The Impact of Background Noise on the Spoken Language of People With Mild to Moderate Aphasia: A Preliminary Investigation

Brenna DeLyn Scadden
Brigham Young University

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The Impact of Background Noise on the Spoken Language of People With Mild to Moderate Aphasia: A Preliminary Investigation

Brenna DeLyn Scadden

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

Tyson G. Harmon, Chair
Christopher Dromey
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Department of Communication Disorders Brigham Young University

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ABSTRACT

The Impact of Background Noise on the Spoken Language of People With Mild to Moderate Aphasia: A Preliminary Investigation

Brenna DeLyn Scadden
Department of Communication Disorders, BYU
Master of Science

This study examined how different background noise conditions affected the spoken language production of people with aphasia (PWA) when performing a story retell task. Participants included 11 adults with mild to moderate aphasia and 11 age- and gender-matched controls. Participants retold stories in a silent baseline and five background noise conditions (conversation, monologue, phone call, cocktail, pink noise). Dependent measures of speech fluency and language production measures (correct information units, lexical errors, lexical diversity, and cohesive utterances) were compared between groups and across conditions. Results reveal that background noise results in significantly lower communication efficiency (i.e., correct information units) for the aphasic group than the control group. PWA also experience background noise costs in relation to speech fluency and lexical production during both conversation and phone call conditions. The control group experience no significant background noise costs. These findings suggest that background noise interferes with discourse more for PWA than neurologically healthy adults.

Keywords: aphasia, acoustics, language, divided attention, distraction
ACKNOWLEDGMENTS

There are not words enough to express my appreciation for everyone who worked to make my thesis possible.

My husband is truly my greatest friend. Thank you, Brent, not only for never questioning my ability to accomplish anything I decide to do, but also for the daily sacrifices you make to support me. I’m grateful I get to enjoy every day with you.

My family’s love and encouragement has sustained and encouraged me; it has pushed me to give my best. I would like to express my gratitude for them, especially to my mom, dad, Shirley, Natalie, Kenna, and Chandler – all of whom spent countless hours with Clark and Dean so I could dedicate time to my thesis. And to Clark and Dean: Thank you for teaching me what is most important and for showing me love even on the hard days. I love being your mom.

I’d also like to thank participants for their willingness to be a part of this study, the McKay School of Education for providing funding for our research, and all of the AphasiaNoise project team members (Tanner Scadden, Kirsten Dixon, Riley Robertson, Kyle Steele, Bailey Wells, Breah Buss, Emily McDonald, Emily Riley, Katie Marriott, Mackenzie Price, Sara Olson, and Anne Nicol) who collectively invested thousands of hours into this vision.

Lastly, I would like to express my gratitude for my committee. Thank you, Dr. Tyson Harmon for seeing the best in me and showing me what it means to genuinely live a Christ-centered life. Thank you, Dr. Douglas Petersen, for inspiring my love of research, and Dr. Christopher Dromey for your expertise and technical guidance throughout this thesis.

I am honored for the opportunity I’ve had to complete a thesis, but even more honored to know each of these individuals.
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DESCRIPTION OF THESIS STRUCTURE AND CONTENT

This thesis, *The Impact of Background Noise on the Spoken Language of People With Mild to Moderate Aphasia: A Preliminary Investigation*, is written in a format that combines traditional thesis requirements with the format of a journal article. The preliminary pages of this thesis reflect requirements for submission to the university. The remainder of this thesis is structured like a journal article; it conforms to the style requirements for submitting research reports to relevant journals. The annotated bibliography is included in Appendix A. Appendix B contains the research consent form for people with aphasia, Appendix C contains the research consent form for control participants, Appendix D contains the training protocol for the Codes for the Human Analysis of Transcripts (CHAT) system, and Appendix E contains a sample participant Computerized Language Analysis (CLAN) file that has been coded according to the CHAT protocol and annotated to explain the codes used.
Introduction

Over 2 million Americans currently live with aphasia (Simmons-Mackie & Cherney, 2018), which is defined as an acquired neurogenic language impairment that affects reception and expression of language across modalities and interferes with life activities and participation (Hallowell, 2017). Thus, by definition, aphasia impacts a person’s linguistic processing and disrupts their ability to participate in communication activities using language. In addition to language deficits, the communication environment can also affect the ability of people with aphasia (PWA) to participate in life. For example, situations that increase attentional demands have been shown to interfere with communication for PWA, which may further impact their communicative participation (Harmon et al., 2019; Lapointe & Erickson, 1991; Murray et al., 1998; Murray, 2012; Villard & Kiran, 2016).

Attention in Aphasia

Theoretical, quantitative, and qualitative research all suggest that people with aphasia experience greater decrements to their spoken language than their peers when attentional demands are high (e.g., Garcia et al., 2000; Harmon et al., 2019; Hula & McNeil, 2008; Murray, 2018; Villard & Kiran, 2016). In explaining this effect, several theoretical accounts have attempted to describe how attention affects language processing in aphasia. One model suggests that aphasia is not necessarily the loss of language itself, but the disruption of cognitive processes that underlie language (Hula & McNeil, 2008). According to this understanding, both linguistic and non-linguistic tasks draw upon a shared pool of processing resources, which are limited for PWA. Thus, the slowed central processing demonstrated by PWA (especially in situations of high attentional demands) could be due to a reduced ability to access or properly allocate their cognitive resources. Another explanation focuses on the domain-generality or
foundational nature of attention. This explanation proposes that attention and language deficits may not simply co-occur in aphasia, but that compromised domain-general attention may, to some extent, cause impaired language (Murray, 2012; Villard & Kiran, 2016). Although these models offer slightly different theoretical perspectives, they both support a connection between attention and language, which has been the focus of recent empirical studies in PWA.

Attentional demands can be conceptualized as occurring on a spectrum from less to more cognitively demanding (Lapointe & Erickson, 1991; Pashler, 1994; Murray, 2000; Villard & Kiran, 2016): sustained attention (i.e., the ability to focus on a specific task for an extended period of time), focused attention (i.e., the ability to attend to one stimulus while filtering out others), and divided attention (i.e., the ability to process multiple responses or react to multiple stimuli simultaneously; Cahana-Amitay & Albert, 2015). Generally, as more stimuli are present and, in turn, conscious processing of the stimuli is required, cognitive demands increase (Cahana-Amitay & Albert, 2015). Over the past decade, aphasia research has investigated how these various types of attention impact language processing with a primary focus on the least cognitively demanding (i.e., sustained attention) and most cognitively demanding (i.e., divided attention).

Sustained attention appears to be a relative strength for PWA, possibly because this is the most basic form of attention and does not require the identification and filtration of multiple stimuli (Murray, 2012; Villard & Kiran, 2016). When asked to complete linguistic tasks (e.g., word identification, word retrieval, and discourse) and non-linguistic tasks (e.g., tone discrimination and visual-spatial identification) in isolation, participants with mild to moderate aphasia have consistently shown no statistically significant difference from age-matched controls (Hunting-Pompon et al., 2011; Lapointe & Erickson, 1991; Murray, 2000; Murray et al., 1998).
Even when sustained attention tasks involve more complex linguistic judgements, PWA seem to perform relatively well. For example, when asked to judge sentences as grammatically correct or incorrect without other distractors, participants with aphasia neared 100% accuracy (Murray, 2018). In a typical therapy session, clinicians most often ask clients with aphasia to complete linguistic tasks in a quiet, distraction-free environment, which engages sustained attention. Because of their strong sustained attention skills, this environment is likely to yield much better performance than the more distraction-filled environments in which communication often takes place.

Everyday communication commonly involves dividing attention between speaking and concurrent tasks, which disproportionately interferes with the performance of PWA as compared to age-matched controls (Harmon et al., 2019; Lapointe & Erickson, 1991; Murray, 2000; Murray et al., 1998). Previous divided attention research in aphasia has investigated tasks ranging from word identification while simultaneously sorting a deck of cards (Lapointe & Erickson, 1991) to picture description or story retell while concurrently discriminating between high and low tones (Harmon et al., 2019; Murray et al., 1998). Divided attention conditions have been shown to result in decreased word identification accuracy and more word finding errors for PWA (Lapointe & Erickson, 1991; Murray, 2000; Murray et al., 1998), but only Harmon et al. (2019) and Murray et al. (1998) examined the effects of divided attention on discourse. Together, these two studies found that when asked to produce spoken discourse while concurrently performing another task, PWA produced more syntactically incomplete sentences and less complex utterances (Murray et al., 1998), increased their frequency of irrelevant or non-accurate responses (Murray et al., 1998; Harmon et al., 2019), produced fewer words (Murray et al., 1998), and decreased their speech rate (Harmon et al., 2019). Because these studies included
only those with mild or moderate aphasia, these findings suggest that even people whose aphasia may not be immediately apparent to a communication partner often experience declines in their linguistic processing when dividing their attention between spoken discourse and a concurrent task.

The conclusions from the studies examining divided attention reveal that a combination of factors likely contributes to the performance of PWA under conditions of high attentional demands. First, overall cognitive ability is highly correlated with performance on divided attention tasks (Murray, 2000; Murray, 2018). For instance, although PWA consistently display poorer performance than age-matched controls on divided attention tasks, more complex cognitive demands cause a wider gap in performance between PWA and age-matched controls than lesser cognitive demands. An example of a complex demand is being asked to complete an open phrase like “He carried the ____.” instead of the less cognitively demanding closed phrase, “Read between the ____.” (Murray, 2000). Second, it seems that PWA may demonstrate more difficulty allocating their available cognitive resources. For example, when asked to complete two tasks simultaneously the performance of PWA is not significantly affected when they are directed to focus more on one task than another, such as paying more attention to accurately completing phrases than discriminating between high and low tones (Murray, 2012; Murray, 2018). Taken together, these results support a complex interaction between overall cognitive function, attention allocation, and language performance. This same complex interaction may influence the performance of PWA under conditions of focused attention, which is another form of complex attention that is common in everyday communication.
Focused attention occupies the middle of the spectrum from least to most cognitively demanding (Cahana-Amitay & Albert, 2015). In one of the earliest aphasia-centered studies to include a focused attention condition, participants with aphasia, participants with right-hemisphere brain damage, and control participants with no history of brain damage were asked to discriminate between high and low tones while simultaneously listening to, but not responding to, a series of phrases. Only participants with aphasia showed a significant decline in accuracy during the focused attention condition compared to the isolation condition (Murray, 2000). Similar disproportionate declines in performance between PWA and age-matched controls under focused attention conditions were found in additional studies (Murray, 2012; Murray, 2018; Murray et al., 1998; Hunting-Pompon et al., 2011). In particular, Murray et al. (1998) showed the same declines in word-finding accuracy, communication efficiency, and syntactic completeness in focused attention conditions as those found under divided attention conditions, though to a lesser extent, presumably because focused attention is less cognitively demanding than divided attention. Although this study formed an important foundation for understanding the effects of focused attention on discourse in aphasia, both speaking and listening tasks lacked ecological validity. During the speaking task, participants described a picture rather than engaging in a more communicative task. During the listening task, participants passively listened to high and low frequency tones that were presented at random intervals, which did not fully simulate background noise in real-world communication environments. The quantitative effect of background noise stimuli that mimic everyday communication environments, therefore, has not yet been investigated.
Communication in Background Noise for People With Aphasia

Although the effects of background noise on language performance for PWA have not been studied quantitatively, numerous qualitative studies have cited background noise as a common source of perceived interference. Over 45 years ago, noise levels were cited as a complaint of PWA recovering in hospitals post-stroke (Skelly, 1975). Other studies have documented additional sources of background noise as interfering with communication for PWA, such as “people talking all at once” (Parr, 2001, p. 276), a “city with a lot of distractions and background noise” (Dalemans et al., 2010, p. 545), and “people talking or music and singing in the background” (Baylor et al., 2011, p. 278). When asked about the impact of similar background noise conditions, PWA respond that they become “discouraged from saying anything” (Harmon, 2020, p. 11), have difficulty communicating (Baylor et al., 2011; Harmon, 2020), and that noise “cause[s] restrictions in participation” (Le Dorze et al., 2014, p. 433). These qualitative reports highlight the real-life consequences of focused attention demands for PWA.

Although completing a task in the presence of background noise can be considered to generally require focused attention, the nature of background noise may affect attentional demands differently. Background noise can be generally classified as energetic or informational noise. Energetic noise is present when overlapping acoustical features between the signal and noise result in parts of the signal being acoustically masked, and thus less audible. An example of energetic masking is conversing with a friend in a noisy restaurant, in which the speech of other individuals is not discerned, but the overall noise level is high as speakers throughout the room talk at the same time. Informational noise, on the other hand, is present when the listener is unable to ignore background sounds that have inherent meaning (Brungart et al., 2001), which
results in involuntary processing of the distractor. An example of informational masking is conversing with a friend while standing next to a radio broadcasting recent news. This would make it difficult to listen to the friend because the auditory system attempts to process both the friend’s speech as well as the speech coming from the radio. Informational masking requires deliberate focus to avoid the distracting message. Thus, informational masking results in a higher cognitive load (Meekings et al., 2016). In the present study, conditions of both energetic and informational masking were included.

Despite the theoretical, quantitative, and qualitative indications that background noise interferes with the communicative participation of PWA, background noise might not be given the attention it warrants in clinical practice. Baylor et al. (2011) interviewed PWA, speech-language pathologists, and human-resource personnel and asked them to identify potential barriers to returning to work for PWA as well as potential solutions. In the focus group for PWA, “noise” was identified as an environmental barrier, but was one of the only barriers for which no possible solutions were offered in the discussion. Notably, none of the speech-language pathologists or human-resource personnel identified noise as a potential barrier, suggesting that although background noise appears to be a barrier for the communicative participation of PWA, there is not yet enough professional awareness of this problem for it to be commonly addressed in a therapeutic setting.

**Purpose of the Study**

The current study aimed to examine both the speech and language of PWA under different background noise conditions – only the language measures will be reported here. We hypothesized that background noise conditions would interfere with spoken language performance for all participants (PWA and age-matched controls) but have a significantly larger
effect on the spoken language of PWA. Specifically, we hypothesized that spoken language interference would be demonstrated for age-matched control participants through significantly more grammatical and linguistic errors as well as a reduced rate of speech (Harmon et al., 2019; Harmon et al., 2021; Morris et al., 1988; Tun et al., 1991) while interference for PWA would result in a significantly lower percentage of communication efficiency, reduced rate of speech, and more lexical, grammatical, and macro-linguistic errors (Lapointe & Erickson, 1991; Murray, 2000; Murray et al., 1998). Furthermore, we hypothesized that greater interference effects would be seen for both groups under informational than under energetic noise conditions (Meekings et al., 2016).

Method

Participants

Participants included 11 adults (3 females and 8 males) with mild to moderate aphasia (see Table 1) and 11 age- and gender-matched adults with no history of brain damage (see Table 2). All participants spoke English as their native language and participated in pure-tone hearing tests at .5 kHz, 1 kHz, and 2kHz in both ears. Participants were recruited from Brigham Young University’s Speech and Language Clinic records and the BYU Stroke and Brain Injury Registry. Study procedures were approved by the university’s Institutional Review Board in March 2020 and an addendum concerning necessary precautions secondary to the COVID-19 pandemic was approved by the university’s Institutional Review Board in June 2020.

The Quick Aphasia Battery (QAB) was used to provide a multidimensional profile of language function and quantify the language deficits of each participant with aphasia (Table 1). The QAB has established concurrent validity with the Western Aphasia Battery, with $r$ ranging from 0.79 to 0.95 between the corresponding subtests (Wilson et al., 2018). However, the
The purpose of the QAB is not to determine whether or not an individual has aphasia, but instead to quantify relative impairments across language domains. Thus, the QAB provided a reliable, time-efficient manner of describing the language impairments of this study’s participants with aphasia. The results of the QAB indicated that participants with aphasia had mild to moderate language impairments and represented a spectrum of fluent and nonfluent aphasia. While five of the participants showed as having “very mild” aphasia on the QAB, all five of these participants sustained damage to the perisylvian area of the brain, had been previously diagnosed by a speech-language pathologist as having aphasia, and displayed characteristics of aphasia noted by the examiner (i.e., word finding difficulties, circumlocution, or paraphasias). The QAB also includes a screening for apraxia and dysarthria (Speech Motor Programming subtest; Wilson et al., 2018), which all PWA completed. Based on the results of these subtests as well as the clinical judgement of the author and advisor, three participants (02, 04, and 08) presented with apraxia of speech in addition to aphasia and two participants (03 and 05) presented with dysarthria. In all cases motor speech deficits were judged to be mild with one exception (08 was judged to have moderate apraxia of speech). Control participants confirmed that they did not have any neurological damage due to stroke or transient ischemic attacks by completing the Questionnaire for Verifying Stroke-Free Status (QVSFS; Jones et al., 2001).

**Instrumentation**

All sessions were held in a quiet research lab located at the university clinic with acoustic data collected in a sound attenuating booth to optimize the quality of acoustic recordings and reduce auditory distractions outside of the presented stimuli. Background noise conditions were played through Seinheiser HD600 open back headphones to prevent masking of participants’ own speech while also allowing for clean audio recordings of participants’ spoken language.
Speech samples were recorded with a boom microphone approximately 50 cm from the mouth. In order to establish the intensity level of the noise stimuli, the experimenters listened to masking noise from an audiometer at 60 dB HL and perceptually matched it to the loudness of the pink noise stimulus from the open back headphones. Using Audacity software (Audacity Team, 2020), all noise stimuli were equalized in mean intensity to the pink noise.
Table 1

*Aphasia Subject Characteristics*

<table>
<thead>
<tr>
<th>Ppt ID</th>
<th>Age (years)</th>
<th>Educ. (years)</th>
<th>Sex</th>
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<th>RHT (dB)</th>
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<th>SC</th>
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*Note.* Ppt. = participant; Educ. = education; MPO = Months Post Onset; LHT = Left Average Hearing Threshold; RHT = Right Average Hearing Threshold; QAB = Quick Aphasia Battery; WC = Word Comprehension; SC = Sentence Comprehension; WF = Word Finding; GC = Grammatical Construction; SMP = Speech Motor Programming; Rp = Repetition; Rd = Reading; O = Overall.
Table 2

Control Subject Characteristics

<table>
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<tr>
<th>Ppt ID</th>
<th>Matched PWA</th>
<th>Age (years)</th>
<th>Educ. (years)</th>
<th>Sex</th>
<th>LHT (dB)</th>
<th>RHT (dB)</th>
<th>QVSFS</th>
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<tbody>
<tr>
<td>13</td>
<td>02</td>
<td>48</td>
<td>18</td>
<td>M</td>
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<td>8.75</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>04</td>
<td>53</td>
<td>15</td>
<td>F</td>
<td>18.75</td>
<td>20.00</td>
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<tr>
<td>15</td>
<td>03</td>
<td>74</td>
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<td>M</td>
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<td>16</td>
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<tr>
<td>17</td>
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<td>0</td>
</tr>
<tr>
<td>18</td>
<td>06</td>
<td>32</td>
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<td>M</td>
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<td>7.50</td>
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<tr>
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<td>07</td>
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</tr>
<tr>
<td>21</td>
<td>12</td>
<td>55</td>
<td>17</td>
<td>M</td>
<td>0.00</td>
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<td>23</td>
<td>08</td>
<td>57</td>
<td>18</td>
<td>F</td>
<td>2.50</td>
<td>7.50</td>
<td>0</td>
</tr>
</tbody>
</table>

Note. LHT = Left Average Hearing Threshold;  RHT = Right Average Hearing Threshold;  QVSFS = Questionnaire for Verifying Stroke-Free Status Scores.

Procedures

Each participant completed one session lasting no more than two hours. At the beginning of the session, each participant reviewed the consent form with a trained research assistant and completed either the QAB (if they were a participant with aphasia) or the QVSFS (if they were a control participant). Participants then completed all experimental conditions, with the exception of one participant (06) who discontinued after four conditions. Finally, each individual participated in a semi-structured interview. Interview data will be analyzed and reported as part of a future study.

Experimental Conditions

The noise condition stimuli included: (a) a silent baseline condition, (b) the speech of one person reading aloud a non-fiction book (c) the speech of a lively conversation between multiple people, (d) the speech of one side of a cell-phone conversation, (e) cocktail noise, and (f) pink noise. The reading stimulus was taken from a commercially available audiobook, the lively
conversation was taken from a dramatized story podcast that was commercially available, and the one-sided phone conversation was recorded by a research assistant. The speech in all three of these conditions was 100% intelligible. To ensure continuity in the audiobook and lively conversation samples, pauses longer than 200 ms were removed. In the cocktail condition, speech was unintelligible and combined with other common sounds that may be found in a restaurant or bar.

Before commencing the conditions, the examiner told the participant, “I will now play several stories for you. After each story, I will ask you to retell the story with as much detail as you remember. Sometimes, you will hear other noises while you are retelling the story. Are you ready for the first story?” When the participant indicated their readiness, a short story played through the open-back headphones without any other noise. Then, when the story ended, the person was asked, “Please retell that story with as much detail as you remember” and the background noise condition commenced. This process was repeated for each of the conditions. All stories were taken from the Story Retell Procedure (Doyle et al., 1998). These stories were matched for content and complexity (i.e., number of words, number of sentences, number of subordinate clauses and mean sentence length, ratio of clauses to T-units, listening difficulty, and number of unfamiliar words) and are comparable to other commonly used discourse elicitation methods across various measures of verbal productivity, information content, and verbal disruptions (McNeil et al., 2007). The sequence of both the short stories and the background noise conditions were randomized. After each retell, the person was asked to complete a short questionnaire that asked them to rate their stress and effort during the retell they just completed. Questionnaire responses, along with speech acoustic data, will be reported elsewhere.
Orthographic Transcription and Text Coding

The digital recordings were orthographically transcribed using speech-to-text software (Scadden, 2019). Trained research personnel then listened to audio recordings and corrected any transcription errors. The transcriptions obtained from each participant were segmented into C-units, which are syntactic units consisting of an independent clause and any associated dependent clauses or modifiers. To ensure strong inter- and intra-rater reliability, research personnel followed the step-by-step procedures for C-unit segmentation outlined in Wright and Capilouto (2012).

Using the segmented orthographic transcriptions, research assistants coded the language samples for phonological, lexical, grammatical, and macro-linguistic errors according to the Codes for Human Analysis of Transcripts (CHAT) format, which allowed for analysis using the Computerized Language Analysis (CLAN) program (MacWhinney, 2000). Research assistants referenced a detailed list of codes to document each type of error (Marini et al., 2005). In addition, research assistants completed extensive training to ensure high inter- and intra-rater reliability, consisting of scoring a standard set of 15 practice transcriptions and comparing them to master transcriptions previously scored through collaboration between the author and the thesis chair, who is an experienced speech-language pathologist and aphasiologist. The research assistants then met with the author to discuss any discrepancies in the training set and were provided with additional practice transcriptions if they did not understand all of the corrections. Once research assistants reached 100% agreement with the practice transcriptions, they could begin coding new files. The author, who has 4 years of experience in language analysis, reviewed each coded transcript for accuracy and resolved discrepancies through discussion with a committee consisting of the author, another experienced coder, and the thesis chair. This
approach prioritized the accuracy of coding over agreement and is consistent with the approach used in previous research (Fromm et al., 2017). The coded transcripts were then ready for analysis to compute the dependent variables.

**Dependent Variables**

Dependent variables included measures examining speech fluency, speech efficiency, lexical production, grammatical production, and macrolinguistic production. These dependent variables are summarized in Table 3 and explained below.

**Table 3**

*Summary of Dependent Variables*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech fluency</td>
<td>Words per minute</td>
</tr>
<tr>
<td>Speech efficiency</td>
<td>Number of false starts and simple repetitions per word, inverted, and multiplied by 100</td>
</tr>
<tr>
<td>Lexical production</td>
<td>Number of correct information units per word multiplied by 100</td>
</tr>
<tr>
<td>Lexical diversity</td>
<td>Moving-average type-token ratio, which analyzes lexical diversity using the type-token ratio while accounting for variability in sample length (Covington &amp; McFall, 2010).</td>
</tr>
<tr>
<td>Grammatical production</td>
<td>Number of words without morphosyntactic errors (i.e., function word omissions or substitutions, bound morpheme substitutions, and content omissions) multiplied by 100</td>
</tr>
<tr>
<td>Macrolinguistic production</td>
<td>Number of utterances without macrolinguistic errors (i.e., incomplete, ambiguous, tangential, incongruent, repeated, and filler utterances)</td>
</tr>
</tbody>
</table>

**Speech Fluency.** Measures of speech fluency assessed the speed at which speech was produced as well as any interruptions to the forward flow of speech. The first dependent variable in this construct was speech rate, which provided a measure of words per minute in each sample. The word count excluded partial words and words which were part of repetitions or revisions.
The second dependent variable in this construct was the disfluency ratio, which was comprised of the number of simple repetitions (repeated sound, syllables, and words) as well as the number of false starts produced and multiplied by 100 in order to be expressed as a percentage.

**Speech Efficiency.** Speech efficiency was assessed using correct information units (CIUs). The correct information units measure is designed to determine what percentage of a given sample is intelligible, relevant, accurate, and informative relative to the stimulus. Following the guidelines given in Nicholas and Brookshire (1993) and Wright and Capilouto (2012), this measure is calculated by dividing the total number of correct information units by the total number of words and multiplying the result by 100 to arrive at a percentage. Correct information units are defined as words that are intelligible, informative, and relevant to the stimulus. The total word count excludes unintelligible, made-up, filler, and partial words as well as comments on the tasks. One research assistant completed all of the analysis for this measure following established, step-by-step guidelines. Intra-rater reliability was measured using a subset of 20% of all samples and was found to be high ($r = .99, p < .001$).

**Lexical Production.** Measures of lexical production accounted for lexical diversity as well as the number of lexical-phonological errors per verbalization. The first dependent variable related to lexical production was lexical diversity. Lexical diversity was measured as the Moving-Average Type-Token Ratio (MATTR) using the Computer Analysis for Psychological Research (Covington, 2007; Covington & McFall, 2010). MATTR calculates type-token ratios across consecutive nonoverlapping word segments from a sample and averages them. The use of consecutive nonoverlapping segments removes the influence of variability in sample size and is, therefore, a reliable measure of lexical diversity in aphasia (Fergadiotis et al., 2013). For the present study, the window length was set at 37 words to account for the shortest sample in the
dataset. The second dependent variable, lexical-phonological errors per verbalization, involved tallying the number of false starts, phonological paraphasias (the substitution of a word with another word or non-word that preserves at least half the syllables of the intended word), neologisms (the substitution of a word with jargon), semantic paraphasias (the substitution of a word with another word that is related in meaning), passe-partout words (the substitution of a word with a general referent), simple repetitions, and fillers (the addition of a word that added no meaning to the story) and dividing the total number of lexical-phonological errors by the total number of verbalizations.

**Grammatical Production.** Grammatical production was quantified by the percentage of words without a grammatical error. To calculate this measure, grammatical errors were first identified and tallied. Grammatical errors included the number of substitutions of a function word, substitutions of bound morphemes, content omissions, and omissions of function words. The total number of grammatical errors was then divided by the total number of words to arrive at a ratio of grammatically incorrect words, inverted to reflect the ratio of grammatically correct words, and multiplied by 100 to arrive at a percentage.

**Macrolinguistic Production.** Macrolinguistic production was assessed by calculating the percentage of coherent and cohesive utterances. To do this, the number of macrolevel errors were first counted. Macrolevel errors included the number of coherence errors, aposiopeses (the abrupt ending of a thought), ambiguous referents (the use of a reference which does not clearly refer to a subject), missing referents (the omission of a necessary referent), filler utterances (the addition of an utterance which does not contribute to the meaning of the story), repeated utterances, and tangential utterances. The total number of macrolevel errors was then divided by the total
number of utterances, inverted to reflect the ratio of coherent and cohesive utterances, and multiplied by 100 to arrive at a percentage.

**Statistical Analysis**

Results were analyzed in two steps. First, group effects across all measures were analyzed using one-way random effects ANOVAs. Second, the effects of background noise were investigated. To accomplish this, we used a relative change score that captured the difference in performance between each noise condition and the silent condition. This score was calculated by dividing the difference in value between noise and silent conditions for a given variable by the silent condition value and then multiplying that value by 100 to express as a percentage (Harmon et al., 2021; Kemper et al., 2005). These scores were inverted for the lexical-phonological errors and disfluency measures so that negative values would consistently reflect deterioration in a background noise condition and positive values would consistently reflect improved performance. This relative change score will be referred to throughout this study as the background noise effect. Positive effects will be referred to as background noise benefits and negative effects will be referred to as background noise costs.

Background noise effects were analyzed with two-way mixed-effects ANOVAs: The between-subject factor (Group) accounted for differences between the aphasia and control groups; the within-subject factor (Condition) accounted for differences across the different background noise conditions; participants were included as a random effect factor. Follow up testing was completed using Tukey’s HSD. To determine whether performance changed significantly as the result of each background noise condition, ANOVAs were followed with independent sample t-tests. Alpha was set at .05 for all statistical tests except t-tests. With t-test analysis, alpha was set at .05 for the control group but .1 for the aphasia group. This was because
we hypothesized interference in the noise conditions for the aphasia group and were, therefore, interested in unidirectional effects. For the control group, on the other hand, we hypothesized possible effects in either direction. Further, because this was a preliminary study, we did not correct t-tests for multiple comparisons. This protected against type II errors; type I errors were not minimized in order to identify trends that might be valuable to explore in future studies.

All statistical analyses were completed using R 4.0.2 (R Core Team, 2020). Mixed-effects ANOVAs were completed on models built using the lme function within the nlme package (Pinheiro et al., 2017), and pairwise comparisons were made on the model using the emmeans package (Length et al., 2017).

Results

This study investigated the language of PWA under different background noise conditions. Significant main effects for group were found across all seven measures of language production. Participants with aphasia produced language samples less efficiently, $F(1, 20) = 19.88, p < .001$, more slowly, $F(1, 20) = 25.01, p = .001$, with more disfluencies, $F(1, 20) = 13.53, p = .002$, and lexical-phonological errors, $F(5, 98) = 5.64, p = .028$, and with fewer grammatically correct words, $F(1, 20) = 7.74, p = .012$, and cohesive/coherent utterances, $F(1, 20) = 32.00, p < .001$. Background noise effects further elucidated several changes relative to the silent baseline condition. Because the primary goal of this study was to investigate these changes, condition effects are emphasized below. Descriptive statistics for all dependent variables are reported in Table 4. Background noise effects are shown in Figure 1.
Table 4

*Descriptive Statistics for All Dependent Variables*

<table>
<thead>
<tr>
<th></th>
<th>Conversation PWA</th>
<th>Conversation Control</th>
<th>Monologue PWA</th>
<th>Monologue Control</th>
<th>Phone call PWA</th>
<th>Phone call Control</th>
<th>Cocktail PWA</th>
<th>Cocktail Control</th>
<th>Pink PWA</th>
<th>Pink Control</th>
<th>Silent PWA</th>
<th>Silent Control</th>
</tr>
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<tbody>
<tr>
<td>Speech Rate</td>
<td>M 80.87</td>
<td>139.63</td>
<td>M 93.47</td>
<td>142.19</td>
<td>M 85.41</td>
<td>141.89</td>
<td>M 88.10</td>
<td>139.03</td>
<td>M 89.46</td>
<td>140.29</td>
<td>M 92.12</td>
<td>147.06</td>
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<tr>
<td></td>
<td>SD 23.13</td>
<td>19.19</td>
<td>SD 34.75</td>
<td>21.01</td>
<td>SD 31.63</td>
<td>26.02</td>
<td>SD 33.57</td>
<td>19.95</td>
<td>SD 34.85</td>
<td>20.36</td>
<td>SD 33.63</td>
<td>23.23</td>
</tr>
<tr>
<td>Percentage of disfluent</td>
<td>M 4.07</td>
<td>0.80</td>
<td>M 2.41</td>
<td>0.50</td>
<td>M 3.05</td>
<td>1.02</td>
<td>M 3.77</td>
<td>0.69</td>
<td>M 3.08</td>
<td>0.54</td>
<td>M 3.02</td>
<td>0.79</td>
</tr>
<tr>
<td>words</td>
<td>SD 2.83</td>
<td>0.67</td>
<td>SD 2.98</td>
<td>0.42</td>
<td>SD 3.16</td>
<td>0.49</td>
<td>SD 3.15</td>
<td>0.68</td>
<td>SD 2.62</td>
<td>0.70</td>
<td>SD 0.37</td>
<td>0.59</td>
</tr>
<tr>
<td>Percentage of correct</td>
<td>M 64.33</td>
<td>88.57</td>
<td>M 67.42</td>
<td>88.90</td>
<td>M 66.35</td>
<td>86.71</td>
<td>M 70.88</td>
<td>88.90</td>
<td>M 68.71</td>
<td>92.00</td>
<td>M 70.63</td>
<td>88.24</td>
</tr>
<tr>
<td>information units</td>
<td>SD 17.42</td>
<td>5.95</td>
<td>SD 12.30</td>
<td>5.08</td>
<td>SD 17.78</td>
<td>5.36</td>
<td>SD 19.32</td>
<td>4.87</td>
<td>SD 20.17</td>
<td>3.85</td>
<td>SD 15.54</td>
<td>6.39</td>
</tr>
<tr>
<td>Lexical diversity</td>
<td>M 0.70</td>
<td>0.78</td>
<td>M 0.72</td>
<td>0.76</td>
<td>M 0.69</td>
<td>0.77</td>
<td>M 0.77</td>
<td>0.79</td>
<td>M 0.69</td>
<td>0.77</td>
<td>M 0.72</td>
<td>0.76</td>
</tr>
<tr>
<td>SD 0.11</td>
<td>0.11</td>
<td>0.11</td>
<td>0.03</td>
<td>0.08</td>
<td>0.08</td>
<td>0.03</td>
<td>0.03</td>
<td>0.10</td>
<td>0.03</td>
<td>0.08</td>
<td>0.03</td>
<td>0.04</td>
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<tr>
<td>Percentage of verbalizations</td>
<td>M 19.03</td>
<td>6.09</td>
<td>M 15.21</td>
<td>5.17</td>
<td>M 19.04</td>
<td>7.61</td>
<td>M 17.17</td>
<td>5.73</td>
<td>M 14.62</td>
<td>4.79</td>
<td>M 15.32</td>
<td>6.47</td>
</tr>
<tr>
<td>with lexical-phonological</td>
<td>SD 15.20</td>
<td>2.28</td>
<td>SD 15.86</td>
<td>2.23</td>
<td>SD 19.55</td>
<td>2.91</td>
<td>SD 14.07</td>
<td>2.87</td>
<td>SD 12.62</td>
<td>2.53</td>
<td>SD 14.04</td>
<td>2.98</td>
</tr>
<tr>
<td>errors</td>
<td>M 96.16</td>
<td>99.69</td>
<td>M 94.38</td>
<td>99.22</td>
<td>M 96.80</td>
<td>99.40</td>
<td>M 95.08</td>
<td>99.41</td>
<td>M 96.14</td>
<td>99.79</td>
<td>M 94.96</td>
<td>99.46</td>
</tr>
<tr>
<td>SD 3.36</td>
<td>0.39</td>
<td>4.88</td>
<td>0.85</td>
<td>4.44</td>
<td>0.59</td>
<td>6.18</td>
<td>0.69</td>
<td>4.66</td>
<td>0.31</td>
<td>5.90</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>Percentage of utterances</td>
<td>M 57.77</td>
<td>90.23</td>
<td>M 73.27</td>
<td>96.42</td>
<td>M 71.13</td>
<td>97.65</td>
<td>M 85.43</td>
<td>97.54</td>
<td>M 68.78</td>
<td>99.04</td>
<td>M 75.22</td>
<td>93.07</td>
</tr>
<tr>
<td>without macrolinguistic</td>
<td>SD 45.59</td>
<td>9.57</td>
<td>SD 20.34</td>
<td>5.03</td>
<td>SD 22.94</td>
<td>5.74</td>
<td>SD 15.59</td>
<td>3.52</td>
<td>SD 24.09</td>
<td>2.22</td>
<td>SD 13.31</td>
<td>9.50</td>
</tr>
<tr>
<td>errors</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
**Note.** A positive change represents background noise benefits, and a negative change represents background noise costs. Background noise effect means and standard errors for grammatical production and lexical diversity were multiplied by 10 to aid in visualization. Error bars illustrate standard error. Asterisks by bars and next to the axis labels indicate significant background noise effects.
Speech Fluency

Across background noise effect measures for speech fluency (speech rate and disfluencies), no main or interaction effects were found. In relation to speech rate, though, the aphasia group showed significant background noise costs in the conversation ($t[10] = -2.82, p = .018$) and phone call ($t[9] = -1.9065, p = .089$) conditions. In relation to disfluencies, no significant changes from 0 were found for aphasia or control groups, but background noise costs for the aphasia group during the conversation condition neared significance ($t[10] = -1.7608, p = .109$).

Speech Efficiency

Analysis of background noise effects for speech efficiency showed a significant main effect for group, $F(1, 20) = 5.024, p = .0365$, but no main or interaction effect for condition. The group effect revealed that, on average, participants with aphasia experienced more interference to their CIUs across noise conditions than control participants. However, no statistically significant changes from the silent baseline condition across individual noise conditions were found.

Lexical Production

Across background noise effect measures for lexical production (lexical diversity and lexical-phonological errors), no main or interaction effects were found with one exception. For lexical-phonological errors, a main effect was found for condition, $F(5, 98) = 3.61, p = .010$. Tukey’s HSD, however, revealed no statistically significant differences between individual conditions. In relation to lexical diversity, significant background noise costs were found for the aphasia group during the phone call condition ($t[9] = -2.6289, p = .027$). Significant background noise costs were also found for the aphasia group in relation to lexical-phonological errors during the conversation condition ($t[10] = -1.9925, p = .074$). Conversely, the control group showed
significant background noise benefits as they increased lexical diversity during the cocktail condition \((t[10] = 2.2393, p = .049)\). The background noise benefit also neared significance for lexical diversity during the conversation condition \((t[10] = 2.1265, p = .059)\). On the other hand, for lexical-phonological errors the background noise cost neared significance for the control group during the phone call condition \((t[10] = -2.1669, p = .055)\).

**Grammatical Production**

Background noise effects for percent grammatically correct words showed a main effect for condition, \(F(5, 98) = 3.48, p = .012\), but no main effect for group or interaction effect. Follow up testing revealed that background noise costs were greater during the monologue condition than during the phone call \((p = .040)\) and pink noise \((p = .035)\) conditions. No statistically significant changes from 0 were found across conditions for either group.

**Macrolinguistic Production**

Background noise effects for percent cohesive and coherent utterances showed a main effect for condition, \(F(5, 98) = 3.21, p = .017\), but no main effect for group or interaction effect. Follow up testing revealed significantly more interference in the conversation than cocktail condition \((p = .006)\). No statistically significant changes from 0 were found.

**Discussion**

Beyond the quintessential language deficits experienced by PWA, previous research has established additional interference to their communication when attentional demands are high (Harmon et al., 2019; Lapointe & Erickson, 1991; Murray et al., 1998; Murray, 2012; Villard & Kiran, 2016). One everyday example of this is communicating in the presence of background noise, which requires focused attention. Besides a handful of qualitative studies (Baylor et al., 2011; Dalemans et al., 2010; Harmon, 2020; Le Dorze et al., 2014; Parr, 2001; Skelly, 1975),
however, background noise has been given little attention in the aphasia literature. The current study aimed to examine how the speech fluency, speech efficiency, lexical production, grammatical production, and macrolinguistic production of people with aphasia compared to age- and gender-matched controls when language samples were taken under various background noise conditions. Findings suggest some differences in how people with aphasia and neurologically healthy adults respond to speaking in noise.

**Costs of Background Noise for People With Aphasia**

We hypothesized that background noise conditions would interfere with the spoken language performance of all speakers but would have a significantly larger effect on the spoken language of PWA than control participants. Although the current study found no significant background noise costs for control participants, which was contrary to our a priori expectation (Harmon et al., 2019; Harmon et al., 2021; Kemper et al., 2003; Murray et al., 1998), noise conditions did interfere with communication across a number of measure and condition combinations for PWA.

The greater interference for CIUs in noise conditions experienced by PWA highlights an important distinction in how the two groups responded to speaking in noise and is consistent with previous research. Murray et al. (1998) showed that an aphasia group—but not a control group—experienced declines in CIUs during a focused attention task, which involved describing a picture in the presence of high and low tones. Although the current study also involved focused attention due to the presence of noise during language production, the conditions could be considered more ecologically valid because they better simulated real-world environments than the high and low tones used previously. Because the CIUs measure grossly quantifies the amount of information conveyed, CIUs could be considered most essential to successful communication
because they closely examine what content is being communicated. The results of the current study suggest that regardless of their degree of grammatical or lexical correctness, people with aphasia are less able to convey their intended message in the presence of background noise than their peers with no aphasia.

In relation to a silent baseline, background noise interfered with production across several measures of spoken language for PWA but not for controls. Specifically, PWA spoke more slowly in two of the conditions (i.e., conversation and phone call), produced significantly more lexical-phonological errors in the conversation condition, and had significantly less lexical diversity in the phone call condition. Additionally, visual inspection of the aphasia group’s background noise effects showed that, on average, PWA experienced background noise costs across most measure and noise combinations even when the change was not statistically significant (see Figure 1). These findings suggest general declines in the quality of the communication of PWA under background noise conditions, which fits with previous qualitative studies in which PWA have cited background noise as a barrier to successful communication (Baylor et al., 2011; Dalemans et al., 2010; Harmon, 2020; Le Dorze et al., 2014; Parr, 2001). Specifically, Baylor et al. (2011, p. 278) cited “people talking or music and singing in the background” which closely aligns with the conditions of the current study. This general decline could be explained by the model presented by Hula and McNeil (2008) or the model presented by Murray (2012) and Villard and Kiran (2016), both of which support a connection between attention and language in aphasia. According to these models, as attentional demands increase, measures of language quality would decrease.

Although in the present study we interpreted a reduced rate of speech as interference (i.e., background noise costs), it should be noted that slowed speech has the potential to be beneficial
in allowing participants additional processing time. In other words, slowing may be an indication that participants are attempting to re-allocate attentional resources between the task being performed and a distractor (Kemper et al., 2003; Kemper et al., 2005), which may provide them with the additional resources and/or processing time necessary to preserve language accuracy (Harmon et al., 2019). Although not statistically significant, control participants did, on average, generally reduce their rate across all noise conditions, which may have contributed to their generally preserved accuracy across other measures. PWA, on the other hand, generally reduced their speech rate across all noise conditions and showed a significant reduction in two conditions but still experienced interference across other language measures. This finding adds to the body of work suggesting that PWA experience decreased attentional capacity and/or difficulties allocating attentional resources (Hula & McNeil, 2008; Murray, 2012; Villard & Kiran, 2016) and suggests that using strategies to preserve effective communication in the face of environmental demands may be more difficult for them than their neurologically healthy peers. For this reason, PWA may benefit from more explicit strategy training to prepare them to communicate in attentionally demanding environments.

Unlike the control group, the aphasia group experienced no significant background noise benefits. In general, across measures of speech efficiency as well as lexical, grammatical, and macrolinguistic production, controls most often showed average background noise benefits. Conversely, PWA rarely showed average background noise benefits (although this was the case in three of the conditions for grammatical production). Importantly, the control group had significantly more lexical diversity in the cocktail condition and trended towards significance in the conversation condition on this measure as well. We offer two potential explanations for this finding. First, the control group may have been able to anticipate the negative effects of
background noise on their own language production or on their listener’s ability to stay focused on the conversation and, therefore, attempted to compensate for the effects in order to keep their listener’s attention. This explanation would suggest that people with aphasia were less able to anticipate, or compensate for, such effects due to decreased attentional capacity or difficulty allocating attentional resources (Hula & McNeil, 2008; Murray, 2012; Villard & Kiran, 2016). Alternatively, the increase in lexical diversity may have been due to an increase in wordiness as the control participants seemed to convey their intended message less precisely when attentional demands were high (see Harmon et al., 2021 for a similar explanation).

**Effects of Focused Attention**

Much of the framework for the current study was based on a conglomerate of studies that conceptualize attentional demands on a spectrum from less to more cognitively demanding, with divided attention being the most demanding, sustained attention being the least demanding, and focused attention occupying the middle of the spectrum (Lapointe & Erickson, 1991; Murray, 2000; Murray, 2018; Pashler, 1994; Villard & Kiran, 2016). Although no divided or sustained attention tasks were included in the current study, the results of this study seem to fit within this proposed spectrum. For example, Harmon et al. (2019) found that PWA decreased their speech rate under dual-task conditions, which was also observed in two of the focused-attention conditions of the current study. Harmon et al. (2019) and the only other known study to examine the impact of dual-task conditions on the discourse of PWA, Murray et al. (1998), also found that PWA increased their frequency of irrelevant or non-accurate responses in dual-task conditions. Murray et al. (1998) also found declines in communication efficiency for PWA in that study’s focused-attention condition. These findings correspond to the difference in background noise effects on speech efficiency between PWA and controls in the current study. Thus, the current
study suggests that while focused-attention conditions may not always be sufficiently demanding to negatively impact the language of neurologically healthy adults, they are sufficiently demanding to affect the language of PWA (even if the effects are less robust than those of divided attention). This explanation is also supported by studies that investigated the effects of divided and focused attention conditions on non-discourse tasks in PWA and control participants (Hunting-Pompon et al., 2011; Murray, 2000; Murray, 2012; Murray, 2018).

One finding of the current study that was not consistent with Murray et al. (1998) was that in the dual-task conditions of Murray et al. (1998), PWA produced more syntactically incomplete sentences and less complex utterances. Although it was not significant, PWA generally experienced similar declines in syntactic completeness during the focused attention condition. As such, the expected outcome for the current study would be that participants with aphasia would demonstrate more grammatical or macrolinguistic errors under background noise conditions than the silent baseline condition, yet no such significant effects were found. In fact, a visual inspection of the data (see Figure 1) suggests a generally positive trend for three of the five background noise conditions. It could be that PWA were better able to regulate their grammatical and macrolinguistic structure in the narrative discourse used in the current study than in the picture description task used by Murray et al. (1998). Another possibility is that although participants in the current study as well as Murray et al. (1998) generally presented with mild severity of aphasia, the former had more months, on average, since the onset of their aphasia than the latter, which may mean that the participants in the current study had developed better strategies for compensating grammatically and macrolinguistically; they had possibly developed better strategies. The discrepancies in findings for grammatical and macrolinguistic production between the current study and Murray et al. (1998) should be the focus of future
studies in order to better understand the effect of background noise on the grammatical and macrolinguistic production of PWA.

**Effects of Informational vs. Energetic Noise**

Another construct examined in the current study was the effect of informational vs. energetic noise. In Meekings et al. (2016), participants spoke over a variety of background noise conditions ranging from energetic (such as pink noise) informational (such as recorded speech) while fMRIs were collected. The findings of Meekings et al. (2016) suggested that the neuronal activations needed to speak under informational conditions are more complex than those needed to speak under energetic conditions. The results of this study are consistent with Meekings et al. (2016) in that all significant background noise costs were experienced under informational conditions and the only significant background noise benefit (increased lexical diversity for the control group) was experienced under an energetic condition (i.e., cocktail noise). Further adding support to the idea that informational noise is more demanding than energetic noise is the finding that the background noise costs in lexical production for the aphasia group were both experienced in informational noise (conversation and phone call). In this study, most participants with aphasia had either very mild or mild severity, which usually manifests as anomia (word finding difficulties). Thus, speaking in conditions of informational noise may have been sufficiently challenging that for the aphasia group, neuronal resources had to be dedicated to getting their point across, leaving insufficient resources to avoid lexical errors (in the conversation condition) or increase the variety of vocabulary used (in the phone call condition). This explanation is consistent with the word-finding costs observed in the focused-attention condition of Murray et al. (1998), in which PWA exhibited more word-finding difficulties when describing a picture in the presence of high and low tones.
The condition effects of background noise (i.e., significantly more grammatical errors during monologue than pink condition and significantly more macrolinguistic errors during the conversation than cocktail condition) also suggest greater interference in informational than energetic noise. Both of these differences suggest that noise of a linguistic nature interfered with participants’ ability to monitor their own linguistic production. This could be due to the higher cognitive load demanded of informational masking as participants’ auditory systems attempted to process the speech coming from the monologue and conversation conditions as well as their own speech. One finding that was inconsistent with the distinction between informational and energetic noise, however, was the significant difference between the number of grammatical errors produced by all participants between the monologue and phone call conditions, despite both conditions being classified as informational noise. Participants may have demonstrated less of a cost to grammatical production during the phone call condition than the monologue condition due to the periodic silence included in the phone call recording, but this finding may also suggest that there are more factors at play than a simple comparison between informational and energetic noise classifications. Future research should help resolve whether or not additional factors are at play by examining the effect of various types of informational and energetic noise on spoken language measures.

**Directions for Future Research and Clinical Practice**

Helping people with aphasia participate more fully in their lives depends upon understanding and addressing barriers to their participation. Because background noise is a documented barrier (Baylor et al., 2011; Dalemans et al., 2010; Harmon, 2020; Le Dorze et al., 2014; Parr, 2001; Skelly, 1975) and occurs every day, it is an important consideration both in future research as well as clinical practice. The current study was preliminary in nature. As such,
limitations in the current study could be addressed in future research to better understand the
effect of background noise conditions on the language of people with aphasia. First, increasing
the number of study participants would improve statistical power and could potentially provide
more support for the findings of this study as well as uncover additional effects that were not
observed in this study. In considering the participants of future studies, it is important to note that
most participants in the current study had very mild or mild aphasia, which likely impacted the
results. Specifically, background noise could interfere more with the grammar and
macrolinguistic production of those with more severe aphasias than those with mild aphasia.
However, including participants with more mild aphasias allowed this study to focus on the
effects of background noise on the language of a population likely to return to activities of daily
living similar to those enjoyed before the onset of aphasia (such as full-time employment).
Second, all but two of the measures used in the current study used the system of language
analysis outlined in Marini et al. (2005). Although there are current efforts underway to unify
discourse analysis in aphasia (Dietz & Boyle, 2018; Stark et al., 2020), there is currently no
single system for doing so and including other measures (such as story grammar analysis or
coherence ratings) in future studies could provide additional insight. Alternatively, limiting a
future study to only one linguistic domain (e.g., morphosyntax) could allow for a more detailed
analysis of the impact of background noise on that specific domain of language for PWA.
Finally, future studies could concentrate on one category of background noise, such as
informational noise. Such a study would include various conditions classified as informational,
like a passionate debate between two people, a monologue, and an emotional conversation
between multiple people. This kind of study would provide the opportunity to identify common
effects as well as nuanced differences across types of informational noise.
Although this study was preliminary and more research is needed, it provides quantitative support for the documented complaints of the challenge of communicating in background noise conditions for PWA (Baylor et al., 2011; Dalemans et al., 2010; Harmon, 2020; Le Dorze et al., 2014; Parr, 2001; Skelly, 1975). If confirmed by future research, it seems that integrating attention-demanding stimuli into therapy might be one way to train PWA within a more real-life context. Speech therapists working with adults with aphasia might consider integrating background noise into therapy sessions. Similarly, if a connection between background noise conditions and negative effects on the spoken language of people with aphasia is better established, future research should also investigate best practices in helping PWA compensate for this difficulty.

**Conclusion**

This study found that different types of background noise resulted in background noise costs for PWA but both primarily background noise benefits for control participants. These findings suggest that background noise interferes with discourse more for PWA than neurologically healthy adults. Future research should continue investigating the effect of background noise conditions on the spoken language of PWA in order to provide direction on how to best address this common distractor in clinical practice.
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APPENDIX A

Annotated Bibliography


*Objective:* This qualitative study examined the self-reported restrictions in communicative participation across communication disorders, including those who suffered a stroke.

*Methods:* Researchers interviewed 44 adults diagnosed with 7 different medical conditions during development of the Communication Participation Item Bank. This article represented a secondary analysis of this data that identified themes in interviewees’ experiences related to communicative participation.

*Results:* Participants described both situations that interfered with their communicative participation as well as sources of interference. Participants had control over some factors, such as priorities and personal decisions, but limited control over others, such as symptoms and environments.

*Conclusions:* The study identified noise as a "very large barrier for most interviewees" and suggested that studies addressing noise as a barrier could lead to improved communication participation.

*Relevance to the current work:* This qualitative study identified noise as a significant self-reported barrier but made no attempt to quantify the impact of noise on
language. However, it is one of the few studies to document noise as a barrier to communicative participation for PWA.


**Objective:** This book makes the argument that recovery from aphasia requires the recovery of more than just language function. It reviews what is known and unknown in aphasia recovery, the neuronal underpinnings of language in the brain, and the role of executive functioning, attention, memory, emotion, praxis, and visual processing in aphasia.

**Methods:** Throughout the book, hundreds of relevant studies are cited, each with unique study methods. The book is organized by discussing each “piece” of aphasia recovery in a separate chapter.

**Results:** Each study referenced in this book had different results.

**Conclusion:** The authors conclude that a recovery from aphasia requires more than simplistic “language recovery” and specifically outline a convincing argument for the role of attention in the deficits associated with aphasia. The authors also conclude that much remains to be learned about the mapping of language in both typical and damaged brains.

**Relevance to the current work:** The authors succinctly organize the types of attention covered in the aphasia literature as well as what is known about people with aphasia’s performance in relation to each type of attention. The current work seeks to add to what is known about one of the lesser studied types of attention in people with aphasia, selective attention.

**Objective:** This pilot study explored the difficulties faced by those with mild aphasia (i.e., score normally on aphasia batteries yet report continued difficulty with aphasia). The purpose of this study was to provide evidence and education to speech-language pathologists which they could use to derive treatment methods for this population.

**Methods:** Five individuals with a history of aphasia but who scored above the Western Aphasia Battery – Aphasia Quotient cutoff for aphasia participated in a semi-structured interview. Their responses were then analyzed for subjective descriptions of difficulties in everyday communication situations.

**Results:** Participants reported communication difficulties resulting in reduced social participation, difficulties returning to work, awareness of persisting deficits, and the need to continually focus when engaged in language tasks.

**Conclusions:** The authors concluded that individuals with very mild aphasia experience challenging language difficulties that interfere with multiple areas of their life. The authors suggest that improved methods of assessment and intervention should be investigated in order to better identify and help those with very mid aphasia.

**Relevance to the current work:** This article quotes Carlsson et al. (2009) saying that this subgroup of PWA is often “considered to have recovered, and thus face expectations they [can]not live up to”; the current work seeks to quantify one aspect of difficulty this population might face, adding to the literature arguing for improved
identification and treatment of mild aphasia. In addition, the results of this study specifically point out environmental difficulties as well as an increased need for focused attention as challenges faced by PWA, both of which will be targeted by the current work.


**Objective:** This thesis examined speech acoustic measures under several different background noise conditions in order to describe how individuals modify their speech when speaking under conditions of informational masking.

**Methods:** Forty young adults monologued under five background noise conditions (i.e., pink noise, dialogue from a movie, two speakers having a debate, classical music, and contemporary music) as well as a silent baseline condition. All speech samples were collected in a sound booth. The recordings were then analyzed using Praat software for intensity, fundamental frequency, the proportional amount of time spent speaking, and fluency characteristics.

**Results:** Participants significantly increased their fundamental frequency in background noise conditions. Participants also significantly increased their intensity in all conditions besides the pink noise condition compared to the silent baseline condition. Participants significantly increased their speaking time ratio in all conditions compared to the silent baseline except for in the classical music condition. All but two of the conditions (pink noise and classical music) involved a significant increase in the disfluency ratio. Participants rated the debate and contemporary music conditions to be the most distracting.
Conclusions: The intensity and fundamental frequency increases were consistent with the Lombard effect. The increases in speaking time ratio could be due to a sense of urgency on the part of the speaker to finish their message in the face of distractors. This finding was contrary to the hypothesis that speakers would pause more in background noise conditions. Participants were most disfluent in the conditions they rated as most distracting and additional reports from the participants suggests that increased familiarity of a distractor corresponds with increased disfluency in speech production.

Relevance to the current work: Although this study looked at speech acoustic measures, the current study will use similar procedures and background noise conditions. The current study is also interested in the differing effect of informational and energetic noise. Furthermore, the analysis of this study and another preliminary study which analyzed the language characteristics of the same data set (Harmon et al., 2021) served as a kind of trial run before completing the current study.


Objective: This qualitative study aimed to explore how PWA perceive social participation and investigate influencing factors.

Methods: Thirteen PWA and 12 caregivers kept a structured diary over two weeks and subsequently participated in a semi-structured interview. Diaries and interviews were transcribed and analyzed by researchers for central themes, categories, and codes. The results were then discussed with all participants in a focus-group format.
Results: The study found that the number of social activities was not as important as the engagement PWA felt in those activities. PWA in the study felt isolated and stigmatized when they wished to feel engaged and respected. They also expressed the inability to work and the desire to contribute to society and function normally. Environmental factors identified in the study were (1) quietness of the environment and (2) familiarity of the place in which the PWA live.

Conclusions: The study concluded that PWA do not use the term “social participation” but instead the terms engagement, involvement, and belonging. PWA describe the degree of engagement as more important than the quantity of activities.

Relevance to current work: This study identified noise as a barrier to social participation but made no attempt to quantify this impact, which is the aim of the current study.


Objective: This study examined the lip movements and other speech measurements of twenty healthy young adults across repetitive speaking conditions with varying distractor conditions as a step towards measuring the impact of real-life conditions on speech.

Methods: Lip movements of twenty healthy young adults were measured under seven repetitive speaking conditions, three of which included concurrent distractor tasks. The isolated conditions included a speech-only task, a linguistic-only task, a cognitive-only task, and a visuomotor-only task. The concurrent distractor tasks were completed by
saying the same phrase as the speech-only task produced simultaneously with a linguistic, cognitive, or visuomotor task.

Results: Utterance duration increased slightly for the speech-plus-cognitive task condition and decreased for the other two combines tasks. While these differences were significant in the ANOVA, the only significant contrast was the decrease in utterance duration for the combined visuomotor condition. Lower lip-plus-jaw displacement decreased for the combined tasks and these changes were significant in the ANOVA; the only condition for which this decrease was significant was the combined visuomotor task. The spatiotemporal index (STI) significantly increased for the combined tasks. SPL also showed a significant increased for all combined tasks.

Conclusions: The study concluded that speech motor activity and linguistic performance influence each other. The authors suggest that potential interactions between the demands for language formulation, cognitive activity, and speech motor performance should not be overlooked by clinicians.

Relevance to the current work: This study attempted to analyze speech as impacted by a variety of conditions that might occur in real-life. Many of the considerations that impacted the method of this study will also affect the method of the current work.

**Objective:** This study aimed to determine how three types of distractor tasks (i.e., motor, linguistic, and cognitive) performed simultaneously with speaking influenced the labial movements of healthy, young adult speakers.

**Methods:** Ten female and ten male young adult native speakers of English participated in this study. Participants completed all tasks in a sound booth while a head-mounted strain gauge system transduced lip and jaw movements. Participants completed four tasks: a speech-only task, a combined speech-motor task, a combined speech-linguistic task, and a combined speech-cognitive task. The speech portion of each task consisted of the same utterance, “Mr. Piper and Bobby would probably pick apples…” Study procedures considered the impact of utterance novelty and sequencing effects.

**Results:** No significant differences were found between the three speech-only conditions that served as baseline comparisons for the divided attention tasks. Lower lip displacement and velocity decreased significantly for the motor distractor task when compared to the speech-only condition but not changes to the STI were found during this task. The negative correlation between the upper and lower lip displacement became somewhat stronger during the motor condition, but not to a significant level. For the linguistic distractor task, the STI for the lower lip increased significantly. Analysis also revealed that significantly more rejected tokens (tokens in which the lower lip waveform was visibly different from other under the same speaking condition) were found during the linguistic distractor condition than other conditions. For the cognitive distractor condition, participants spoke significantly faster. The STI for the lower lip and the negative correlation between the upper and lower lip also increased significantly under this condition.
Conclusions: The study concluded that distractor tasks during speech can significantly influence several labial kinematic measures, which the authors suggested supported the hypothesis that neural resources required for human communication shift according to situational demands.

Relevance to the current work: The current work might also support the hypothesis that neural resources required for human communication shift according to situational demands as PWA speak under varying situational demands. The theoretical framework of this article will be important to the background of the current work.


Objective: This study examined changes in articulatory kinematics when speakers were exposed to qualitatively different types of noise.

Methods: Thirty male and 30 female native speakers of English participated in this study. There were 10 male and 10 female speakers in each of three age groups: 20-30, 40-50, and 60-70. Participants repeated a pre-determined sentence fifteen times under each condition while their lip and jaw movements were transmitted via a head-mounted strain gauge system. Conditions included a silent, pink noise, 1-talker, 2-talker, and 6-talker noise conditions.

Results: There was a significant effect of noise condition on duration when compared to the silent condition. There were no differences in displacement across the noise conditions. The velocity of closing movements was significantly higher in all noise conditions when compared to the silent condition. The correlation between the upper and
lower lips did not change across noise conditions. The lower lip STI was lower for the pink noise condition and the 6-talker condition. All noise conditions resulted in a lower number of velocity peaks than in the silent condition. All noise conditions also resulted in a higher intensity than the silent condition.

Conclusions: The study did not find a connection between specific speech changes and the nature of different noises, but it did note changes in speech production under several of the noise conditions. The authors recommended that future studies utilize non-repetitive speaking tasks in order to more fully utilize language generation resources.

Relevance to the current work: The current work expands on this article by utilizing non-repetitive speaking tasks to analyze the impact of noise conditions on language measures. In addition, the current work expands on this line of research by extending the participants to include PWA, who might notice a more significant decline in their speech and language in noisy conditions than typical speakers.


Objective: This study examined the functional distance hypothesis, which predicts that tasks regulated by brain networks in closer anatomic proximity will interfere more with each other than tasks controlled by spatially distant regions.

Methods: Twenty young adults (10 male and 10 female) completed a number of tasks: repeating a sentence, listing words beginning with the same letter, placing pegs and washers in a peg board with the right hand, and placing pegs and washers in a peg board
with the left hand. They then completed these tasks concurrently. The order of both isolated and concurrent tasks was fully randomized. While completing these tasks, lip and jaw movements were measured with a head-mounted strain gauge system. Data from concurrent task conditions were compared to data from the speech-only condition.

Results: The displacement of the lower lip and peak velocities decreased significantly while the sound pressure level significantly increased in the concurrent left- and right-handed pegboard conditions. The STI increased significantly in the left-hand concurrent pegboard task. Participants placed significantly less pegs when this task was performed concurrently with the word listing task but not when performed with the sentence repetition task.

Conclusions: The study concluded that the functional distance hypothesis might not fully explain the control of concurrent tasks. The authors suggested that future studies use more detailed measurements of motor activities, as there measured may not have been sensitive enough to recognize compromised motor functioning. The authors also suggested the word listing task may have challenged the participants in a way that the sentence repetition task did not.

Relevance to the current work: This article suggested that linguistically demanding tasks might show different effects on participants than simple repetition tasks. Thus, this article provides some support for the hypothesis that significant effects might be expected when participants are asked to complete a linguistically demanding task in a distracting environment. The current work aims to test this hypothesis.

Foreman, K. B., Sondrup, S., Dromey, C., Jarvis, E., Nissen, S., & Dibble, L. E. (2013). The effects of practice on the concurrent performance of a speech and postural task in persons...
Objective: This pilot study examined the effects of age and Parkinson's disease on motor learning during dual-task performance.

Methods: The performance of seven people with Parkinson's disease, seven age-matched individuals, and ten healthy controls on speech and postural tasks was recorded in a motion capture facility during three different time periods (acquisition, 48-hour retention, and 1-week retention). The speech task measured in this study consisted of two target sentences that were read from a sheet of paper at a comfortable rate and loudness.

Results: Neurologically healthy young participants consistently performed better on all measured postural and speech variables. The healthy young participants were also the only group to show consistent changes in motor performance in any of the postural tasks as a result of practice.

Conclusions: The results of the study suggested a decreased efficiency of motor learning in older adults as well as those with Parkinson's disease, which the authors suggest argues for increased practice dosages in balance training. The repetitive nature of the sentence reading task likely limited the researchers’ ability to observe any practice-related improvement.

Relevance to the current work: The current work is one of the first steps in a line of research aimed to help develop effective therapy techniques for PWA who need to improve their language in real-life situations. Since many PWA are older adults, this study offers important possible implications for the retention of skills taught in therapy.
However, it should be noted that this study had limitations and may have been subject to error.

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*Objective:* This qualitative study described barriers to work reintegration of persons with aphasia as described by employers, speech-language pathologists, and persons with aphasia.

*Methods:* Three sets of participants took part in this study: fourteen PWA (mild or mild-moderate), thirteen speech-language pathologists, and twenty-two employers working as human-resource personnel. These participants were organized into multiple focus groups in which they were guided through three phases of discussion: identification of barriers, identification of the most important barriers, and identification of potential strategies. The conversations were then classified to extract common points from the focus groups.

*Results:* In the focus group for PWA, "noise" was identified as an environmental barrier, but was one of the only barriers for which no possible solutions were offered in the discussion section. Noise was also not identified by any of the focus groups composed of speech-language pathologists and employers.

*Conclusions:* The study concluded that speech-language pathologists might be detached from the work environment of their clients. The study also concluded that decisions regarding work reintegration should not be made based only on a PWA’s personal factors (including abilities) because environmental concerns play such a large
role in the workplace. Finally, the study concluded that because the results of this study were only perceptions, future studies should verify these perceptions in real-work situations.

Relevance to the current work: The current work seeks to quantify a barrier to societal reintegration for PWA (i.e., noise) that was cited in this article. Although this study identified noise as a potential barrier, no attempt was made to measure the extent of the impact on PWA’s speech and/or language. The current work will quantify the extent of the impact as a first step towards offering potential solutions.


**Objective:** This study explored everyday communication challenges as perceived by PWA as well as how PWA cope with these challenges.

**Methods:** Twenty-one participants with mild or moderate aphasia participated in semi-structured interviews following their participation in a larger experimental project. These interviews asked for descriptions and examples of communication experiences from their everyday life that mirrored the situations they experienced during the experiment (i.e., retelling stories to communication partners while completing a concurrent tone discrimination task). These interviews were recorded and coded using thematic analysis.

**Results:** This study found relationships, environmental distractions, and coping to be major themes from the interviews. Participants who complained about the impact of environmental distractions specifically mentioned background noise and said that such
noise makes it difficult for them to focus on communication or other language tasks (like reading). One participant said that background noise caused him to become “discouraged from saying anything” and another participant said that she needs it “absolutely quiet [to] concentrate.”

Conclusions: This study concluded that everyday communication is challenging for PWA when they are not supported by communication partners, are exposed to background noise, or are performing a concurrent task. Although many PWA implement coping mechanisms involving their thoughts, attitudes, and beliefs, the author concluded that additional research is needed to understand how cognitive strategies in aphasia therapy can improve generalization and social participation of PWA.

Relevance to the current work: This study adds to the few articles available that site background noise as a barrier to successful communication for PWA.


Objective: This study sought to examine the effects of dual-tasks on content accuracy, delivery speed, and perceived effort of PWA while completing a narrative discourse. This study also examined PWA’s reactions to retelling a story while completing another task.

Methods: In the first part of this study, participants with mild to moderate aphasia as well as age- and gender-matched controls retold stories while discriminating between high and low tones. The participants’ accuracy, speech, and perceived effort were
measured. In the second portion of this study, participants participated in a semi-structured interview about their retell experience. These interviews were then transcribed and qualitatively analyzed.

Results: This study found that the dual-task interfered more with the language of PWA than it did with the language of the controls. Participants with mild aphasia slowed their speech and did not experience declines in other measures while participants with moderate aphasia maintained their speech rate and experienced declines in their accuracy. PWA expressed more negative reactions to the dual-task condition than controls.

Conclusions: This study concluded that communicating in a dual-task condition is more challenging for PWA than neurotypical controls, but that there seems to be differences in the effects on people with various severities of aphasia.

Relevance to the current work: This study presents quantitative measures of the language of PWA under a dual-task condition alongside PWA’s qualitative perception of the task. The current study seeks to build on a conglomerate of qualitative studies that suggest that speaking in a focused-attention condition (i.e., in the presence of background noise) is similarly difficult for PWA. In addition, the current study will collect qualitative data during the same session that PWA complete a semi-structured interview about their experience, similar to this study.


Objective: This paper presented two models of attention that could more completely explain the underlying deficits in aphasia. The authors state that these models
are important alternatives to consider because, "a consequence of assuming that the relevant linguistic units are permanently deleted or made permanently unavailable is that treatment is then directed toward the restoration of those units with the intent of replacing the lost components."

**Methods:** This article did not present information from a single study, but instead explained how multiple theories might interact to explain the attention and dual-task performance of PWA.

**Results:** One of the studies cited in this article says that neurologically intact people can be made to perform similarly to PWA when challenged linguistically and neurologically. This study combined degradation of auditory stimuli with concurrent noise and showed a negative impact on semantic and grammatical comprehension.

**Conclusions:** The study concluded that while multiple theories might explain the deficits seen in PWA, such impaired processes should be treated in the context of the linguistic operations in which they function. In other words, linguistic and communicative behaviors should always be the target of treatment.

**Relevance to the current work:** While more recent research has negated such a strong cause-effect relationship, attention deficits do seem to be a major underlying contributor to language difficulties. This is an important theoretical possibility to draw on for the current work as PWA are asked to perform under conditions that require selective attention. This article is also relevant to the current work because it argues that language deficits should always be described and targeted in treatment; the current work seeks to provide quantitative support for a speaking situation repeatedly reported to be difficult for PWA.
Objective: This study sought to determine whether or not people with mild anomia have impaired performance on tasks which require automatic processing, controlled processing, and/or selective attention compared to neurotypical controls.

Methods: Fourteen participants with mild anomia and nine controls completed the Covert Orienting of Visuospatial Attention Test (COVAT) alone and with linguistic interference at two interstimulus intervals which represented automatic and controlled processing.

Results: Participants with mild anomia showed significantly slower responses on the COVAT alone during automatic processing but did not different significantly with controlled processing. In addition, participants with mild anomia showed significantly delayed response times with both automatic and controlled processing when linguistic interference compared to control participants.

Conclusions: The study concluded that participants with anomia demonstrated the most impairments when linguistic interference was present, indicating deficits in automatic processing and selective attention. The study also concluded that non-linguistic cognitive abilities in individuals reporting anomia but who score normal or near-normal limits on language assessments should be evaluated.

Relevance to the current work: The current work examines linguistic abilities of PWA in attention-demanding environments. This study supports the hypothesis that
background noise containing linguistic interference will cause decreased performance in PWA compared to background noise without linguistic interference.


Objective: This study sought to build on a previous validation study by comparing the QVSFS with the stroke status of participants as determined by their neurological history and by testing the QVSFS in a population with higher prevalence of stroke than in the previous study.

Methods: The QVSFS was administered to outpatients of Veterans Administration medical clinics. Subjects were defined as negative if their answers to all eight questions were negative and were defined as positive if they answered any single question as “yes”. Then, neurologists who were blind to the QVSFS scores interviewed each participant to determine stroke-free status. Results between the test scores and the neurologists’ determination were compared.

Results: The negative predictive value of the QVSFS was 0.96 and the positive predictive value was 0.71. 14.2% of all participants required clarification of at least one question.

Conclusions: The authors concluded that the QVSFS is highly accurate at identifying stroke-free individuals, even in a population with a large proportion of prior stroke or TIA.
Relevance to the current work: The current study will use the QVSFS to verify that control participants have no history of neurological damage. A research assistant will be available to clarify any questions when necessary.


https://doi.org/10.1080/02687039108248556

**Objective:** This study sought to (a) examine the nature and extent of auditory vigilance deficits in PWA and to (b) investigate the effect of a divided attention, dual-task paradigm on PWA’s auditory vigilance performance.

**Methods:** Six male participants with aphasia and six gender and age-matched controls completed the experiment tasks. First, each participant was asked to listen to an auditory tape of 500 words and identify a specific word that randomly appeared fifty times throughout the sample. Then, the participants were asked to complete this same task while simultaneously completing a card sorting task.

**Results:** Under the first condition, the participants with aphasia performed nearly the same as the control group. However, their performance deteriorated significantly under the divided-attention condition while the control participants’ performance remained nearly the same.

**Conclusions:** The authors concluded that a combination of processing deficits and linguistic deficits may explain the nature of aphasia and possibly provide an explanation concerning the variability characteristic of aphasic performance.

Relevance to the current work: This is one of the few studies done outside of Murray’s lab on people with aphasia and divided attention. It supports Murray’s
conclusions and provides evidence for an attentional component inherent to aphasia. The current work seeks to expand on this line of research by examining a functional application of another attention type.


**Objective:** This study attempted to provide an overview of healthy adults’ linguistic abilities as well as how these abilities change across the lifespan.

**Methods:** Sixty-nine healthy Italian adult speakers provided three language samples based off a picture stimulus and two cartoon stimuli. These language samples were then analyzed for micro linguistic, macro linguistic, and informative aspects according to strict procedures established by the research team.

**Results:** The study found age-related differences with semantic paraphasias, paragrammatisms, syntactic complexity, degree of local and global coherence, local coherence errors, and in the level of informativeness. The study also showed significant effects with a drop in performance in the oldest group and several effects suggesting a gradual decrease in performance across age groups. Story-type (single picture vs. comic strips) had a significant impact on some measures.

**Conclusions:** The study concluded that an age-induced morpho-syntactic weakening is likely supported by the cooccurring decline in the measure of syntactic complexity. In addition, the study concluded that global and local coherence might also by impacted by language and that stimulus type is important to consider when eliciting language samples from adults.
Relevance to the current work: The current study will closely follow the strict procedures outlined in this study to analyze the language samples collected. This study is also relevant because it establishes linguistic differences across the lifespan, supporting the current study’s design which will recruit age-matched controls for comparison to the PWA group.


**Objective:** This study compared the effect of focused and divided conditions among groups of PWA, right hemisphere brain damage, and no brain damage on word-finding abilities.

**Methods:** Fourteen PWA, eight subjects with right hemisphere brain damage, and nine control subjects were asked to perform a phrase completion task alone and in competition with a secondary, tone discrimination task. Responses were than transcribed and analyzed for five types of errors: auditory perceptual errors, semantic errors, phonemic errors, irrelevant responses, and no responses.

**Results:** During the isolation condition, there were no significant differences between the accuracy of the three participant groups. However, the no brain damage group achieved significantly higher accuracy scores than the PWA group in the focused and divided attention conditions and the right hemisphere brain damage group in the divided attention condition. The PWA group performed the tone-discrimination task more accurately during the isolation condition than during the focused or divided attention conditions. In contrast, the right hemisphere brain damage group’s performance
did not differ significantly as a function of listening condition. Only aphasic subjects demonstrated a significant effect of phrase type, responding more accurately when completing constrained versus unconstrained stimuli.

**Conclusions:** The study concluded that increased attentional demands may negatively affect the word retrieval abilities of mildly aphasic adults. The study also concluded that clinicians must consider the extralinguistic demands of tasks used to assess and remediate the word retrieval problems of the aphasic clients because overly simplistic tasks may overestimate the abilities of these individuals in more demanding situations, such as the noise involved in a restaurant environment.

**Relevance to the current work:** The background information for this article provided a strong theoretical framework for the impact of resource limitations in performance on demanding tasks. This is also one of the few studies related to the speech and language performance of PWA under demanding conditions that described the type of errors as opposed to simply the number of errors. The current work will follow a similar description as to the types of errors noted. The current work will also require PWA to participate in a task that used relatively unconstrained stimuli.


**Objective:** This study built on Murray’s previous work and examined the relationship between cognition and aphasia, with a focus on attention. It hypothesized that PWA would display variable deficit patterns on tests of attention and that their attention deficits would be related to their language and communication status.
Methods: A group of individuals with varying types and severities of aphasia and a group of age- and education-matched adults with no brain damage completed tests of attention, short-term and working memory, and executive functioning.

Results: Overall, the PWA group performed significantly more poorly than the control group on the cognitive measures but displayed variability in severity and types of attention deficits. Further analysis showed significant correlations between the participants’ language abilities and attention deficits. The aphasia group also showed more significantly impaired performance on complex attention skills than basic attention skills (such as sustained attention).

Conclusions: The study concluded that most, but not all, individuals with aphasia display attention and cognitive deficits. It also concluded that the profile of attention deficits will look different in each individual with aphasia but that significant correlations exist between attention, cognition, and language.

Relevance to the current work: This study highlighted the intra-group variability in performance among PWA. However, it also concluded that as a group, basic attention (i.e., sustained attention) seems to be a relative strength compared to complex attention (i.e., selective, alternating, and divided). The current work seeks to quantify the impact of a type of selective attention (i.e., speaking under noisy conditions) on language abilities.

Objective: This study was another article in Murray’s line of work in examining the sentence processing deficits in acquired aphasia. The ultimate goal of this line of
research is to determine whether a specific approach to language deficits is preferable to a generalized language therapy approach.

Methods: 23 adults with aphasia and 26 education- and aged-matched adults with no brain injury participated in formal cognitive-linguistic tests as well as a sentence judgement task performed alone and in focused attention and divided attention conditions.

Results: Results indicated that regardless of task or condition, the control group performed significantly better than the PWA group. The PWA performed best in the isolation condition and in fact achieved near perfect scores in this condition. However, their performance significantly declined under both focused and divided attention conditions.

Conclusions: The author concluded that the results of this study were consistent with resource models of aphasia and supported the need to acknowledge the strength and nature of interactions between linguistic and extra-linguistic cognitive processes.

Relevance to the current work: This study demonstrated comprehension deficits in PWA in complex listening situations. The current work seeks to explore the impact of complex auditory conditions on the linguistic production of PWA but we expect similar results.

Objective: This study examined the spoken language of individuals with mild aphasia and age-matched control subjects under conditions of isolation, focused attention, and divided attention.

Methods: Eight control participants and 14 PWA completed a picture-description task was completed alone and concurrently with tone-discrimination task. The responses of all participants were transcribed and coded for errors.

Results: PWA performed more poorly on most morphosyntactic, lexical, and pragmatic measures of language than the control group regardless of condition. Increasing the complexity of the condition significantly impacted the language outcomes of the PWA group while resulting in little to no change in the language measures of the control group. PWA showed evidence of dual-task interference through fewer syntactically complete and complex utterances, fewer words, and poorer word-fluency accuracy.

Conclusions: The study concluded that impaired attentional capacity may negatively impact the quantity and quality of spoken language of individuals with mild aphasia. The researchers also concluded that picture-description may have elicited more labeling behaviors, which may have limited the nature of the participants’ responses; they suggested that future studies should include conversational or story-retell tasks.

Relevance to the current work: Although this study focused on a different type of attention in PWA than the current work, it was one of the first works to document the type of errors PWA exhibit when the attention demands of a task exceed their resources. The current work will expand on this article to more extensively document the types of
errors exhibited by PWA as well as examine selective attention as opposed to isolated, focused, or divided attention.


**Objective:** This article describes language-specific attention treatment as a feasible treatment option for those with a moderate degree of attention impairment. In explaining the theoretical basis for this treatment option, the authors explain, "language is not merely an outcome of our attending to the environment. The allocation of cognition resources to language-specific operations is intrinsic to the interpretation and formulation of language." After describing the rationale for the treatment approach, the study describes the outcomes of four people exposed to the program.

**Methods:** Four participants were administered a battery of standardized measures of attention and language. The participants subsequently participated in language-specific attention treatment and then participated in another battery of language assessment.

**Results:** The treatment effects observed among the participants were highly variable. Three of the participants showed treatment effects for 50-75% of the language-specific attention treatment tasks while the fourth participant showed a treatment effect for only 25% of the tasks.

**Conclusions:** The researchers concluded that language-specific attention treatment could be an alternative treatment approach for patients with no worse than moderate aphasia. It also concluded that, “successful cognitive training programs engage
participants in complex ecological activities requiring simultaneous mastery of skills while encouraging social interactions.”

Relevance to the current work: This study proposes a therapy approach that incorporates known principles of attention into therapy that is centered on language and conversational skills. The current work seeks to quantify a common element of real-life conversational settings (i.e., noise) which place additional demands on PWA’s attention capacities.


Objective: This article outlined the results of a study involving interviews of PWA who had regained a “useful” level of speech and were able to discuss their perception of events in the hospital and therapy following their stroke.

Methods: Fifty PWA who had recovered a “useful” level of speech participated in individual interviews composed of structured questions and open-ended questions. All participants were originally classified as “severely impaired” upon admission to the hospital. From these interviews, 12 common themes were identified and described in the article.

Results: The twelve common themes identified from the interviews were: ability to comprehend, speed of input, amount of input, length of response time, perception of cues, level of evaluation tests, destructiveness of noise, influx of personnel, need for information, respect for personhood, and responsiveness to needs.
Conclusions: The article concluded that PWA can continue to make improvements for years after their initial injury. Furthermore, the article argued that nurses are in a position to advocate for PWA.

Relevance to the current work: This article has been cited in other literature as one of the first to cite the challenge noise poses to PWA. Although speech in noise was not specifically mentioned, several participants complained about the high levels of noise in hospitals and suggested they were more sensitive to noise post-stroke. This provides further support to the current work’s hypothesis that background noise will have a greater negative impact on PWA’s speech than typical speakers.


Objective: This study aimed to explore how PWA process speech in complex acoustic environments through identifying the influence of acquired aphasia on a speech processing task under masked listening conditions by systematically examining the effects of different types of masking. In particular, this study aimed to differentiate between the effects of energetic masking and informational masking on PWA’s speech processing.

Methods: Twelve PWA and twelve age-matched healthy controls participated in a closed-set, forced choice speech identification paradigm that was specifically adapted for use with PWA. This task involves the presentation of an auditory presentation of target stimuli followed by the presentation of a corresponding set of pictures. At this point, the participant would select the target words they had heard. Participants were required to
demonstrate ceiling-level performance on the task in quiet before beginning the full set of conditions.

Results: PWA showed poorer performance when exposed to informational masking than the healthy age-matched control group. The results of the study could not be attributed to age, hearing loss, or comprehension deficits.

Conclusions: The researchers concluded that the deficits seen in PWA under the condition of information masking were the consequences of acquired cognitive linguistic impairments associated with aphasia. The results of this study suggested that aphasia may result in difficulty separating target speech from masker speech, which may result in difficulties comprehending target speech in multitalker environments.

Relevance to the current work: While this study aimed to quantify the performance of PWA in a selective attention task through their listening and processing of information with background noise, the current work seeks to quantify the performance of PWA under a sustained attention task through their retelling of information with background noise. Thus, the current work builds on the findings of this study and could assist in identifying the extent of the breakdown experienced by PWA in noisy environments.


Objective: This study examined the impact of task complexity on reaction time during a non-linguistic attention task in PWA and controls. This study also examined the
effect of task complexity on intra-individual variability in reaction time as well as inter-individual differences in between session intra-individual variability.

Methods: Eighteen PWA and five age-matched controls completed a computerized non-linguistic attention task measuring five types of attention on four non-consecutive days.

Results: Task complexity significantly impacted the response time of both PWA as well as the controls. However, only the PWA group showed a significant difference in between session intra-individual variability. The study also found different patterns in intra-individual variability.

Conclusions: The study concluded that increased complexity in tasks might result in higher session-to-session variability among PWA.

Relevance to the current work: This study found domain-generic deficits in attention, supporting other literature that states linguistic deficits in PWA may be partially due to or amplified by domain-generic attention deficits. This has important theoretical implications for the current work, which seeks to quantify and characterize the impact of background noise on language.


Objective: This article reviewed the current understanding of attention in aphasia and proposed a model for understanding how attention may influence language in those with aphasia.

Methods: The authors discussed both the domain-generality of attention and the existence of multiple types of attention. They then discussed the connection between
attention and language in aphasia as well as a principle they termed intraindividual variability.

Results: This was a theoretical article and did not give the results of a specific study.

Conclusions: Based on the work of studies reviewed in the article, the authors concluded that sustained attention appears to be a relative strength in PWA (when compared to divided attention). The article states, “PWA’s vigilance was significantly lower than that of controls on both conditions…vigilance did not differ between the linguistic and nonlinguistic conditions…as long as demands on the attention system are relatively low, PWA perform similarly regardless of the presence or absence of language processing demands.”

Relevance to the current work: Despite being cited as a barrier for societal reintegration for PWA, sustained attention in this population may not be sufficiently researched due to evidence that sustained attention is actually a relative strength for PWA. The current work will build on this article by acknowledging that while sustained attention might be a relative strength for PWA, it still warrants attention in research and clinical fields. Furthermore, if sustained attention is indeed a relative strength for PWA, further strengthening language skills under conditions of sustained attention might allow PWA to compensate for other areas of relative weakness (such as divided attention). The current work will aim to design sustained attention tasks that while feasible for PWA to complete, will be sufficiently difficult to determine if there is a significant impact of sustained attention on the language of PWA.

**Objective:** This article describes the Quick Aphasia Battery (QAB), which is a standardized assessment designed to assess language function in PWA in about 15 minutes. The article aims to establish the QAB as a reliable, quicker alternative to tests such as the Western Aphasia Battery (WAB) to evaluating language profiles of PWA.

**Methods:** The QAB was administered to 28 people with acute stroke and aphasia, 25 people with acute stroke but no aphasia, 16 people with chronic post-stroke aphasia, and 14 healthy controls. Those with chronic post-stroke aphasia were tested on three separate occasions and their tests were scored with by two raters to establish test-retest and inter-rater reliability. The WAB was also administered to the chronic post-stroke participants to assess concurrent validity.

**Results:** All of the QAB summary measures were sensitive to aphasic deficits. All measures had good test-retest reliability and inter-rater reliability. Sensitivity of diagnosis of aphasia was 0.91 and specificity of diagnosis of aphasia was 0.95. All of the measures were highly correlated with the corresponding WAB measures.

**Conclusions:** The researchers concluded that the QAB “efficiently and reliably” characterized individual profiles of language deficits.

**Relevance to the current work:** Due to the large amount of information that will be collected in the current study, data-collection sessions will be long. The QAB will be used to characterize the language profiles of PWA participants in a relatively short amount of time.
Consent Form for People With Aphasia

Consent to be a Research Subject

Introduction

This longitudinal research study is being conducted by Tyson Harmon, Ph.D., CCC-SLP and Dr. Christopher Dromey, Ph.D., CCC-SLP at Brigham Young University. The purposes of this study are to (1) determine the impact of background noise conditions on spoken language and (2) learn about the communication experiences of people recovering language after a stroke or brain injury from their own perspective. You were invited to participate because you had a stroke or other brain injury that affected your communication.

Procedures

Your participation in this study will involve a single evaluation session lasting 1.5 to 2 hours.

During this session, you will be asked to complete a number of tests, retell stories in background noise conditions, and respond to some questionnaire and interview questions.

The tests, questionnaires, and interview will involve:

<table>
<thead>
<tr>
<th>Speech, Language, and Attention Tests</th>
<th>Story Retell Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naming pictures and objects</td>
<td>Listening to and retelling short stories</td>
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<tr>
<td>Repeating words and phrases</td>
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<tr>
<td>Answering questions</td>
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<td>Following directions</td>
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<tr>
<td>Describing pictures</td>
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<tr>
<td>Looking for symbols and listening for tones</td>
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</tbody>
</table>
Several of these tests, questionnaires, and a brief interview will be audio or video recorded to check scores and complete more detailed analysis after the session. The session will be held on BYU campus (John Taylor Building room 110).

As noted above, audio and video recordings will be obtained throughout the evaluation session.

Please indicate what uses of these recordings you are willing to permit, by initialing next to the uses you agree to and signing at the end. This choice is completely up to you.

____ Yes       ____ No Audio and/or video recordings can be studied by the research team for use in the research project.

____ Yes       ____ No Short excerpts of audio and/or video recordings can be used for scientific publications, conferences, or meetings.

____ Yes       ____ No Short excerpts of audio and/or video recordings can be shown in university classes.

Risks/Discomforts

Risks associated with this study are minimal. Because some of the test items may be difficult, you may become anxious or embarrassed. You might also become tired or frustrated. We will make every effort to be sure you are as comfortable as possible during the testing. You can take a break or discontinue your participation at any time. If the session is too long, the length and number of sessions can be changed according to your needs.

Benefits

Since this is not a treatment study, there is likely no direct benefit to you. However, your participation in this study will provide us with information that might generally improve
assessment and treatment of people with communication impairments following stroke or brain injury.

**Confidentiality**

All data collected for the purposes of this study will be kept confidential and will only be reported without personally identifiable information.

You will be given a number that will identify you for this study. All data obtained from you will be associated with this number instead of your personally identifiable information. Any paper forms or test protocols will be kept in locked cabinets in a locked research lab at BYU. Any electronic forms or files (e.g., audio files) will be kept on a secured, password protected server. Only those directly involved with the research will have access to these data.

**Compensation**

You will receive $15.00 cash after completing the session.

**Participation**

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely. You do not have to be in this study to receive clinical services through the BYU Speech and Language Clinic. Choosing to not participate will not jeopardize your services at BYU or any other healthcare service you receive.

**Questions about the Research**

If you have questions regarding this study, you may contact Tyson Harmon, Ph.D., CCC-SLP by phone at 801-422-1251 or email at tyson_harmon@byu.edu.

**Questions about Your Rights as Research Participants**

If you have questions regarding your rights as a research participant contact IRB Administrator at (801) 422-1461; A-285 ASB, Brigham Young University, Provo, UT 84602; irb@byu.edu.
Statement of Consent

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

Name (Printed):                                    Signature:                                    Date:

___________________                                    ______________________                  ___________
APPENDIX C

Consent Form for Control Participants

Consent to be a Research Subject

Introduction
This research study is being conducted by Tyson Harmon, Ph.D., CCC-SLP and Dr. Christopher Dromey, Ph.D., CCC-SLP at Brigham Young University. The purposes of this study are to (1) determine the impact of background noise conditions on spoken language and (2) learn about the communication experiences of people recovering language after a stroke or brain injury from their own perspective. You were invited to participate in this study as a pilot or control participant.

Procedures
Your participation in this study will involve a single session lasting 1.5 to 2 hours. During the session, you will be asked to complete an attention test. You will also complete a questionnaire intended to verify that you have not experienced a stroke or other neurological damage.

During the experimental task, you will listen to a variety of short stories and retell them in background noise conditions. You will also answer questionnaire and interview questions about your experiences retelling these stories. This session will be held on BYU campus (John Taylor Building room 110).

Audio/video Recordings
During the session audio and video recordings will be obtained so that we can complete more detailed analysis after the session. Please indicate what uses of these recordings you are willing to permit, by initialing next to the uses you agree to and signing at the end. This choice is completely up to you. We will only use the recordings in the ways that you agree to. In any use of the audio/video, you will not be identified by name.

_____ Audio and video recordings can be studied by the research team for use in the research project.

_____ Short excerpts of audio and/or video recordings can be used for scientific publications, conferences, or meetings.

_____ Short excerpts of audio and/or video recordings can be used in university classes.
**Risks/Discomforts**
Risks associated with this study are minimal. Because some of the tasks may be difficult, you may become anxious or embarrassed. You might also become tired or frustrated. We will make every effort to be sure you are as comfortable as possible during the testing. You can take a break or discontinue your participation at any time. If the session is too long, the length and number of sessions can be changed according to your needs.

**Benefits**
Although there will likely be no direct benefit to you for participating in this study, your participation will provide us with information that might generally improve assessment and treatment of people with aphasia.

**Confidentiality**
All data collected for the purposes of this study will be kept confidential and will only be reported without personally identifiable information. Any personally identifiable information will be stored separate from research data in a locked cabinet in the researcher’s office.

You will be given a number that will identify you for this study. All data obtained from you will be associated with this number instead of your personally identifiable information. Any paper forms or test protocols will be kept in locked cabinets in a locked research lab at BYU. Any electronic forms or files (e.g., audio files) will be kept on a secured, password protected server. Only those directly involved with the research will have access to these data.

**Compensation**
You will receive $15.00 cash after completing the session.

**Participation**
Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely.

**Questions about the Research**
If you have questions regarding this study, you may contact Tyson Harmon, Ph.D., CCC-SLP by phone at 801-422-1251 or email at tyson_harmon@byu.edu.

**Questions about Your Rights as Research Participants**
If you have questions regarding your rights as a research participant contact IRB Administrator at (801) 422-1461; A-285 ASB, Brigham Young University, Provo, UT 84602; irb@byu.edu.
Statement of Consent

I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

Name (Printed):                                                Signature:                                                          Date:

_________________________                                     ________________________                                    ____________
APPENDIX D

Training Protocol for Codes for Human Analysis of Transcripts (CHAT) System

Phonological Analysis:

False Starts: [&)]

- When the word is not finished (the word is left unfinished). Note: Listening to the audio files with headphone/earbuds helps with hearing false starts that aren’t heard using the computer speaker.
  - Example: I &wa want to the store.

Phonological Paraphasias: [* p]

- The substitution of a word with another word or non-word that preserves at least half of the segments and/or number of syllables of the intended word
  - Example: The mice wanted to <heat> [* p]
  - Note: do not code common colloquial versions of a word (ex: ‘gonna’ for ‘going to’, ‘cause’ for ‘because’)

Neologisms: [* n]

- A substitution of a word for a gibberish word
  - Example: she had all her gæstidʒɪz@u [* n] ← (add @u to error)

Lexical Analysis:

Lexical Fillers: [* fil]

- When a word or phrase adds no meaning to the story.
  - Example: <well> [* fil] the mouse family decided to go on a picnic
  - Example: the mouse ran <I think> [* fil] into the forest *
  - Example: <It look like>[* fil] the mouse is running into the forest.
    - *Note: Do not count “I think/I believe/I feel etc for expository discourse (DrivingLang, NoiseLang)

Repetitions [/]

- When a word or phrase is repeated
  - Example: He felt a <little> [/] little scared
  - Example: <He felt> [/] he felt a little scared
  - Note: do not code repetitions if the participant is using repetition as a rhetorical device and you can tell they meant to do it, such as the house was really really big when describing a massive house. Often the person who transcribes the discourse will
go ahead and mark these as repetitions so be on the lookout for this and change if necessary. (ex: he ran and he ran and he ran all the way down the tunnel)

Rephrase/Revision [//]

- When a sentence or phrase is rephrased or restructured.
  - This could be syntactic-Example: <he felt a little> [//] the boy feels scared
  - It could also be semantic-Example: a family of <rats no> [//] mice.
  - Note- the person who does the transcription will often go ahead and put the rephrasals in as they transcribe but sometimes they don’t so if something looks like it needs to be a rephrasal to make sense, go ahead and code it.

Semantic Paraphasias [* s:r]

- The substitution of a word on the basis of a meaning between the two words
  - Example: The mice got into the <van> [: truck] [* s:r]
  - Also, in story retell tasks, we have been coding incorrect names as a semantic paraphasia. <Bob> [* s:r] went to the baseball game. (instead of George)
  - Note: sometimes there can be a question of whether a misused word should count as a semantic paraphasia or a semantically anomalous utterance. If you feel that the participant simply used the wrong word but understands what’s going on in the story, code it as a semantic paraphasia. If you think the participant has misinterpreted what’s going on in the story, code it as semantically anomalous (ex: the many people who think that the dog in ‘flowerpot’ is an elephant)

Passe-partout words [* ppw]

- The substitution of a word for a general referent (something, someone, somehow)
  - Example: There is <something> [* ppw] on the table. (Couldn’t remember word for book potentially, just depends on context.)
  - We won’t use this code every time we see something, someone, or somehow. This code is used when there is a clear substitution of the more specific referent.

Grammatical and Morpho-syntactical Analysis:

Substitution of Function Words (Closed Class Words) [* f]

- When a function word is changed for another function word. (e.g., he, she, it, in, on, the, a, etc.)
- This includes the incorrect use of pronouns, which is common in the aphasia files.
  - Example: I went <on> [* f] the circus. (should’ve said to)
  - Example: <He> [* f] talked to the manager. (when talking about a woman)

**Substitution of bound Morphemes: [* m]**

- Typically the incorrect tense or plurality. Basically, any grammatical error will be coded as [* m]
  - Example: They will <eats> [* m] the sandwiches and cupcakes.
  - Example: The <mice> [* m] fell out of the truck.
  - Example: They had a <trucks> [* m]

**Omission of Function Words (Closed Class Words) [* ofw]**

- The missing of a closed class word (e.g., he, she, it, in, on, the, a, etc.)
  - Example: [* ofw] cat ran down [* ofw] hallway

**Content Omission [* oc]**

- The missing of any content.
- If the person ends a sentence or phrase after the verb, we code it as an aposiopesis and content omission
  - Example: [* oc] ran into the attic. ← We need to know what ran into the attic
  - Example: I hate +… [* ap][* oc]. ← We need to know what they hate

**Marco-Linguistic Analysis:**

**Wrong use of Cohesive Markers [* cm]**

- Cohesive markers are linking words/phrases that signal the relationship between sentences.
  - Example: using ‘all of a sudden’ when it doesn’t make sense to do so.
  - Example: <so therefore>[* cm] just because the bible and that might go back to separation between church and state may . . .
  - Example: the little baby mouse holds his little toy very tightly so that he doesn’t <at least>[* cm] lose him too
- Anaphoric References between utterances
  - Example: They were fighting. / So <he>[* mr][* cm] hit <him>[* mr][* cm].
- Misuse of number and gender agreement between pronouns or noun phrases across utterances
  - Example: The family didn’t care about mouse. / <It>[* mr][* cm] was too busy with the picnic. ← It refers to the family, so this is a disagreement in number.
Aposiopesis [* ap]

- The leaving of a thought incomplete; a sudden breaking off in a sentence
  - Example: I [* ap] +//.
  - Example: I want [* ap] [* oc] +…

Ambiguous Referent (existing words) [* mr]

- When the listener cannot tell what ‘he’/’she’/’it’ refers to
  - *note- we are not overly strict about this. If the participant uses ‘he’ without specifically telling us who ‘he’ is, we don’t code it as long as we can reasonably tell who it refers to by looking at the book’s pictures.
  - Do code in cases where you’re not sure who the pronoun refers to even after looking at the pictures. (Ex: He jumps on the bed and plays with the mother’s jewelry. We can’t tell who is doing this since Carl and the baby are both jumping and playing).
  - If the participant gives the character’s name but then changes the names throughout the story, this is also an ambiguous referent.

Missing Referent (omission) [* mro]

- When there is a missing referent
  - Example: *SUB: an(d) the truck keeps going [* mro] doesn't even know that she has fallen off.

Filler Utterances [* uf]

- When a filler extends to the whole utterance. Often this will be cases of the participant giving their own commentary on the story.
  - Example: <What a beautiful day the mice are having> [* uf].
  - <This story is really confusing> [* uf].
  - <I don’t know> [* uf].

- Note: do not code the following as fillers:
  - Introductory statements (ex: This book is called Picnic) or closing statements (ex: The end)
  - Questions that the participant asks before beginning the story/answering the expository question
Repetitions of Utterances [* s:per]

- When an utterance is repeated
  - Example: *I ran into the tree* [* s:per]. I ran into the tree.
  - If a participant says essentially the same thing twice, you can still code it as a repetition even if the wording is not exactly the same and even if the utterances do not occur back-to-back. These do get a little tricky in terms of knowing which utterance to code (first or second). Usually for repeated utterances, we code the first utterance and keep the second. But if the utterances are separated, it is usually best to code the second utterance. For example:
    - I went there yesterday. It was nice. *I went there yesterday* [* s:per].

Conceptually Incongruent Utterances [* exc]

- When an utterance or phrase does not make sense within the context of the story.
  - Example: *the mice abandoned the baby because they deeply hated her face.* [* exc]
  - For the expository, [* exc] codes don’t happen often but if a participant says something that is incompatible with his own argument, code it as [* exc].
    - Example- SUB: *I think healthcare is a right* [* exc]
      SUB: but if people can’t afford healthcare, they shouldn’t get to have it.

Par: The woman goes to *either take the book back or to buy it* [* exc].

- Sometimes a participant will say something incorrect but then go back and correct it. If this occurs in the same c-unit, code as a rephrasal. If it occurs across c units, code the incorrect parts as [* exc] and leave the correct parts alone.
  - Example- SUB: *she making the pancakes* [* exc]
SUB: <nevermind> [* fil] Shes thinking about making the pancakes

Tangential Utterances [* tu]

- A phrase or utterance that is off-topic/doesn’t relate to the stimulus.
  - Example: The mouse went to the store. <I need bread for my dinner party on Friday>[* tu].
  - <I’m sorry> [* tu] is also a common example.
  - For expository, code as tangential if the participant is giving information that doesn’t answer the question (Ex: someone who tells you all about their last doctor visit without linking it to the question of whether healthcare is a right or privilege).
APPENDIX E

Sample Person With Aphasia (PWA) Computerized Language Analysis (CLAN) File

This is a substitution of a bound morpheme error because the word "go" is used in the incorrect tense.

This is an example of a repetition, since "Neal is" is said again after the filler, "um".

This is an example of a revision because the speaker goes on to restructure their thought.

The speaker exhibited several phonological paraphasias as they tried to produce their target word.

An abandoned utterance was coded as an apophasia as well as missing content.

The speaker substituted the word "new" for the word "old", which is a semantic paraphasia.