations

Neurological Status

The ANOVA indicated a significant difference in the pause durations between the participants with aphasia and neurologically healthy individuals, $F(1,15) = 27.13$, $p < .001$, partial $\eta^2 = .64$. Significant differences across neurological status were due to longer pause durations for PWA ($M = 1.405$ s) when compared to typical speakers ($M = .744$ s). A descriptive comparison of the overall number of pauses between the two groups as a function of the length of the pauses revealed that PWA produced over six times more pauses that were two seconds or longer compared to the control group, as seen in Figure 2. Figures 3 and 4 provide a different perspective of the frequency of pauses across time category by reporting the data in terms of the percentage of each pause duration relative to the total number in each speaker's sample.

Figure 2

Overall Number of Pauses Across Time Category and Neurological Status

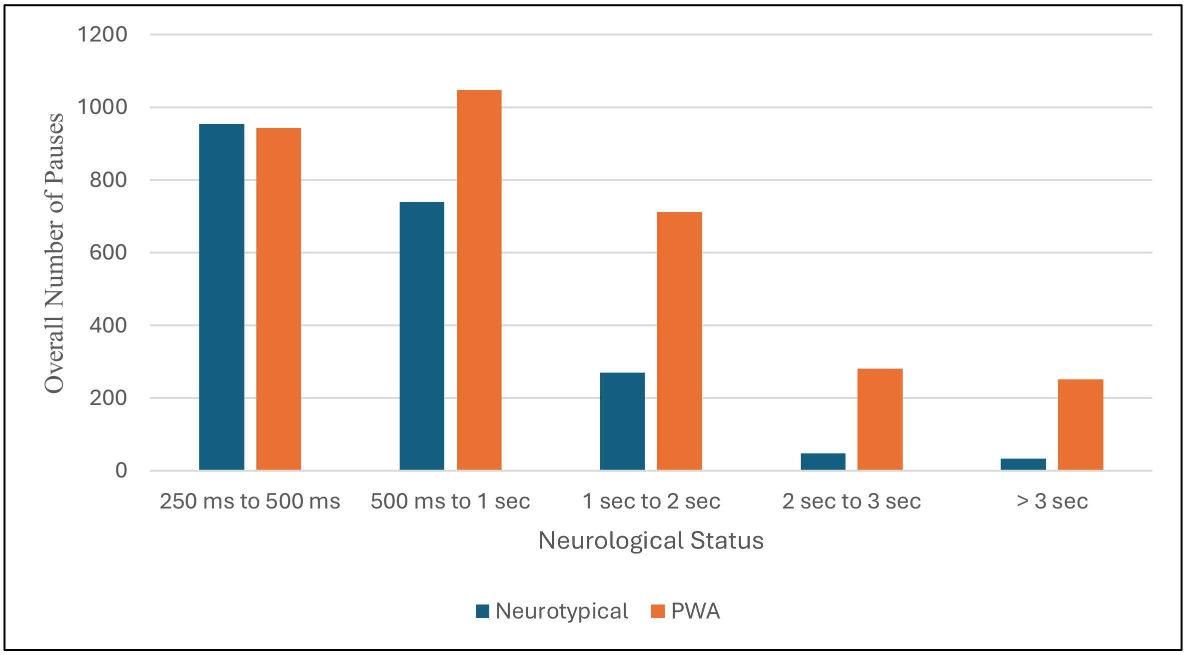


Figure 3

Percentage of Overall Pauses Across Pause Duration in Neurologically Healthy Speakers

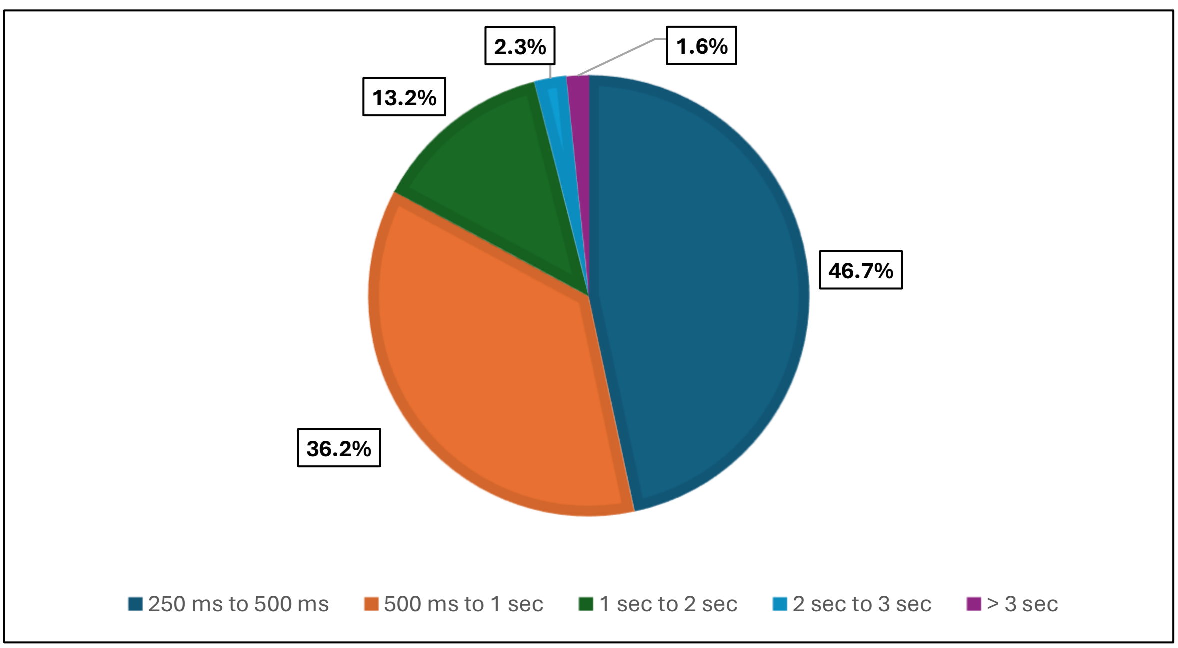
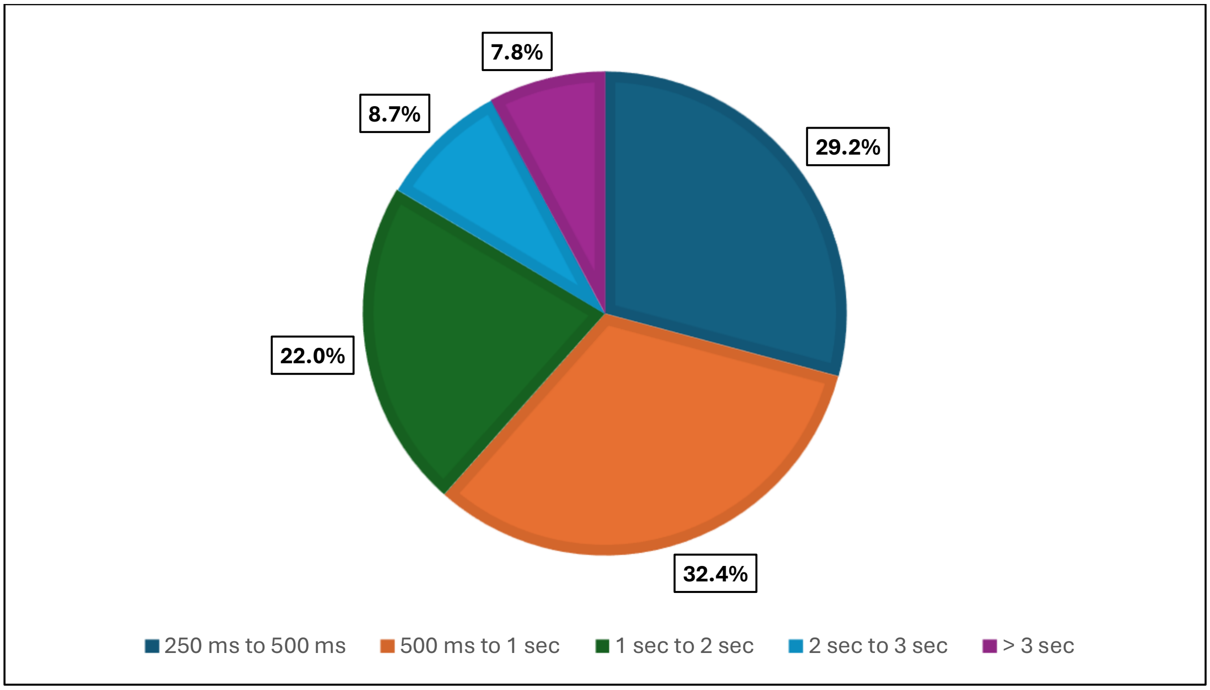


Figure 4

Percentage of Overall Pauses Across Pause Duration in PWA

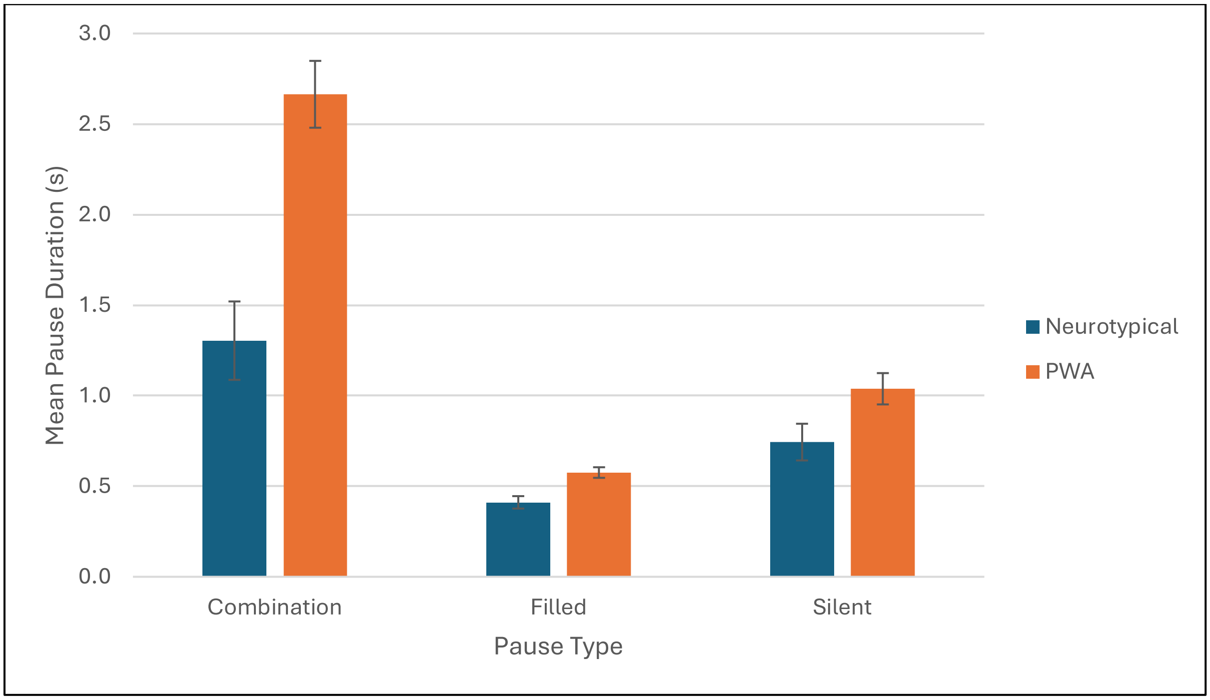


Pause Type

A significant main effect was also found for pause type, $F(2, 30) = 86.54$, $p < .001$, partial $\eta^2 = .85$. As expected, when collapsed across participants, the combination pauses were the longest in duration ($M = 1.950$), followed by the silent pauses ($M = .773$ sec) and filled pauses ($M = .500$ sec). In addition, a significant interaction between neurological status and pause type was found, $F(2,30) = 14.73$, $p < .001$, partial $\eta^2 = .50$. The combination type pauses were significantly longer for PWA ($M = 2.641$ sec) than for typical speakers ($M = 1.260$ sec). These differences are illustrated in Figure 5.

Figure 5

Pause Duration Across Pause Type and Neurological Status



Task Type

No significant main effects or interaction were found as a function of speaker gender or task type, as displayed in Figure 6. A detailed listed of the mean and standard deviations can be found in Table 4.

Figure 6

Pause Duration Across Task Type and Neurological Status

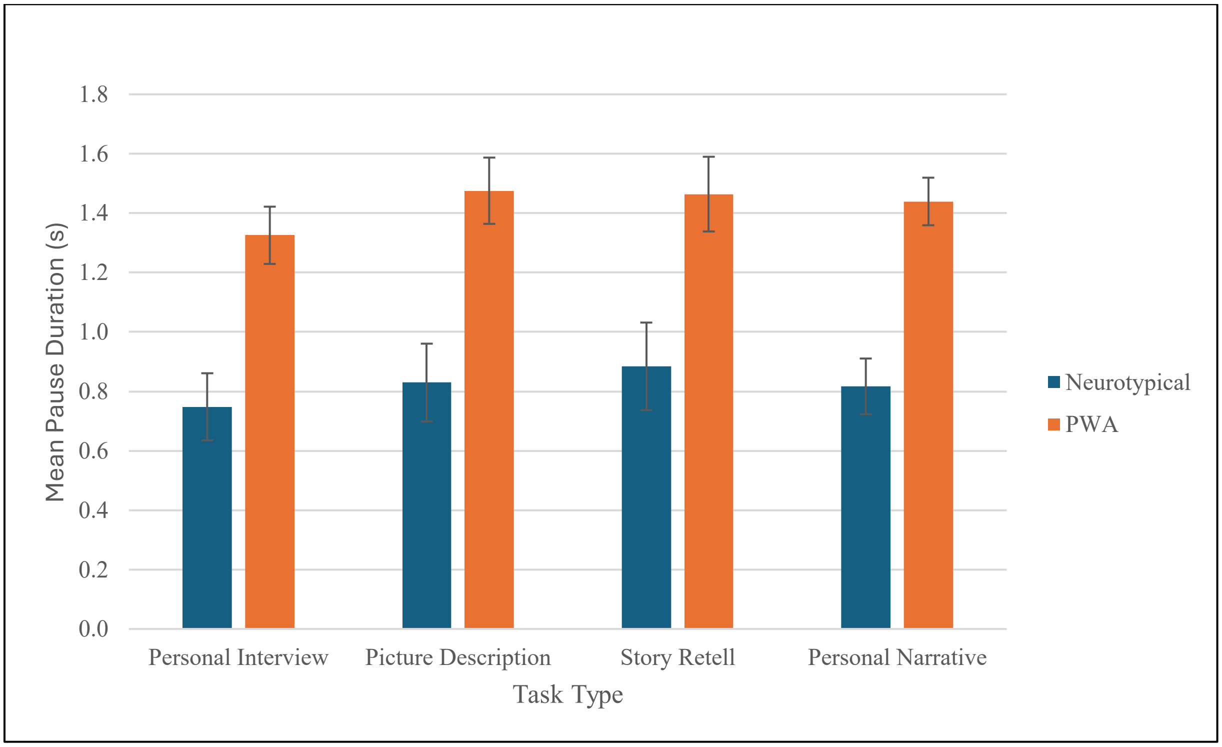


Table 4

Within-Utterance Pause Duration, Standard Deviation, and Frequency Across Neurological Status, Task Type, and Pause Type

Neurologic Status	Task Type	Pause Type	Mean Duration	SD	Mean Frequency
Typical	Personal Interview	Combination	1.190	0.340	0.295
		Filled	0.395	0.046	0.623
		Silent	0.523	0.094	0.462
	Picture Description	Combination	1.297	0.373	0.157
		Filled	0.420	0.064	0.378
		Silent	0.558	0.088	0.812
	Story Retell	Combination	1.225	0.438	0.514
		Filled	0.399	0.039	0.698
		Silent	0.578	0.084	0.613
	Personal Narrative	Combination	1.326	0.253	0.168
		Filled	0.432	0.048	0.334
		Silent	0.585	0.131	0.674
PWA	Personal Interview	Combination	2.425	0.292	0.268
		Filled	0.551	0.039	0.582
		Silent	0.972	0.081	1.124
	Picture Description	Combination	2.852	0.320	0.336
		Filled	0.576	0.055	0.777
		Silent	1.127	0.076	1.413
	Story Retell	Combination	2.755	0.376	0.527
		Filled	0.636	0.033	0.238
		Silent	0.751	0.072	1.012
	Personal Narrative	Combination	2.530	0.217	0.337
		Filled	0.592	0.041	0.787
		Silent	1.092	0.112	1.271

Pause Frequency

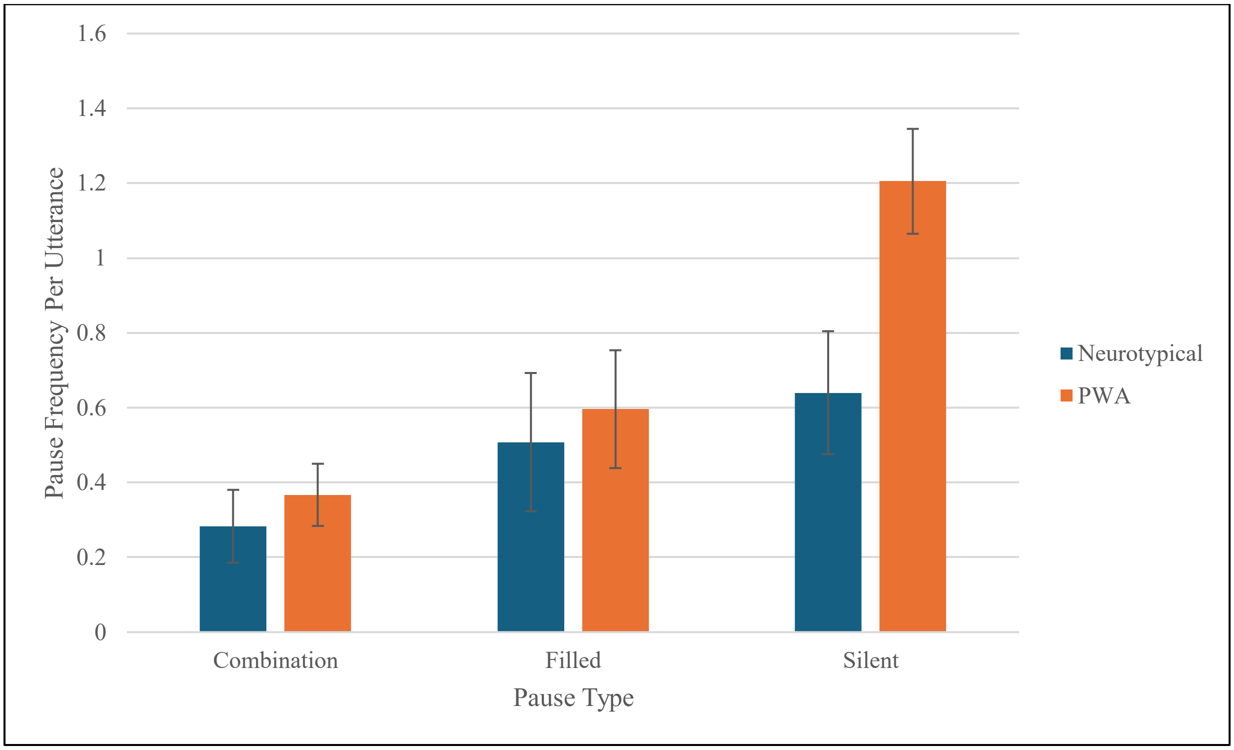
Neurological Status

There was a significant difference in the total number of utterances spoken by the speakers in each group, $F(1,17) = 104.93$, $p < .001$. As expected, the neurologically healthy individuals produced a greater number of utterances ($M = 33.63$ per sample) compared to PWA ($M = 26.5$ per sample). Due to the significant difference in the amount of speech production between the two groups, the frequency of each pause type was normalized by calculating the number of pauses as a ratio per utterance.

The ANOVA did not indicate a significant difference in the frequency of pausing per utterance between the two groups of speakers, $F(1,17) = 3.36$, $p = 0.08$, partial $\eta^2 = .16$. Although statistical differences across neurological status were insignificant, it is important to note that the trend in the data was a difference in the pause frequency for PWA ($M = .72$ per utterance) when compared to typical speakers ($M = .48$ per utterance). The difference in mean frequency between speaker groups was largely due to a difference in the frequency of silent pauses, as shown in Figure 7. The analysis found no additional statistically significant interactions.

Figure 7

Pause Frequency Across Pause Type and Neurological Status



Pause Type

Significant differences in the frequency of pausing were indicated by the ANOVA as a function of the specific type of pause being produced by the speakers, $F(2, 30) = 10.69$, $p < .001$, partial $\eta^2 = .39$. As illustrated in Figure 6, the silent pauses were most frequently produced at a mean rate of .92 pauses per speaker utterance, followed by a mean of .55 for filled pauses, and .33 for combination pauses. The total number of pauses broken into percentages is illustrated in Figures 8 and 9, which reveal that more than half of the overall pauses produced by both groups were silent pauses. For the dependent measure of pause frequency, no interactions involving pause type were found to be statistically significant.

Figure 8

Percentage of Total Number of Pauses Across Pause Type in Neurologically Healthy Speakers

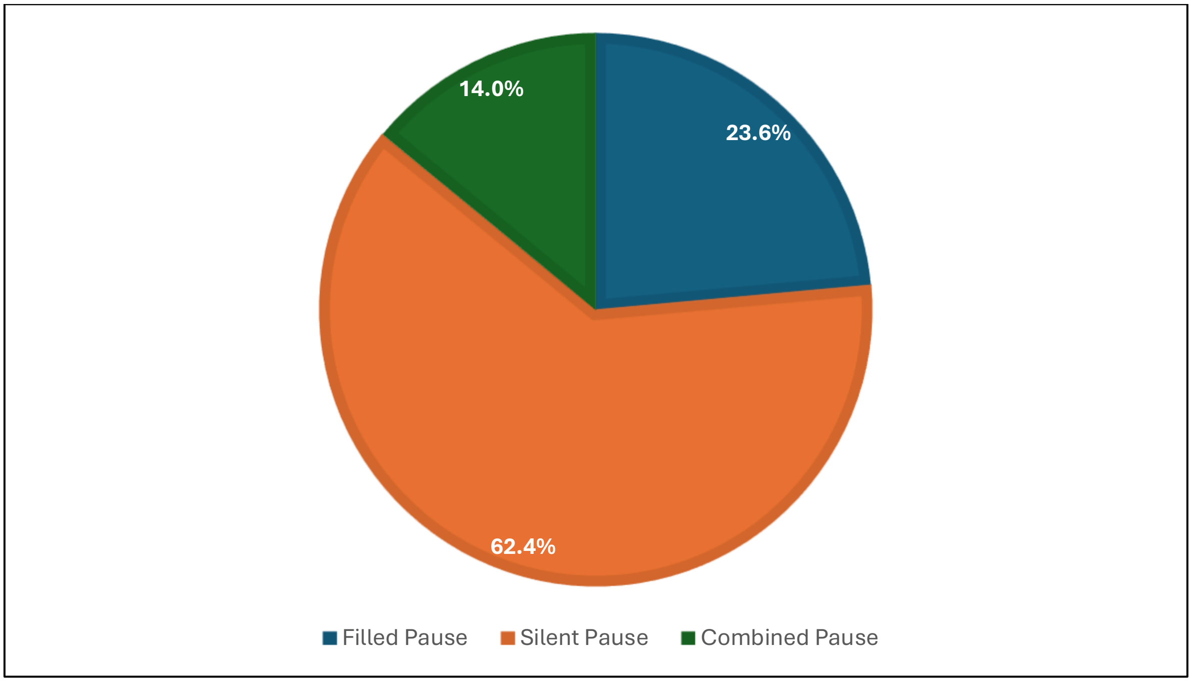
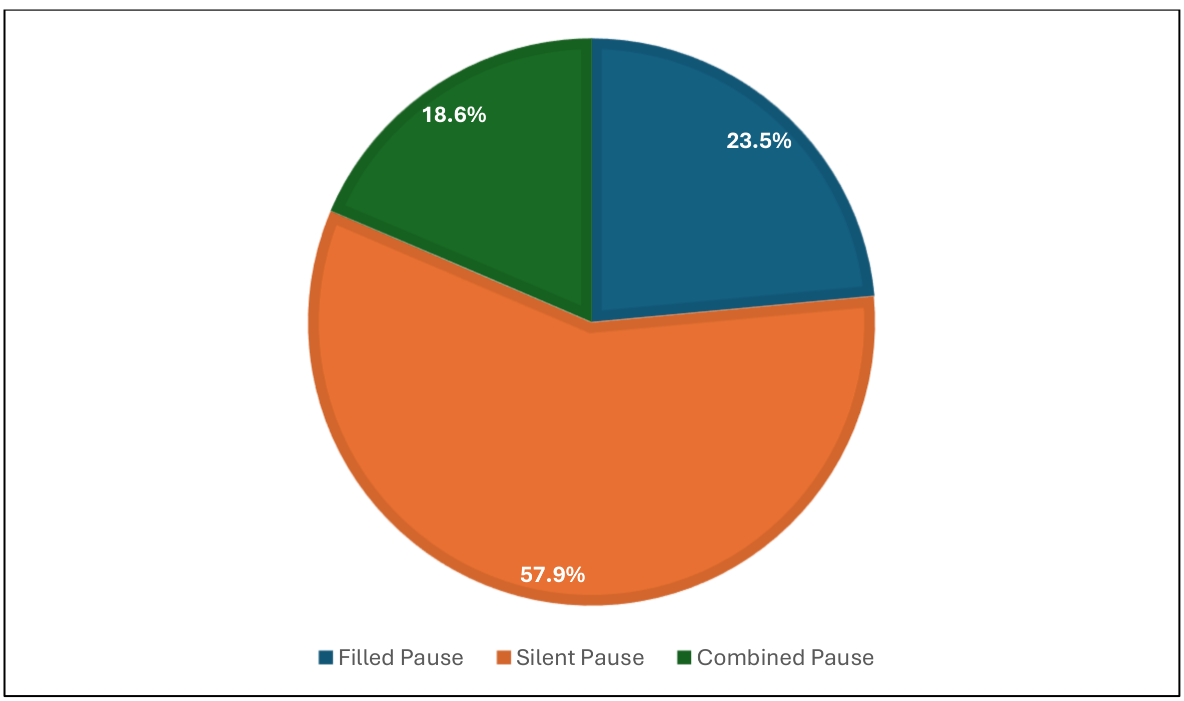


Figure 9

Percentage of Total Number of Pauses Across Pause Type in PWA



Task Type

No significant main effects were found as a function of task type. However, there was an interaction between the frequency of each pause type and the task type, $F(6,102) = 3.73$, $p = 0.04$, partial $\eta^2 = .16$. As seen in Figures 10 and 11, the frequency pattern is different in the story retell task, with an increase in combination pauses. Although the overall number of pauses is not significantly different as a function of task type, as displayed in Figures 12 and 13, the majority of pauses for neurologically healthy speakers were produced during story retell, whereas for PWA, pauses were distributed fairly evenly across task types.

Figure 10

Pause Frequency Across Task Type and Neurological Status

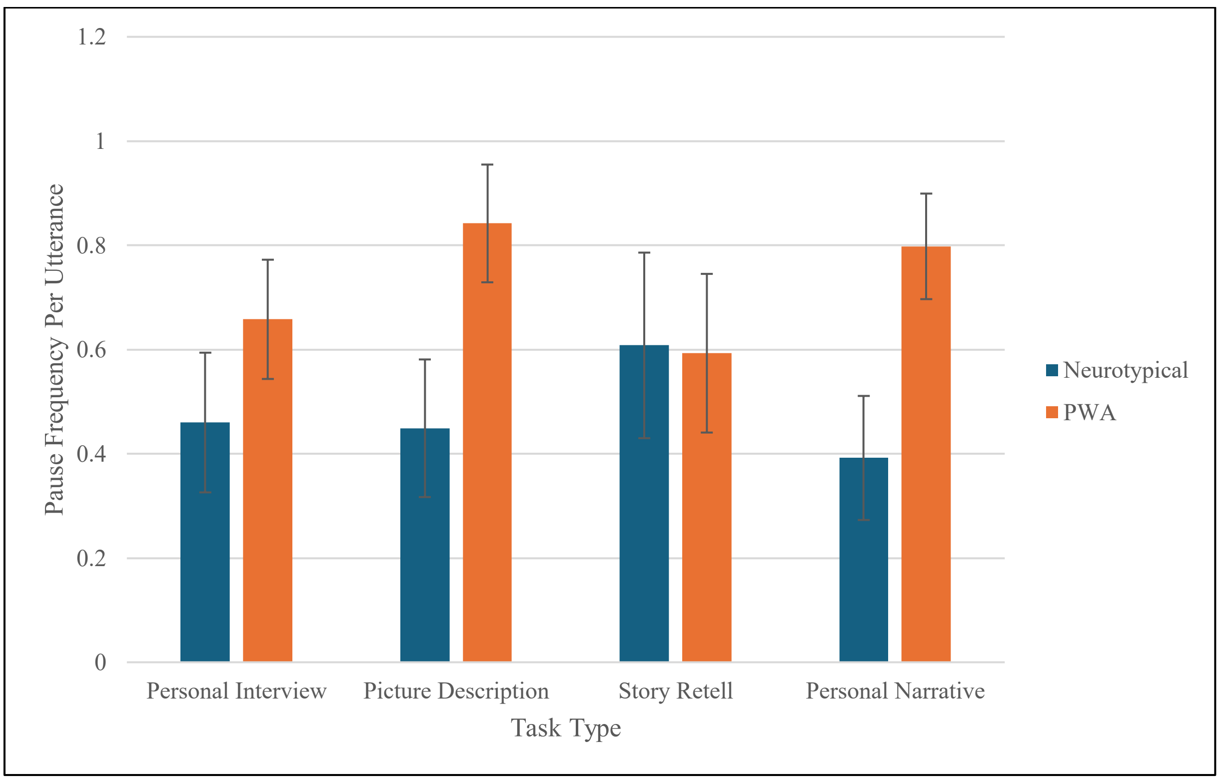


Figure 11

Pause Frequency Across Pause Type and Task Type

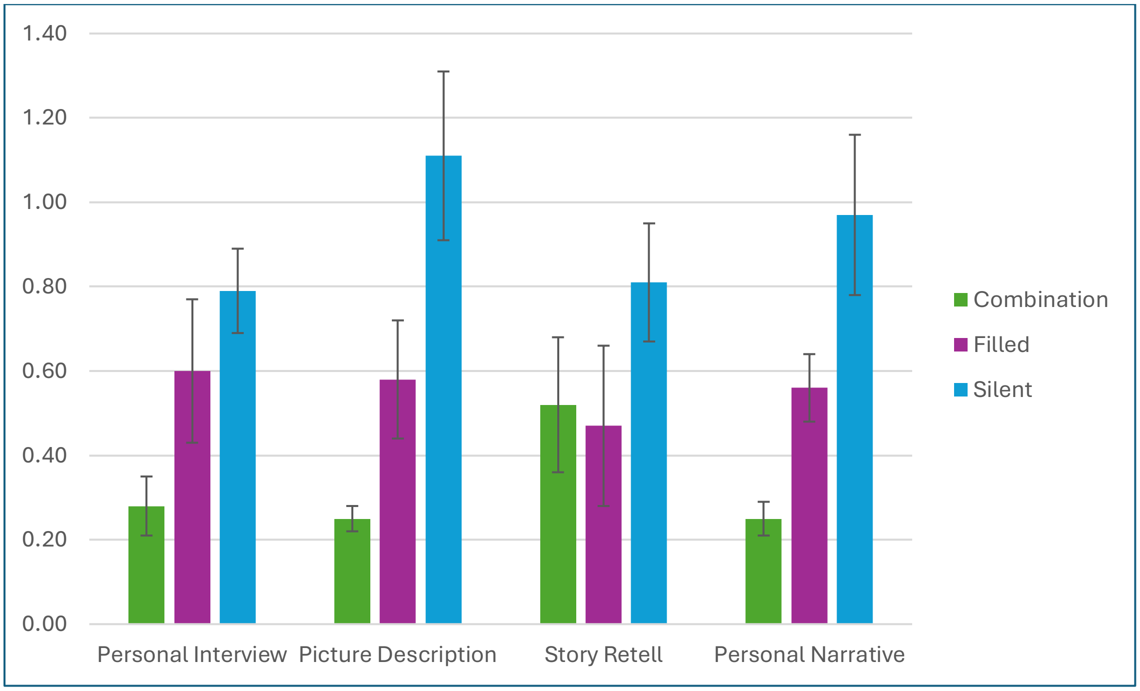


Figure 12

Percentage of Total Number of Pauses Across Task Type in Neurologically Healthy Speakers

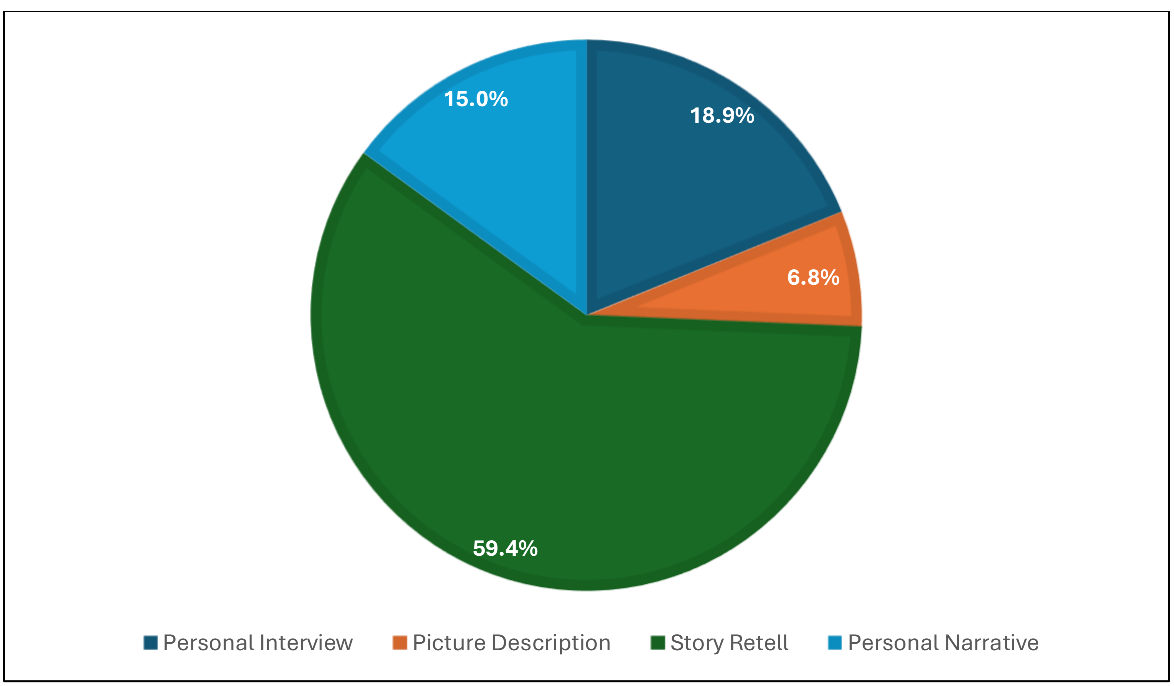
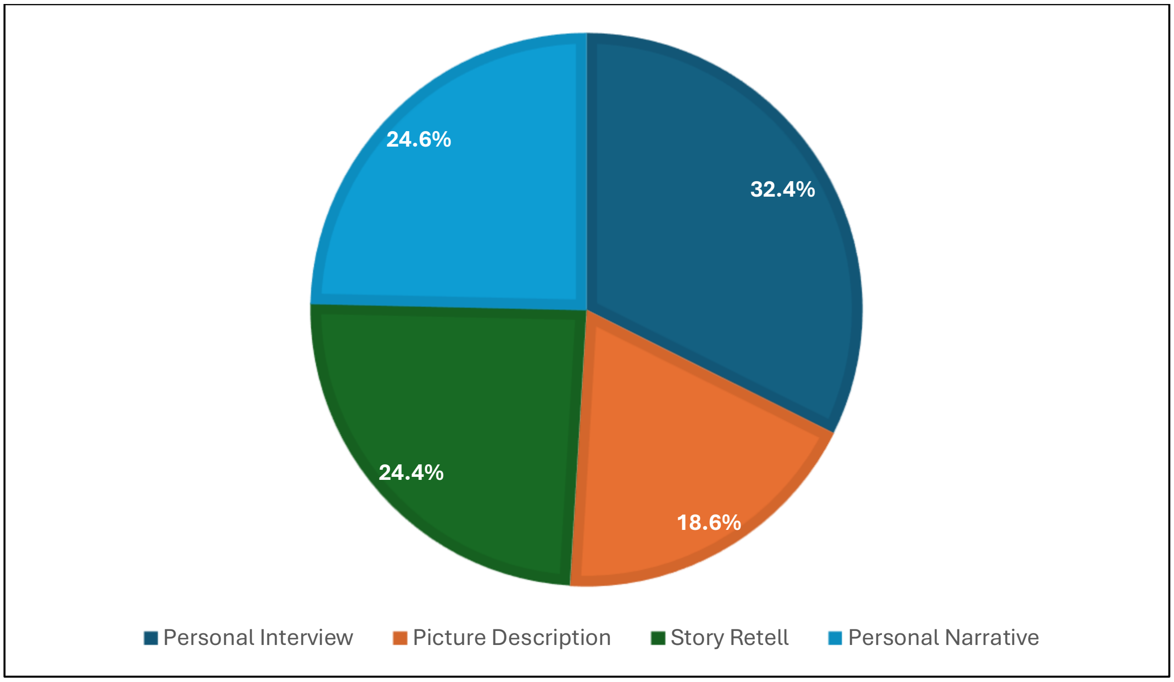


Figure 13

Percentage of Total Number of Pauses Across Task Type in PWA



Discussion

Previous research conducted by Newcombe (2024) examined pause patterns in nonfluent aphasia as a function of pause type (filled and silent) and location (between and within). Our study expanded upon these findings by investigating how pause patterns vary based on task type and neurological status of the speaker when examining within-utterance pauses.

Pause Durations and Frequencies Across Neurological Status

The first aim of this study was to identify how neurological status influences within-utterance pause durations and frequencies. As hypothesized, individuals with moderate Broca's aphasia demonstrated significantly longer pause durations compared to neurologically healthy controls, with pauses being measured almost double the length of time as typical speakers. This finding aligns with a general understanding that PWA require additional time for word retrieval due to compromised language processing and motor planning (Le & Lui, 2023).

The pause duration differences between PWA and neurologically healthy individuals has important clinical implications and give insight into how best to help PWA in treatment. The marked increase in pause duration among PWA may impact conversational flow and listener comprehension. Some key intervention priorities can be drawn from these findings. First, it would be beneficial to implement word-finding and other compensatory strategies to reduce pause durations. Second, it is important to educate caregivers and communication partners about typical pause patterns to foster understanding and reduce frustration during interactions.

Somewhat unexpectedly, no statistically significant differences were found for how often a speaker paused per utterance across the speaker groups. While the data showed a trend toward more frequent pausing in PWA, the analysis of variance between groups did not reach statistical significance.

There are several possible explanations for the unexpected findings in pause frequency between neurologically healthy and disordered speakers. One possible reason may be due to the way in which pauses were defined. In this study, a pause was defined as any filled, silent, or combination hesitation lasting 250 ms or longer. This protocol was followed in order to remain consistent with the methods of Newcombe (2024), since our study expanded on her findings. However, as shown in other research studies, we know that typical speakers often exhibit pausing during everyday speech, therefore, a relatively shorter pause of 250 ms may not be unusual (Corley et al., 2007). For example, Bóna (2016) found that neurologically healthy speakers had an average pause duration of 590 ms for silent pauses and 336 ms for filled pauses when telling spontaneous narratives. Additionally, Bilá and Džambová (2011) categorized a short pause as being between 100 and 300 ms and a normal/optimal pause to be between 300 ms and 1350 ms. Therefore, the threshold of 250 ms may have been too inclusive, capturing naturally occurring brief pauses in typical speech. Upon reexamining the data, it was noted that the pause frequency disparity between groups became more pronounced with longer pause durations. This suggests that pause length, rather than frequency alone, may be a more reliable diagnostic indicator. This insight has implications for future research and clinical assessment. The current 250 ms threshold may not optimally differentiate between typical and disordered speech patterns. Additionally, clinicians should note that frequent brief pauses are normal in connected speech; it is the duration of these pauses that may better indicate impairment.

A second explanation for the findings in pause frequency is that while our study took into account the discrepancy in number of utterances between the two experimental groups, we did not take into account the utterance length or complexity. Due to the impaired expressive language in PWA, the language and syntax of neurologically healthy speakers is often more complex than that of PWA (Le & Lui, 2023). In typical speech, the more complex the syntactical structure of a phrase, the more opportunities for linguistically appropriate short pauses. Some examples of typical pausing include marking commas, indicating lists of items, or adding stress or emphasis (Shriberg & Kent, 2013). The increased number of linguistically appropriate pauses in neurologically healthy speakers may explain why there was no significant difference in frequency of pausing between the two groups, as typical pausing was coded the same as atypical pausing. To remedy this phenomenon in future research, it would be beneficial to only code for pauses that occur in syntactically inappropriate places and that do not contribute to the linguistic meaning of the utterance.

Pause Durations and Frequencies Across Task Type

Our second research aim examined how pause durations and frequencies differ as a function of the specific speech task type. Based on previous research, it was expected that speech tasks requiring more cognitive planning and containing less context and structure would yield longer pause durations and higher pause frequencies per utterance. This hypothesis was made on the basis of studies that found that increased cognitive demands result in longer pauses (Robinson, 2001) and that task complexity affects fluency and pause patterns (Skehan & Foster, 1999; Tavakoli & Foster, 2008). Contrary to our hypothesis, we found no significant differences in pause duration across personal interviews (*M* = 1.009s), picture descriptions (*M* = 1.139s), story retells (*M* = 1.057s), and personal narratives (*M* = 1.093s).

These results could be due to a number of different reasons. One reason for the insignificant findings could be that each of the four task types may have required a similar cognitive load. Studies have shown that speech tasks that require higher cognitive effort often yield longer pause durations (Robinson, 2001). These types of tasks tend to be open-ended without structure, such as spontaneous personal interviews and narratives (Skehan & Foster, 1999). However, the specific prompts used for the more unstructured tasks in our study may have inadvertently lowered the cognitive demand. For the personal interview, participants were asked to recall what they remembered about their stroke, while the personal narrative prompted them to tell a story about an important life event. Stroke survivors often recount the story of their stroke to family members, friends, and healthcare providers, which could potentially help them to develop a well-rehearsed response to this question. This may, in turn, make their account less spontaneous. Similarly, people often tell important life events on multiple occasions, which may lessen the cognitive effort required to produce the particular narrative due to previous practice. In future studies, this could be remedied by using less predictable prompts that minimize rehearsal effects, such as "Tell me what you did yesterday," rather than recounting significant life events.

Another reason for these results could be that there were no time requirements for how long the participants were expected to speak or how much detail they were required to give. Due to this, the participants had the option to cater their response to comfort level, rather than task demand. The more open-ended and seemingly cognitively challenging tasks of personal interviews and personal narratives could be answered more briefly if wanted, as participants were able to give as much information as they desired. Shorter samples could potentially lead to less pausing. The more structured tasks that required participants to follow more specific requirements, such as telling the story of Cinderella, could lead to a longer sample size, which would likely result in more opportunities for pausing. For example, it was noted that personal narratives and personal interviews had an average of 21.81 and 28.31 utterances, respectively. The more structured story retells had an average of 68.56 utterances. These differences in sample length could contribute to skewed pausing patterns and mask the cognitive complexity of the more demanding, unstructured tasks. A potential solution to this problem could be to standardize a certain time requirement for participants to speak for each task type in order to control for sample length.

Additionally, another potential reason as to why the results were insignificant could be that the tasks may be too similar in nature. All of the tasks required the participant to tell a type of narrative, whether personal (interview, narrative) or structured (picture description, story retell). Since it has been found that alike tasks yield similar fluency, it would be expected that narratives would lead to similar pause patterns (Tavakoli & Foster, 2008). Perhaps the prompts for each task type were not unique enough to highlight different pause patterns. A way to solve this issue could be to compare narrative tasks to other task types, such as informational or persuasive. This could include tasks that require the participant to describe the process of how to do something or debate an issue. Changing the type of task could lead to more significant differences in pausing.

Although the findings of this study are unexpected, there are still important implications that can be drawn and applied to assessment and treatment of pausing in PWA. From our data, we have learned that task type does not influence the within-utterance pause durations or frequency in PWA or neurologically healthy individuals. Current aphasia assessments typically evaluate connected speech using a single task type. Our results suggest this approach adequately captures an individual's pause patterns, as these patterns remain stable across contexts. This stability implies that improvements in pause patterns achieved during treatment may generalize across different communication situations, potentially making assessment and treatment processes simpler and more efficient.

Limitations to Study and Future Research Implications

As mentioned previously, the findings of this study may have been skewed due to how pausing was defined in our methods. Since pauses were defined as hesitations of at least 250 ms, this included many typical pauses when calculating the pause frequency, potentially masking significant differences between PWA and neurologically healthy individuals. Further research and data analysis is warranted in order to find the length of pausing that reveals a significant difference between PWA and neurologically healthy individuals. Future studies should investigate higher thresholds (e.g. only greater than 500 ms) to better differentiate typical from atypical pause patterns. Moreover, in order to further avoid including typical pauses when coding for disordered pause patterns, it would also be beneficial to only code for pauses that occur in linguistically inappropriate places.

Also mentioned previously, there were some limitations in the task types used in our study that may have skewed our findings. Future solutions to this problem could be to ensure that tasks that are meant to be unstructured and spontaneous are prompted in a way that does not encourage rehearsal bias. Additionally, it would be beneficial to examine other types of tasks besides narratives, such as informational or persuasive, in order to compare pause patterns across more diverse tasks. Specific time requirements would also help to control for sample length across task type samples.

Additionally, the statistics used in this study was a repeated measures ANOVA with one between subject factor and two within subject factors. A follow up evaluation of the data revealed that not all the 16 subjects produced all types of pauses in every task type. Thus, the statistical model was working with a number of missing data cells. Although this does not render the statistical analysis invalid, it does open the possibility that a different type of statistical analysis may be needed in future evaluation of these data. The difficulty is that traditional repeated measures ANOVA treats each measurement as a separate variable. Since the statistical model uses listwise deletion, if one measurement of a variable is missing (e.g., the combined type pauses), the entire case gets dropped. It may be more effective to use a different model of statistical analysis that treats each instance as a different observation of the same variable, thereby losing the evaluation of the missing data cell and not all other points of measurement from the same subject (Grace-Martin, n.d.; UCLA: Statistical Consulting Group, 2024).

Another limitation of this study is that we only examined the pause patterns in individuals with moderate Broca's aphasia. While this gives insight into this specific population, the findings of this study cannot be generalized to other subtypes and severities of aphasia. Further research exploring the pausing patterns of mild and severe aphasia, as well as different subtypes of nonfluent aphasia would be beneficial in order to enhance generalizability.

The relatively small sample size included in this study (16 PWA, 16 controls) also limits our ability to generalize our findings to all individuals with moderate Broca's aphasia. Larger-scale studied are needed to confirm these results.

Conclusion

While increased pausing is a hallmark symptom of nonfluent aphasia compared to neurologically healthy individuals, our study provides new insights into how pause patterns manifest across different task types (personal interviews, picture descriptions, story retells, and personal narratives) and between neurological groups (PWA and neurologically healthy). Our findings suggest that pause duration, rather than frequency, may be a more reliable diagnostic indicator. The consistency of pause patterns across task types has important clinical implications for assessment and treatment efficiency. Future research should focus on establishing more precise definitions of atypical pausing and expanding these findings to diverse aphasia populations.

References

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

Bauman-Wängler, J. A. (2009). *Introduction to phonetics and phonology: From concepts to transcription.* Pearson.

Baylor, C., Burns, M., Eadie, T., Britton, D., & Yorkston, K. (2011). A qualitative study of interference with communicative participation across communication disorders in adults. *American Journal of Speech-Language Pathology, 20*(4), 269–287. https://doi.org/10.1044/1058-0360(2011/10-0084)

Behrman, A., & Finan, D. (2016). *Speech and voice science*. Plural Publishing, Incorporated.

Bilá, M., & Džambová, A. (2011). A preliminary study on the function of silent pauses in L1 and L2 speakers of English and German. *Brno Studies in English*, 37(1), 21–39. https://doi.org/10.5817/bse2011-1-2

Boersma, P., & Weenink, D. (2023). Doing phonetics by computer (Version 6.2.14) [Computer program]. Praat. http://www.praat.org/

Bóna, J. (2016). Characteristics of pausing in normal, fast and cluttered speech. *Clinical Linguistics & Phonetics*, *30*(11), 888–898. https://doi.org/10.1080/02699206.2016.1188421

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

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

Corley, M., MacGregor, L. J., & Donaldson, D. I. (2007). It's the way that you, er, say it: Hesitations in speech affect language comprehension. *Cognition, 105*(3), *658–668.* https://doi-org.erl.lib.byu.edu/10.1016/j.cognition.2006.10.010

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. DOI: https://doi.org/10.1109/ICTTA.2008.4530030

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

Deloche, G., Jean-Louis, J., & Seron, X. (1979). Study of the temporal variables in the spontaneous speech of five aphasic patients in two situations, interview and description. *Brain and Language, 8*(2), 241–250. https://doi.org/10.1016/0093-934x(79)90052-x

Duffy, J. R. (2012). *Motor speech disorders: Substrates, differential diagnosis, and management* (3rd ed.). Elsevier Health Sciences.

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

Gavarró, A., & Salmons, I. (2013). The discrimination of intonational contours in Broca's aphasia. *Clinical Linguistics & Phonetics*, *27*(8), 632–646. https://doi.org/10.3109/02699206.2013.800908

Goodglass, H., Barresi, B., Weintraub, S., & Kaplan, E. (2001). *The Boston Diagnostic Aphasia Examination, Third Edition* (*BDAE-3)*. Lippincott Williams & Wilkins.

Grace-Martin, K. (n.d.). *When does repeated measures ANOVA not work for repeated measures data?* The Analysis Factor. https://www.theanalysisfactor.com/when-repeated-measures-anova-not-work-for-repeated-measures-data/

Gussenhoven, C., & Chen, A. (2020). *The Oxford Handbook of Language Prosody*. Oxford University Press. https://academic.oup.com/edited-volume/34870

Helm-Estabrooks, N., Albert, M. L., & Nicholas, M. (2014). *Manual of aphasia and aphasia therapy (3rd ed.)*. Pro-Ed.

Hoffer, J. (2023). *Quantifying speech pause durations in typical English speakers* [Master's thesis, Brigham Young University]. BYU ScholarsArchive. https://scholarsarchive.byu.edu/etd/10035

Howell, P., & Kadi-Hanifi, K. (1991). Comparison of prosodic properties between read and spontaneous speech material. *Speech Communication*, *10*(2), 163–169. https://doi.org/10.1016/0167-6393(91)90039-v

Kertesz, A. (1982). *The Western Aphasia Battery: Examiner's manual.* Pearson.

Kertesz, A. (2006). *Western Aphasia Battery—Revised (WAB-R)* [Database record]. APA PsycTests. https://doi.org/10.1037/t15168-000

Laan, G. P. M. (1997). The contribution of intonation, segmental durations, and spectral features to the perception of a spontaneous and a read speaking style. *Speech Communication*, *22*(1), 43–65. https://doi.org/10.1016/s0167-6393(97)00012-5

Le, H., & Lui, M. Y. (2023). *Aphasia*. StatPearls.

Leaman, M. C., & Edmonds, L. A. (2023). Analyzing language in the picnic scene picture and in conversation: The type of discourse sample we choose influences findings in people with aphasia. *American Journal of Speech-Language Pathology*, *32*(4), 1413–1430. https://doi.org/10.1044/2023_AJSLP-22-00279

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

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

MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk (3rd ed.).* Lawrence Erlbaum Associates. https://doi.org/10.21415/3mhn-0z89

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

National Institute on Deafness and Other Communication Disorders (NIDCD). (2017). *Aphasia*. National Institutes of Health. https://www.nidcd.nih.gov/health/aphasia

Newcombe, M. (2024). *Speech prosody in people with nonfluent aphasia and apraxia: A descriptive study of between and within utterance pause*. [Master's thesis, BYU ScholarsArchive]. https://scholarsarchive.byu.edu/etd/10416.

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

Robinson, P. (2001). Task complexity, task difficulty, and task production: Exploring interactions in a componential framework. *Applied Linguistics, 22*, 27–57.

Ross-Swain, D. (1996). *Ross information processing assessment, Second edition* (RIPA-2). Pro-Ed.

Shriberg, L., & Kent, R. (2013). *Clinical Phonetics*. Pearson.

Skehan, P., & Foster, P. (1999). The influence of task structure and processing conditions on narrative retellings. *Language Learning*, *49*(1), 93–120. https://doi.org/10.1111/1467-9922.00071

Stark, B. C., & Fukuyama, J. (2021). Leveraging big data to understand the interaction of task and language during monologic spoken discourse in speakers with and without aphasia. *Language, Cognition, and Neuroscience*, *36*(5), 562–585. https://doi.org/10.1080/23273798.2020.1862258

Tavakoli, P., & Foster, P. (2008). Task design and second language performance: The effect of narrative type on learner output. *Language Learning, 58*(2), 439–473. https://doi.org/10.1111/j.1467-9922.2008.00446.x

UCLA: Statistical Consulting Group (2024). Introduction to SAS. https://stats.oarc.ucla.edu/spss/seminars/spss-mixed-command/

Wilson, S. M., Eriksson, D. K., Schneck, S. M., & Lucanie, J. M. (2018). A quick aphasia battery for efficient, reliable, and multidimensional assessment of language function. *PloS One*, *13*(2), Article e0192773. https://doi.org/10.1371/journal.pone.0192773

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: The aim of this study was to investigate whether individuals with aphasia exhibit different pause duration patterns compared to individuals without neurological impairments, and to explore the correlation between pause length and linguistic elements. *Methods:* A total of eighteen participants with aphasia, aged between 40 and 74, were selected for the study. They underwent assessment using the Greek-adapted Boston Diagnostic Aphasia Examination short form (BDAE-SF), the Boston Naming Test (BNT) standardized in Greek, and the Controlled Oral Word Fluency (COWF) test. Additionally, CT or MRI scans were taken for each patient to identify and code the locations of the brain lesions. *Conclusions:* Individuals with aphasia tend to use more frequent and longer pauses both between and within their spoken expressions. *Relevance to current study:* This research demonstrates that individuals with aphasia exhibit increased usage of pauses and longer pause durations in their speech.

Behrman, A., & Finan, D. (2016). *Speech and voice science*. Plural Publishing, Incorporated.

Objective: Chapter 9 of this book goes into depth on the suprasegmental elements of prosody, such as fundamental frequency contour, duration and juncture, intensity contour, syllabic stress and prominence, and speech rhythm. *Relevance to study*: This chapter highlights that during speech, not only is linguistic information conveyed, but also

paralinguistic information through the use of prosody. Paralinguistic information is not conveyed through written words and can only be perceived through spoken language.

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

Objective: To determine how pause, speed, and repairs affect perceived fluency.

Methods: Native Dutch Speakers listened to recordings of both native and non-native Dutch speakers and were tasked with evaluating overall fluency. Their evaluations were based on factors such as the use of pauses, speech tempo, and instances of hesitations and corrections. In three separate experiments, participants were specifically instructed to assess one of these three components: pauses, speech speed, or hesitations. The rating scale used ranged from "not fluent at all" to "very fluent." Additionally, acoustic measurements of the speech recordings were collected. *Conclusions*: This research revealed that all three aspects of fluency (pause, speed, and repairs) significantly impacted how speech fluency was perceived. Listeners demonstrated sensitivity to both pauses and speech tempo. Second language (L2) speakers who delivered speech at a relatively fast pace with fewer pauses were rated as more fluent compared to those who spoke more slowly and with more pauses, even if their accuracy was higher. *Relevance to current study:* This investigation emphasized the role of pauses in speech as a key factor in the perceptual assessment of fluency.

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 aims to review the literature regarding the emotional implications of language use in people with aphasia and to find any gaps in research. *Conclusions:* Stress, anxiety, and depression are very common in people with aphasia and are often overlooked in therapy. These factors play an important role in language performance and prognosis for recovery. Further research is needed to explore the effects of "linguistic anxiety" on people with aphasia. Linguistic anxiety is stress due to anticipating error during language production. *Relevance to current study:* People with aphasia experience emotional changes, which directly impact their ability to produce language, as well as their prognosis for recovery. There is often a large amount of anxiety around conversing with others. This article will give a basis when discussing how an aphasia diagnosis can affect emotional health.

Corley, M., MacGregor, L. J., & Donaldson, D. I. (2007). It's the way that you, er, say it: Hesitations in speech affect language comprehension. *Cognition, 105*(3), *658–668.* https://doi-org.erl.lib.byu.edu/10.1016/j.cognition.2006.10.010

Objective: This study explores the way disfluencies affect how listeners process and comprehend spoken language. *Methods:* Twelve neurotypical British English speakers participated in the study. They used 80 pairs of sentence frames that paired with corresponding utterance-final words, which consisted of a predictable word and a non-predictable word. Each sentence was recorded in a fluent and disfluent version. The disfluent version had "er" before the final word. The participants listened to the 160 recorded sentences while an EEG recorded their brain activity. They then were presented visually with the previously heard utterance final words, interspersed with 160 new words. Participants were asked to determine if the words were "old" or "new."

Conclusions: The N400 effect was reduced in the presence of disfluency. Also, words that followed a disfluency were more likely to be remembered by the participants. *Relevance to current study:* Pauses occur in normal, everyday speech, especially preceding unpredictable and low frequency words. These pauses, or disfluencies, change the way the brain processes language.

Cutler, A. & Dahan, D. & Donselaar, W. (1997). Prosody in the comprehension of spoken language: A literature review. *Language and Speech, 40*(pt 2). 141–201. https://doi.org/10.1177/002383099704000203.

Objective: An overarching literature review of prosody and how it affects the comprehension of spoken language, specifically at the word, sentence, and discourse levels. *Methods:* The researchers analyzed and summarized various studies regarding prosody. All of the studies included in their review had similar methods for data collection, which included measurements of response times, question-answering tasks, and ratings of appropriateness, and judgements of familiarity. *Conclusions:* The current evidence on word recognition and prosodic structure is incomplete, with significant gaps in knowledge. It is known that boundaries can be signaled using prosodic elements, but there is still much research to be done regarding how prosodic information affects syntactic analysis. How words are prosodically expressed directly impacts the processing of discourse structure. New information is typically stressed and old information is typically unstressed. *Relevance to current study:* This review article highlights how prosody affects language comprehension and provides an accurate and thorough definition of prosody.

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: The aim of this study is to create a compiled resource of information that highlights the prosodic features of speech in those with aphasia. *Methods:* The study consisted of nine individuals diagnosed with Broca's aphasia. Speech samples were collected from the participants, which included CV and VC syllables, simple words, complex words, and complex sentences. The suprasegmental features of the speech samples were examined using statistical analysis, including fundamental frequency, intensity, intonation, duration, and speaking rate. *Conclusions:* This study determined that intonation and rhythm are key features that are impaired in individuals with Broca's aphasia, can be used to differentiate them from neurotypical individuals. *Relevance to current study:* Impaired rhythm, including pausing and speaking rate is a key characteristic of Broca's aphasia.

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

Objective: This study aims to examine the perspectives of individuals with aphasia regarding their engagement in society and to explore the factors that may impact such participation. *Methods:* This study was a qualitative study that included 13 participants with aphasia and 12 primary caregivers. They were asked to maintain a pre-structured diary over a 2-week period, which was subsequently followed by a semi-structured interview. The transcription of both diaries and interviews were conducted verbatim and independently analyzed by two researchers utilizing coding, categorization, and central themes. The results of the analysis were then discussed with the participants in a focus group interview. *Conclusions:* Individuals with aphasia experience a sense of isolation and desire meaningful engagement. They want to live ordinary lives and often feel burdensome to others. Comprehension of social interactions is difficult, but they still have a desire to understand what is going on. Limited work capability does not diminish their wish to contribute to the community in alternative ways. Despite frequently encountering stigma, they seek respect, which they don't always attain. *Relevance to current study:* People with aphasia do not participate in society as much as they would like to, due to a language comprehension difficulties, lack of respect, feelings of isolation, limited work capability, and feeling burdensome to others.

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

Relevance to current study: 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 of word type and frequency on prosody in individuals with aphasia.

Deloche, G., Jean-Louis, J., & Seron, X. (1979). Study of the temporal variables in the spontaneous speech of five aphasic patients in two situations, interview and description. *Brain and Language, 8*(2), 241–250. https://doi.org/10.1016/0093-934x(79)90052-x

Objective: This study aims to explore how phonation rate, number of silent pauses, and mean duration of silent pauses contribute to variations in the verbal rate of spontaneous speech of people with aphasia. These measures are calculated across two distinct task types: interview and picture description. *Methods:* Five male participants who were receiving speech-language therapy were selected to participate in this study. The participants were diagnosed with Broca's, conduction, Wernicke's and anomic aphasia. There was also one male neurotypical control participant. A spontaneous speech sample was recorded from each participant as they participated in an interview. They were then asked to describe a black and white picture of activities occurring at a park and their responses were recorded. The analysis of each recording from both task types involved various methods, such as determining the ratio of articulation time to locution time (aka pause time), assessing verbal and phonation rates, examining the overall number and average duration of pauses. *Conclusions:* In the control participant, the study found that the mean duration in pauses was longer, phonation rate was reduced, and an increased number of pauses was present during the picture description task compared to the interview task. The participants with aphasia had opposite results and their speech rate was greater in the picture description task, due to decreased pauses durations and faster phonation rate. It is theorized that the patient with Broca's aphasia did better in the picture description task because they had the picture to depend on for context. *Relevance to current study:* People with aphasia have more pausing in interviews than in picture description, while neurotypical people are the opposite.

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: This study aimed to create a program that analyzes speech samples and distinguishes those with primary progressive aphasia (PPA) and semantic dementia (SD) from control participants. The study also aimed to pinpoint the specific features that best differentiate impaired individuals from neurotypical individuals. *Methods:* The study consisted of 24 individuals diagnosed with either fluent or nonfluent PPA, as well as a control group of 16 neurotypical individuals. The participants were asked to tell the Cinderella story with a book of illustrations to aid them. Their speech samples were transcribed with coding to signal pauses, fillers, and false starts. The speech samples were then analyzed for specific features, including number of words, syntactic complexity, mean length of utterance, word type, and speech rate, among others. *Conclusions:* This study found that the main features that differentiated those with PNFA (progressive nonfluent aphasia) from the control group were slower speech rate and word length, as well as less variety of words (especially verbs). The main features that distinguished those with SD from the control group were less variety of words (especially nouns), more adverbs and demonstratives, shorter clauses, and lower speech rate and length of words. *Relevance to the current study:* Individuals with nonfluent aphasia have reduced speech rate and word length. These features in rhythm can help in differentiating aphasic individuals from neurotypical individuals.

Gavarró, A., & Salmons, I. (2013). The discrimination of intonational contours in Broca's aphasia. *Clinical Linguistics & Phonetics*, 27(8), 632–646. https://doi.org/10.3109/02699206.2013.800908

Objective: This study aims to determine whether comprehension of prosody is intact in people with Broca's aphasia. *Methods:* Ten people with Broca's aphasia and 10 control participants participated in this study. Each participant listened to a recording of four different sentence types (declaratives, yes–no questions, topicalizations, and contrastive focus constructions). All of the sentences were recorded in an unfamiliar language, Catalan, so that the participants were only listening to the prosody of the utterances. While listening to the recordings, the participants were asked to identify if sentence pairs were identical or not. *Conclusions:* The participants with Broca's aphasia were able to identify prosody with 89.1% accuracy and the control participants with 95.6% accuracy. *Relevance to current study:* People with Broca's aphasia have intact prosody comprehension, but it is less accurate than neurotypical people. This article also details what prosody and intonation are, as well as how they differ based on sentence type.

Gilabert, R., Barón, J., & Llanes, Á. (2009) Manipulating cognitive complexity across task types and its impact on learners' interaction during oral performance. *International Review of Applied Linguistics in Language Teaching, 47*, 367–395. https://doi.org/10.1515/iral.2009.016

Objective: The aim of this study is to explore how manipulating complexity across three different task types affects the ability to interact with others. *Methods:* Twenty-seven English learners between the ages of 18–40 were selected to participate in this study. They were each asked to perform three different language tasks in a random order. The tasks included a narrative reconstruction task, an instruction-giving map task, and a decision-making task. Each task was performed twice, once at a simple level and once at a more complex level. The participants were then asked to rate each task based on difficulty, stress, confidence, interest, and motivation using a Likert scale. Number of repairs and confirmation/comprehension checks were also noted. *Conclusions:* Only perception of difficulty, stress, and confidence were affected by complexity of task type. Participants rated the three more complex task types to be more difficult. The complex narrative was rated to be the most difficult task, as well as the one with the lowest confidence levels and greatest amount of clarification/confirmation checks. More repairs were counted during the complex tasks. Complex tasks tended to encourage more interaction in the form of repairs and clarification/confirmation checks. The instruction-giving map task generated the greatest amount of clarification/confirmation checks because there was only one specific answer required. *Relevance to current study:* Narrative tasks are more difficult than instruction-giving or decision-making tasks in English-learners. My study will further this research to see if it is the same case for people with aphasia by measuring number and length of pausing.

Kertesz, A. (2006). Western Aphasia Battery-Revised (WAB-R) [Database record]. APA PsycTests. https://doi.org/10.1037/t15168-000

Objective: The Western Aphasia Battery (WAB-R) is a comprehensive language assessment that identifies the type and severity of aphasia. It is also used to determine the patient's level of performance in order to establish baseline skills for therapy, and identifies strengths and weaknesses that will guide treatment. This exam also aids in inferring the origin and cause of the lesion responsible for the aphasia diagnosis. The WAB-R consists of eight subtests: spontaneous speech, auditory verbal comprehension, sequential commands, repetition, object naming, reading, writing, and apraxia. There are 32 short tasks embedded into the eight subtests. *Relevance to current study:* Although the

WAB-R is a widely-used, comprehensive language assessment, it does not evaluate the use of prosody in expressive language. More specifically, there is no objective way to evaluate fluency based on speech pause length and frequency.

Goodglass, H., Barresi, B., Weintraub, S., & Kaplan, E. (2001). BDAE: The Boston Diagnostic Aphasia Examination (3rd edition.). Lippincott Williams & Wilkins.

Objective: The Boston Diagnostic Aphasia Examination (BDAE-3) is a comprehensive language assessment that diagnoses aphasia and related disorders. There are eight subtests included in this examination, including fluency, auditory comprehension, naming, oral reading, repetition, automatic speech, reading comprehension, and writing. It is important to note that in the fluency subtest, melodic line, or intonational pattern, is a feature of the patient's spontaneous speech that is assessed. Melodic line is assessed on a scale from 1–7, 1 being "word-by-word or aprosodic speech," 4 being "sentence intonation limited to short phrases," and 7 being "normal speech melody." *Relevance to current study:* The BDAE-3 includes an assessment of the patient's intonation, but how to measure intonation seems ambiguous. There is no measure for speech pause.

Holland, A. L., Wozniak, L., & Fromm, D. (2018). *Communication activities of daily living (3rd ed.)* (Cadl-3): Examiners Manual. Pro-Ed.

Objective: The Communication Activities of Daily Living (CADL-3) is an assessment designed to assess functional communication skills of adults with neurogenic communication disorders. It was normed on a sample of 115 adults with communication disorders due to stroke, dementia, traumatic brain injury, primary progressive aphasia, or other type of brain injury. This exam assesses seven areas: reading, writing, and using numbers; social interactions; contextual communication; nonverbal communication;

sequential relationships; humor, metaphor, and absurdity; and Internet basics. *Relevance to current study:* This aphasia assessment doesn't assess prosody and how dysprosody may impact a person's daily living and quality of life.

Le, H., & Lui, M. Y. (2023). *Aphasia*. StatPearls.

Objective: This book outlines the basics of aphasia, including the pathophysiology, symptoms present in different types, intervention techniques, and how to collaborate interprofessionally to treat patients. *Conclusions:* Aphasia is most commonly caused by CVA, which results in lesions in the left hemisphere around the language centers of the brain. There are 180,000 new aphasia cases per year in the U.S. Each type of aphasia has a unique set of symptoms. Aphasia patients are evaluated using a CT scan, MRI, and aphasia battery, such as the WAB. Goals for treatment depend on the case, but the ultimate goal for the patient is to be as independent as possible. There are many health professionals involved in treating people with aphasia, including physiatrists, psychiatrists, neurologists, speech-language pathologists, and neuropsychologists. *Relevance to current study:* This book gives a good overview of what aphasia is, which will be helpful in creating a framework for my thesis. It also explains the symptoms of Broca's aphasia and explains the difference between fluent and nonfluent aphasia. This book also highlights the struggles and frustrations that people with nonfluent aphasia experience.

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 study aims to investigate how perception and production of affective prosody are affected by left-hemisphere damage (LHD). It also aims to confirm the correlation between aphasia severity and impaired affective prosody processing. *Methods:* This study consisted of 11 participants with LHD due to stroke (six males, five females) and 15 neurotypical control participants (four males, 11 females). The two groups were matched based on age, cognitive functioning, anxiety and depression. The LHD group's aphasia quotient ranged from 8.2–99.4. In order to measure perception of affective prosody, the participants were asked to listen to a conversation and then match the perceived emotional tone to a corresponding facial photo. To measure affective prosody production, participants were asked to produce nonsense syllables and words using different emotional tones, such as angry, disinterested, happy, etc. Three raters were asked to listen to the recordings and determine the emotional tone. The participants were also asked to fill out questionnaires addressing their quality of life in general, such as the WHO-QOL, V-RQOL, and QASD. *Conclusions:* Neurotypical participants were able to perceive and produce affective prosody more accurately than participants with LHD. Raters were less likely to accurately identify emotional tone in participants with LHD compared to neurotypical participants. Participants with LHD had reduced pitch variation in their speech in comparison to neurotypical participants. Those in the LHD group rated their quality of life significantly lower than the neurotypical group. A significant correlation between prosody perception and quality of life was found in both groups. The study also confirmed the correlation between increased aphasia severity and decreased prosody perception/production. *Relevance to current study:* This article gives basic descriptions of aphasia and prosody that will aid in creating the framework for my

thesis. It also highlights how prosody in aphasia is often overlooked. People with aphasia experience difficulties with perceiving and producing affective prosody, which creates communication breakdowns and affects overall quality of life.

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

Relevance to current study: 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: The aim of this study was to explore different types and distributions of hesitations in spontaneously spoken language. *Methods:* A sample of 163 utterances was taken from a conference given by 13 professional male speakers. Each of their speeches were recorded and transcribed. The speech samples were then analyzed for hesitations. Hesitations were grouped in one of four categories: repeats, false starts, filled pauses, or unfilled pauses. Repeats were defined as "all repetitions, of any length, that were judged to be non-significant semantically." False starts were defined as "all incomplete or self-interrupted utterances." Filled pauses were defined as "all occurrences of the English hesitation devices." Finally, unfilled pauses were defined as "an abnormal hesitation in speech that could not be referred to the three previous categories.” This could be a prolonged silence or a lengthening of phonemes. *Conclusions:* The results of the study found that there were differences among speakers in the types of hesitations in their speech, as well as in their ability to produce speech spontaneously. It also found that false starts, filled, and unfilled pauses are typically surrounding lexical items, whereas repeats often involve function words. They also found that filled and unfilled pauses most commonly occur at word and phrase boundaries, with filled pauses often occurring before function words and in between phrase boundaries, and unfilled pauses often occurring before lexical words and within phrases. *Relevance to current study:* This article outlines the different types of pauses and their characteristics, as well as when they occur in neurotypical speech.

Osada, N. (2003). Analysis of pause occurrence in three kinds of modified speech: Public address, caretaker talk, and foreigner talk. *Journal of Pan-Pacific Association of Applied Linguistics, 7*(1), *77–123.*

Objective: This study aims to determine how modified speech differs from unmodified speech in speech rate, articulation rate, pause unit length, individual pause length, and percentage of pauses. *Methods:* Forty-one audio recordings were analyzed, looking at three types of modified speech (public speeches, children's audio books, and radio broadcasting for nonnative English speakers) and unmodified speech (adult audio books and radio broadcastings for native English speakers.) The recordings were analyzed for speech rate, articulation rate, pause unit length, individual pause length, and percentage of pauses using a software for acoustic analysis and editing. *Conclusions:* Modified speech is used to help the communication partner understand. This study found that in modified speech, speech and articulation rate are slower, pause unit length is shorter, individual pause length is longer, and percentage of pauses is higher. *Relevance to current study:* This article gives a good definition of pausing, as well as how pausing differs based on task type and audience.

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

Objective: The aim of this study was to investigate the impact of pause location on sentence comprehension and recall. *Methods:* Four undergraduate students participated in the study, during which they were exposed to 12 practice sentences and 44 test sentences. These sentences included pauses in either a structural or grammatical location (between clauses) or a nonstructural location (within a clause). The participants were instructed to recall the sentences as quickly as possible after their presentation. The study assessed response time, within-response pauses, and the accuracy of content recall. *Conclusions:* Sentences with pauses in nonstructural, nongrammatical locations required more time for the participants to recall, resulted in more pauses during recall, and had lower accuracy in content recall. *Relevance to current study:* This research highlights the significant influence of pause placement on speech perception and comprehension.

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: To compare neurotypical people and people with left hemisphere damage (LHD) in their ability to produce lexical stress differences. *Methods:* The study consisted of nine LHD subjects and 10 control subjects. Experiment 1: They used ten pairs of two-

syllable words. Each word had stress on either the first or second syllable. Those with stress on the first syllable were nouns and those with stress on the second syllable were verbs. Ex. "*com*bine" vs, "com*bine*." The words were presented to each subject to be read aloud, and their responses were recorded. Ten naive listeners were then asked to listen to the recordings and interpret what was being said. Experiment 2: They used five pairs of sentences that were identical, except that the meaning changed depending on segmental boundaries. Ex. "The woman said, watch my *boyfriend."* vs. "The woman said, watch my *boy, friend.*" The subjects were recorded producing each sentence, and then naive listeners were asked to listen. Experiment 3: They used ten pairs of sentences, each with a statement and a question. Ex. "The house is white." vs. "The house is white?" The subjects were recorded reading each sentence, and unfamiliar listeners then listened to them and judged whether they were a statement or a question. *Conclusions:* Experiment 1: The study found that nouns have an emphasized first syllable, while verbs have an emphasized second syllable, with greater intensity, duration and fundamental frequency. The study also found that the control group had a greater difference between stressed and unstressed syllables as compared to the LHD group. The listeners were better able to perceive the correct word in the control group than the LHD group. Experiment 2: The naive listeners were able to perceive the control group's sentences more accurately than the LHD group. Experiment 3: Unfamiliar listeners more accurately perceived when questions were being asked in the control group than the LHD group. They accurately perceived statements equally across both groups. *Relevance to current study:* Increased intensity, fundamental frequency, and duration are used to mark stress, separate word boundaries, and denote type of sentence. Individuals with aphasia could not use these prosodic elements as efficiently as neurotypical speakers, which caused communication breakdowns with unfamiliar listeners.

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

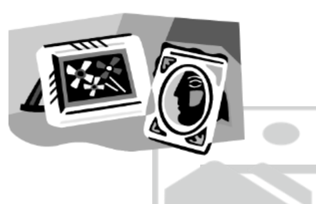
PURPOSE

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

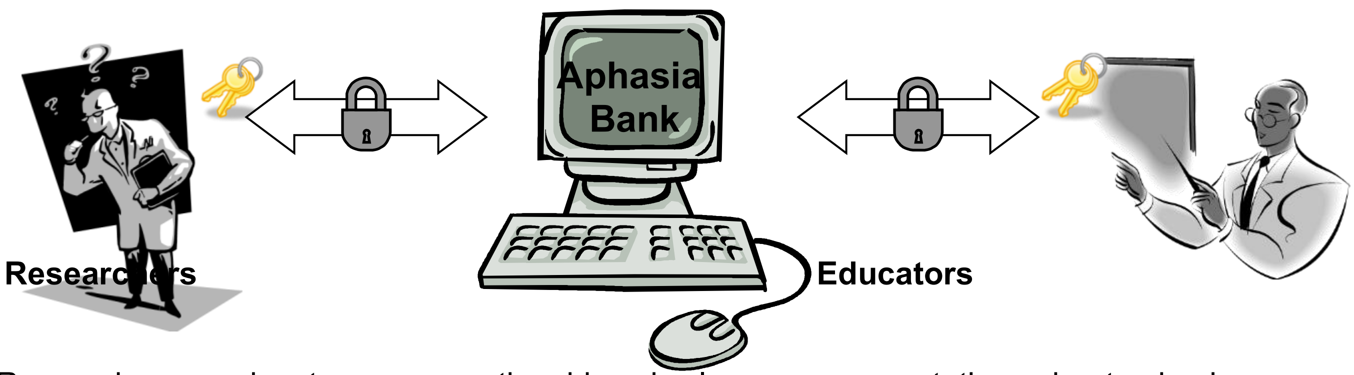
Your responses will be written out.

Your name and address will not be recorded.

<u>USE</u>

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

Researchers and educators with a password will h[illegible] access the data.



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

There are NO **known** risks or discomf[illegible] this study.

COMPENSATION

There is no monetary compensation for participating.

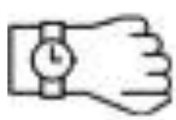
BENEFITS

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.

<u>Questions about the study:</u>

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

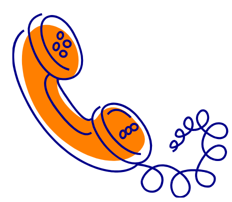
<u>Questions about your rights:</u>

Contact

IRB Chair

at

201-368-8585



<u>CONSENT TO PARTICIPATE</u>

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