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An Exploratory Study of Behavioral Engagement in People With and Without Aphasia: Comparisons and Relationships

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A thesis submitted to the faculty of
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Master of Science

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ABSTRACT

An Exploratory Study of Behavioral Engagement in People With and Without Aphasia: Comparisons and Relationships

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Previous research suggests that attentional deficits could be the underlying cause of language impairments in people with aphasia (PWA) and that behavioral engagement ratings can be an accurate way to measure attention to specific tasks. Previous research also suggests that PWA have lower levels of behavioral engagement than neurologically healthy adults. Participants in the present study included 9 PWA and 18 neurologically healthy adults. This was an exploratory study investigating the relationships and differences between behavioral engagement and physiological measures, perceived arousal, and naming accuracy and response time in PWA and neurologically healthy adults. Participants completed a confrontational naming task while physiological measures (heart rate, heart rate variability, and skin conductance) were taken simultaneously. Subsequent video footage was used to rate participants' behavioral engagement (i.e., how engaged the participant was in the naming task). In general, PWA had lower behavioral engagement ratings of attention than neurotypical adults. Significant correlations were found between behavioral engagement ratings of attention, naming response time, and naming accuracy. No statistical significance was found between behavioral engagement ratings of attention and heart rate, heart rate variability, and skin conductance. Further research is needed to support these findings.

Keywords: aphasia, behavioral engagement, attention, physiological arousal, heart rate variability, skin conductance

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DESCRIPTION OF THESIS STRUCTURE AND CONTENT

This thesis, *An Exploratory Study of Behavioral Engagement in People With and Without Aphasia: Comparisons and Relationships*, is part of a larger project analyzing the effect of emotion on confrontational naming in people with aphasia. Portions of this thesis may be submitted for publication, with the thesis author being included in the list of contributing coauthors. The annotated bibliography is included in Appendix A, Institutional and Review Board approved consent forms used in the study are provided in Appendix B, and a list of stimuli used for confrontational naming task is provided in Appendix C.

Introduction

Aphasia is an acquired neurogenic language disorder that is associated with damage to the left hemisphere of the brain. It causes multi-modal deficits, which may involve impaired oral language production, writing, reading, and auditory comprehension (Berthier, 2005). Although aphasia is defined by difficulties with language, people with aphasia (PWA) commonly show deficits in other areas, including attention (Hunting-Pompon et al., 2011; Laures et al., 2003). Attention in PWA has traditionally been measured through various physiological measures, including electrocardiography (ECG) and skin conductance, although standardized behavioral tests have also been used. The present study investigated how PWA are affected by impaired attention and the idea that behavioral engagement measures may be more appropriate for measuring attention during a language task than physiological measures. This was done by comparing behavioral engagement ratings of attention to ECG and skin conductance measures of attention during a confrontational naming task.

Attention in Aphasia

Attention can be defined as "focused activation of the cerebral cortex that enhances information processing" (Oken et al., 2006, p. 1886). Attention can be divided into different types, including focused attention, sustained attention, selective attention, attention switching, and divided attention. Focused attention refers to the ability to actively focus on a stimulus without being distracted by other stimuli. Sustained attention can be defined as maintaining the ability to respond to and process a certain specific stimulus over a period of time. Selective attention can be defined as identifying and processing relevant stimuli while disregarding stimuli that are not relevant. Attention switching is the ability to shift focus back and forth between different stimuli, and divided attention refers to simultaneously focusing on and processing two or more relevant stimuli (Murray, 2012).

Attention plays a critical role in aphasia therapy because most, if not all, therapy tasks require some degree of attention to be completed. If a patient is unable to maintain attention to stimuli while performing a therapy task such as confrontational naming, then processing, encoding, and manipulation is difficult (Villard & Kiran, 2017). A number of studies that draw upon attention-specific measures indicate that PWA have impaired attention when compared with their peers with no aphasia (Erickson et al., 1996; Hunting-Pompon et al., 2011; Murray, 1999). In one study, 14 PWA and nine control participants completed the Covert Orienting of Visuospatial Attention Test (COVAT; Posner & Cohen, 1980), with PWA demonstrating significantly slower response times compared to control participants (Hunting-Pompon et al., 2011). In another study, 39 PWA and 39 control participants were given the Test of Everyday Attention (TEA; Robertson et al., 1996), with PWA performing significantly worse than control participants on all administered subtests (Murray, 2012). The results of this study indicate that PWA have deficits in all types of attention; however, PWA have particular difficulty with tasks requiring sustained, selective, and divided attention.

In relation to sustained and selective attention, Villard and Kiran (2015) administered two sustained attention tasks to 18 PWA and five control participants. In the first task, participants identified visual stimuli (a dot on a screen) by pushing certain keys on a keyboard. In the second task, participants identified auditory stimuli (a tone played in their ears). Although PWA performed worse than control participants, the difference was exacerbated further with the addition of a selective attention task wherein the visual and auditory stimuli were administered simultaneously. PWA completed the selective attention task much more slowly than the sustained attention task in every instance. These results further support the idea that PWA have impairments in attention, especially in tasks that require selective attention (Villard & Kiran, 2015).

Similar to selective attention, divided attention has been shown to lead to greater task interference for PWA than controls (Erickson et al., 1996; Murray, 2000). In a study by Erickson et al. (1996), ten PWA and ten neurologically typical adults were presented with two sets of non-linguistic stimuli. One set was presented with no distractions, while the other set was presented with distractions to test the divided attention skills of the participants. The results of this study indicated that PWA had significantly decreased performance on the divided attention task compared to control participants (Erickson et al., 1996). Murray (2000) investigated the effects of divided attention during word retrieval tasks in nine control participants with no history of brain damage and fourteen PWA. The study concluded that the group with no brain damage was significantly more accurate on naming tasks that required divided attention than the aphasia groups (Murray, 2000). These studies suggest that PWA have increased difficulty completing tasks when their attention is divided between more than one area.

Several studies have investigated the relationship between attentional and language deficits in PWA to further explore whether deficits in attention could potentially be the underlying cause of impaired language (Murray, 1999; Murray, 2012). Murray (2012) administered various cognitive tests targeting language abilities to 39 control participants and 39 PWA. These tests included the Weschler Memory Scale – Revised (Weschler, 1987) and the Ruff Figural Fluency Test (Ruff, 1996). The TEA was also administered to participants to obtain measures of attention. Results showed that PWA performed worse than control participants on the cognitive and attention tests, and that the language and communication skills of PWA were directly correlated with their attention skills (Murray, 2012).

More recently, physiological measures have been found to be a valid way to investigate and measure attentional responses in PWA (Ayres et al., 2021; Johannessen et al., 2020). Physiological measures quantify changes occurring in the body in response to different stimuli. Common physiological measures used to track attentional and neurological arousal in PWA include Electroencephalography (EEG), skin conductance, and Electrocardiography (Riley et al., 2019). EEG measures use electrodes attached to the scalp to record signals from the cerebral cortex (Liu et al., 2013). Skin conductance measures levels of attention by detecting cognitive load. This is done using electrodes placed on the plantar and palmar sides of the hand. When someone has high levels of attention, their cognitive load increases, which leads to increased sweating. Increased sweating then lowers the resistance and increases the electrical conductance of the skin (Ayres et al., 2021). Electrocardiography (ECG), which can be used to obtain measures of heart rate and heart rate variability, uses electrodes attached to the chest to record electrical activity in the heart. Electrical activity in the heart has been shown to fluctuate relative to attentional changes in individuals, which makes ECG a viable method for measuring levels of attention (Belle et al., 2012; Bai et al., 2020). Heart rate measures levels of attention by detecting cognitive load through heart rate variability (Ayres et al., 2021). Heart rate variability is the variability in the interval between heartbeats, which can be used to measure activity in the automatic nervous system (Ashaie et al., 2022). Higher heart rate variability is associated with better cognitive performance, while lower heart rate variability is associated with lower cognitive performance (Forte et al., 2019). In order to further the validity of heart rate variability measured through ECG, a recent study by Ashaie et al. (2022) investigated the test-retest reliability of these measures in PWA, with the results showing moderate test-retest reliability. Although all of these measures are beneficial because they have high accuracy and can measure real-time changes, they have some disadvantages. These disadvantages include high cost, the need for specialized equipment, and the need for someone with specific skills and training to administer the evaluations.

In addition to physiological measures, standardized behavioral tests, such as the TEA, can also be used to determine if a person with aphasia has a deficit in attention (Robertson et al., 1996). Tests like these can be beneficial, but they do have limitations. Because they approach attention and attentional abilities as stagnant rather than dynamic, they are unable to identify real-time changes in an individual's attention during task performance. Recent research has indicated that a possible alternative to using physiological and standardized behavioral measures of attention could be to rate the behavioral engagement of an individual through an observational rating system, which will be referred to as behavioral engagement (Riley & Owora, 2020).

Behavioral Engagement and Language Performance

Behavioral engagement has been used as a measure of attention in multiple populations, including typically developing children and adults with communication disorders. Behavioral engagement can be defined as observable behavioral signs that indicate the level of attention in an individual (Riley & Owora, 2020). Examples of behavioral engagement include, but are not limited to, amount of eye contact, fidgeting behaviors, and response or lack of response.

Several studies have investigated behavioral engagement ratings and have concluded that these ratings can be reliable methods to measure attention. Rezazadeh et al. (2011) investigated the relationship between measures of attention derived from cognitive tests and behavioral ratings of attention in 31 typically developing children between the ages of three and seven. This study required participants to locate a particular target among distractors and complete the Conners' Rating Scale (questionnaire asking about behavior, work, and social life to show how distractors affect personal life) to determine if the cognitive performance of the typically developing children was related to inattentive behaviors. Results indicated that the Conners' Rating Scales (specifically the Cognitive/Inattention and Hyperactivity Subtests) were able to accurately identify inattentive behaviors (Rezazadeh et al., 2011).

Similarly, Whyte et al. (1996) developed a scale for rating behavioral engagement in traumatic brain injury (TBI) patients. They investigated four participants with severe TBI that were medically stable. Each participant was required to make a collage using colored paper, sort objects into eight categories, and complete a block puzzle. The researchers observed each participant and provided cues to return to the task if they became distracted. Results concluded that a reliable method to quantify behavioral inattentiveness had been found. Similarly, Ponsford and Kinsella (1991) assessed TBI patients during various activities using a behavioral rating scale. Additionally, they compared the behavioral engagement ratings to neuropsychological measures given to the participants. These neuropsychological measures included the Stroop Color Word Test (requires individuals to view words listed in a color different than the meaning of the word and say the color the word is written in instead of reading the word), Simple (a response to a single stimulus) and Choice (distinguishing among two or more stimuli) Reaction Time, Symbol Digit Modalities Test (requires individuals to substitute digits for abstract symbols using a reference key), Letter Cancellation Task (requires individuals to locate and cross out a certain letter that appears multiple times among other letters), and Paced Auditory Serial Addition Test (requires participants to listen to a recording of numbers presented one at a time and then add the number to each one immediately preceding it). The behavioral engagement ratings and neuropsychological measures were then analyzed to examine the correlation between scores. The results of the scale were found to correlate with the neuropsychological measures. However, one problem with this study was poor inter-rater reliability, due to lack of training on how to use the behavioral rating scale. This problem, however, was solved in a later study in which raters were trained and required to achieve above 90% reliability prior to rating participants (Riley & Owora, 2020; Whyte et al., 1994). This was also the first study that we know of that applied a behavioral engagement rating scale to measurement of attention in aphasia.

Behavioral Engagement in Aphasia

Although behavioral engagement has been measured in several populations, there is only one study that we know of that measured behavioral engagement in participants with aphasia. Riley and Owora (2020) used a behavioral rating scale to investigate whether observable behavioral signs of attentiveness could measure fluctuations in attention in ten PWA and ten neurologically typical adults. They also compared behavioral engagement ratings with physiological measures of attention. During the study, participants were required to complete a sentence-reading task while concurrent EEG recordings were being obtained. After participants completed the tasks, audiovisual recordings were used to score each patient's level of attention using a behavioral rating scale. The study concluded that behavioral engagement was significantly correlated with task performance, and that behavioral engagement scores positively correlated with EEG measures.

Based on these findings and studies of behavioral engagement in other populations, measures of behavioral engagement using an observational system to rate behavioral engagement may indicate whether a patient with aphasia is actively engaging in assessment and/or intervention tasks. No study that we know of, however, has investigated the use of an observational rating scale in conjunction with a confrontational naming task, which is one of the most common assessment and treatment tasks used with aphasia. Furthermore, the impact of emotion on engagement has not yet been considered.

Purpose of Present Study

The purpose of the present study is to investigate the relationship between behavioral engagement, physiological measures, perceived arousal, response time, and accuracy. This research will contribute to the growing literature on behavioral engagement and how it can be used to measure attention in people with aphasia. Understanding how behavioral engagement correlates with attention in people with aphasia can provide a more cost efficient, convenient way to guide and improve future intervention approaches. The following research questions will be addressed:

1. Is there a difference in behavioral engagement ratings between PWA and control participants?

   We hypothesized that control participants would have higher behavioral engagement ratings than PWA. We expected this result due to the idea that PWA have impaired attention (Hunting-Pompon et al., 2011; Laures et al., 2003) and behavioral engagement indicates observable signs of attention (Riley & Owora, 2020).

2. Are there relationships between behavioral engagement and response time and behavioral engagement and accuracy during a confrontational naming task?

   We hypothesized that the higher the behavioral engagement rating, the shorter the response time would be and the higher accuracy the response would have. We expected this result due to the idea that attention is required to complete a therapy task, and the more engaged a participant is, the faster they will be able to respond (Villard & Kiran, 2017).

3. Does behavioral engagement, based on ratings from a behavioral rating scale, correlate with physiological arousal or perceived arousal?

We hypothesized that behavioral engagement and physiological arousal would have a positive correlation because physiological measures have been found to be a valid way to measure attentional arousal (Ayres et al., 2021; Johannessen et al., 2020).

4. Are these relationships the same for people with and without aphasia?

We hypothesized that the relationships between behavioral engagement, response time, and physiological measures would be the same for PWA and control participants. We expected this result due to the PWA having impairments in attention and the control participants having intact attentional abilities (Hunting-Pompon et al., 2011; Laures et al., 2003).

Method

This thesis was part of a larger project analyzing the effect of emotion on confrontational naming in people with aphasia and provides a secondary analysis of the previously collected data as well as introducing a new measure of behavioral engagement during confrontational naming.

Participants

Nine people with aphasia participated in this study (See Table 1). These participants ranged in age from 34 to 76 years. Each participant had aphasia as the result of left hemisphere brain damage and was at least six months post onset. These participants presented with some degree of word-finding difficulty as shown by a score of less than 13 on the Boston Naming

Test-short form (BNT-short form; Goodglass et al., 1983). Eighteen adults without aphasia also participated in this study (See Table 2). The control participants each reported that they had no history of stroke or TIA. Of note, one aphasia participant was excluded due to a reported history of manic depression prior to his stroke. Three control participants were also excluded due to reporting diagnosed depression or bipolar disorder.

Table 1

Participants With Aphasia Demographic and Assessment Information

Ppt ID	Sex	Age (yrs)	Education (years)	TPO (yy;mm)	Location of Testing	WAB-AQ	WAB Type	TEA 6	TEA 7	BNT% Correct
AE01	M	52	19	6;01	Lab	81.8	Anomic	4.74	9.83	80
AE03	F	64	14	7;07	Lab	62	Broca's	6.45	4.07	27
AE04	M	76	17	3;01	CS	60.3	Wernicke's	6	2.56	60
AE05	F	40	13	1;01	CS	83.4	Anomic	3.6	7.3	80
AE06	M	42	16	6;06	CS	85.9	Anomic	5.4	10.1	73
AE08	M	58	16	14;10	Home	66	Broca's	5.3	13.33	27
AE09	F	48	12	16;04	Home	68.8	Broca's	5.1	13	80
AE10	M	34	13	5;11	Lab	63.2	Broca's	-	-	20

Note. PPt ID = Participant ID; TPO = Time Post-onset of aphasia; WAB-AQ = Aphasia Quotient on the Western Aphasia Battery Revised; TEA 6 = Test of Everyday Attention Subtest 6; TEA 7 = Test of Everyday Attention Subtest 7; BNT = Boston Naming Test; CS = Community Space

Table 2

Control Participants Demographic and Assessment Information

PptID	Sex	Age (years)	Education (Years)	Location of Testing	QVSFS
AEc01	F	42	16	Lab	0
Aec02	M	61	13	Lab	0
Aec03	M	44	20	Lab	0
Aec04	M	79	20+	Lab	0
Aec05	F	42	16	Lab	0
Aec06	F	35	16	Lab	0
Aec07	M	34	NR	Lab	1
Aec08	M	38	16	Lab	0
Aec09	M	32	18	Lab	0
Aec10	M	48	2	Lab	0
Aec11	M	57	20	Lab	0
Aec13	M	59	18	Home	0
Aec15	F	48	18	Home	1
Aec17	M	64	18	Home	0
Aec18	M	66	NR	Lab	0

Note. QVSFS = Questionnaire for Verifying Stroke-Free Status; A QVSFS score of 0 indicates no symptom with a number score correlating to the number of symptoms experienced associated with neurological disease.

Procedure

Each session consisted of a pre-experimental evaluation and an experimental portion. The testing took place in a variety of different settings.

Research Design

This study was conducted as an ABACA format, or a return to baseline design. In this study, condition A consisted of neutral stimuli, condition B consisted of positive high arousal stimuli, and condition C consisted of negative high arousal stimuli. The order of conditions C and B were counterbalanced. Each participant was given a three-minute resting period between each condition to reduce the potential carryover effects from one condition to another.

Setting

Most of the testing for this study was conducted at the John Taylor Building at Brigham Young University. However, some participants chose to complete the testing in their homes or in a community space (a private, secluded meeting room within an outpatient center). When participants chose to complete testing in their homes, efforts were made to limit external distractions by finding quiet, secluded places for testing to be completed. Participants were able to choose the time of the testing and the environment was modified to have as few external distractors as possible. Each session was audio-video recorded with a Canon Vixia HF R80 or HFR21 camera with a Sony ECM-AW4 microphone. The participants were shown the stimulus pictures on a MacBook Pro displayed with Microsoft PowerPoint.

Pre-Experimental Evaluation

In the pre-experimental evaluation, each participant was assessed to make sure that they qualified for the study. Participants completed a hearing screening, a vision screening, the Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986), and the Dynamic -Visual

Analogue Mood Scale (D-VAMS; Barrows & Thomas, 2017). In addition to these measures, participants with aphasia completed subtests 6 and 7 of the Test of Everyday Attention (TEA; Robertson et al., 1996), the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2006), and the Boston Naming Test (BNT; Goodglass et al., 1983). All participants without aphasia were also required to complete the Questionnaire for Verifying Stroke-Free Status (QVSFS; Jones et al., 2001). Participants with aphasia scoring a 13 or less on the BNT moved on to the experimental session.

Experimental Protocol

Participants completed a confrontational naming task under different emotional conditions. Participants were instructed to name the picture "as quickly and accurately as you can using only one word." Before the testing began, each participant practiced until they showed understanding of the task. Once the testing began, participants were shown two colored images for 6 seconds each. The participants looked at the colored images but did not name them. Then, a black and white image correlating with the emotional condition being assessed was presented with a beep. The black and white pictures following each pair of colored pictures were to be named by the participant. The black and white target pictures were consistent with the emotion that each colored image was associated with. The examiner then waited until the test participant gave an answer, an attempt at an answer, indicated that they were unable to answer, or 30 seconds had passed. The examiner then said the target word, whether the participant answered or not, after which the next stimulus picture was presented. Each group of pictures consisted of 20 targets.

Measures

Behavioral Rating Scale

For this study, a previously developed behavioral rating scale was used (Riley & Owora, 2020). This scale was based on the Whyte et al. (1996) scale and modified for PWA. Videos of confrontational naming trials were rated by the first author (a graduate student in Speech and Language Pathology) and two undergraduate research assistants. These individuals were trained to use the behavioral rating scale by reading a training document and then participating in the scoring of practice videos to ensure high reliability between raters. These individuals were not permitted to rate the videos for the study until they achieved a level of 90% accuracy when rating the practice videos compared to the graduate student's ratings.

The behavioral rating scale that was used had three levels of behavioral engagement: 0 = off-task behavior, 1 = partially on-task behavior, and 2 = completely on-task behavior (See Table 3). The rating scale also included a list of extraneous behaviors that qualified as off-task. Every two-seconds interval was rated according to this scale. In other words, each participant received a score for every two seconds of their naming response. For each condition, these scores were added together and averaged to give each participant one overall score. Each of the three raters reanalyzed 11% of trials and showed high intrarater reliability (> 97% agreement). Raters also completed 11% to 14% of the same samples to measure interrater reliability, which was also high (> 87% agreement).

Table 3

Rating Scale for Behavioral Engagement

Rating Score	Classification	Definition
2	Completely On-Task Behavior	Eyes and head are directed towards the task for entire interval, attempts verbal response, has no off-task behaviors
1	Partially On-Task Behavior	Eyes and head are directed towards task for part of interval, attempts verbal response, off-task behaviors present during interval
0	Off-Task Behavior	Eyes and head directed away from task for entire interval with no attempts at response, off-task behaviors present during interval

Note. Off-task behaviors include, but are not limited to: fidgeting, yawning, closing eyes, scratching body/face. This rating scale was modified from Riley and Owora (2020).

Physiological Measures

In addition to behavioral ratings of engagement, physiological measures were obtained from each participant throughout the duration of the experiment. ECG and skin conductance were measured using the NeXus-10 system. Each participant had three disposable silver-silver chloride electrodes placed on the undersides of each wrist and the underside of the non-dominant forearm. The sampling rate for the ECG was collected at 256 samples per second. The sampling rate for the skin conductance readings was collected at 32 samples per second. The ECG recordings were analyzed using the Kubios HRV analysis software (Tarvainen et al., 2014) for heart rate (BPM) and heart rate variability. The average skin conductance was analyzed and calculated using the BioTrace+ software (Mind Media, 2019).

Accuracy and Response Time

Each participant was given up to 30 seconds to respond to the stimulus. If their response matched the target word or a predetermined alternative, it was considered correct. Response time was measured from the offset of the auditory stimulus to the onset of the initial phoneme of the correct response in accordance with the Philadelphia Naming Test criteria (PNT; Dell et al., 1997).

Data Analysis

For this study, video recordings of participants performing a naming task were used. The videos were clipped to include when the stimulus was given and when the patient gave their final response, or if unable to give a response, the clinician administering the test said the stimulus word to indicate that the trial was over after the allotted 30 seconds had passed. These videos were then analyzed using the behavioral rating scale that was previously described. Using VLC Media Player, each clipped video was broken down into two second segments. Each segment was rated using the behavioral rating scale. The ratings were added up and then averaged to give each participant a behavioral engagement score for each stimulus item. These behavioral engagement ratings were then used to analyze whether differences existed between groups. This was done with a Mann-Whitney U test. Relationships between behavioral engagement ratings, physiological measures, perceived arousal, naming accuracy, and response time were analyzed using Pearson's R (R Core Team, 2020).

Results

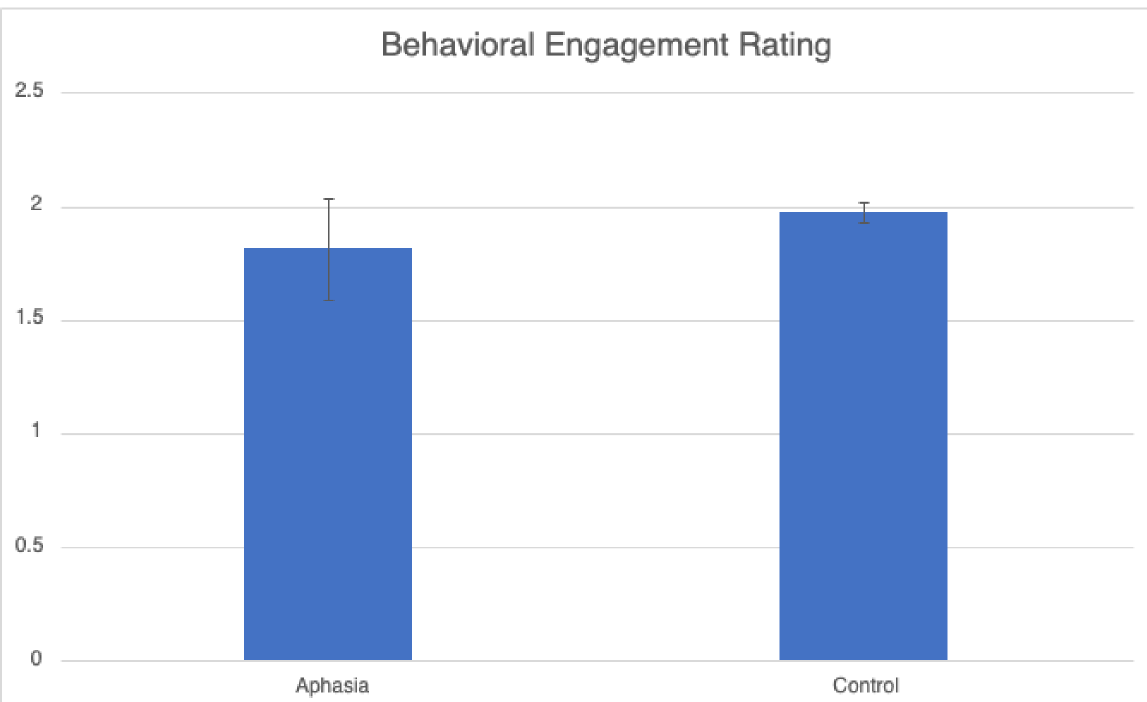
Four main hypotheses were made at the start of this exploratory study. First, it was hypothesized that control participants would have higher behavioral engagement ratings than PWA. Second, we hypothesized that the higher the behavioral engagement ratings were, the shorter the response time would be. Third, we hypothesized that behavioral engagement ratings and physiological arousal would have a positive correlation. Fourth, we predicted that the relationships between behavioral engagement, response time, and physiological measures would be the same for both PWA and control participants. The tentative findings of this exploratory study are discussed below and will lead to further research in these areas.

Behavioral Engagement in People With Aphasia Versus Control Participants

Consistent with our hypothesis, a Mann-Whitney U test showed a significant difference in behavioral engagement ($W = 454$, $p = 0.00004211$) between the aphasia and control groups (See Figure 1). A nonparametric test was used because behavioral engagement rating data was not normally distributed.

Figure 1

Group Mean for Behavioral Engagement Ratings



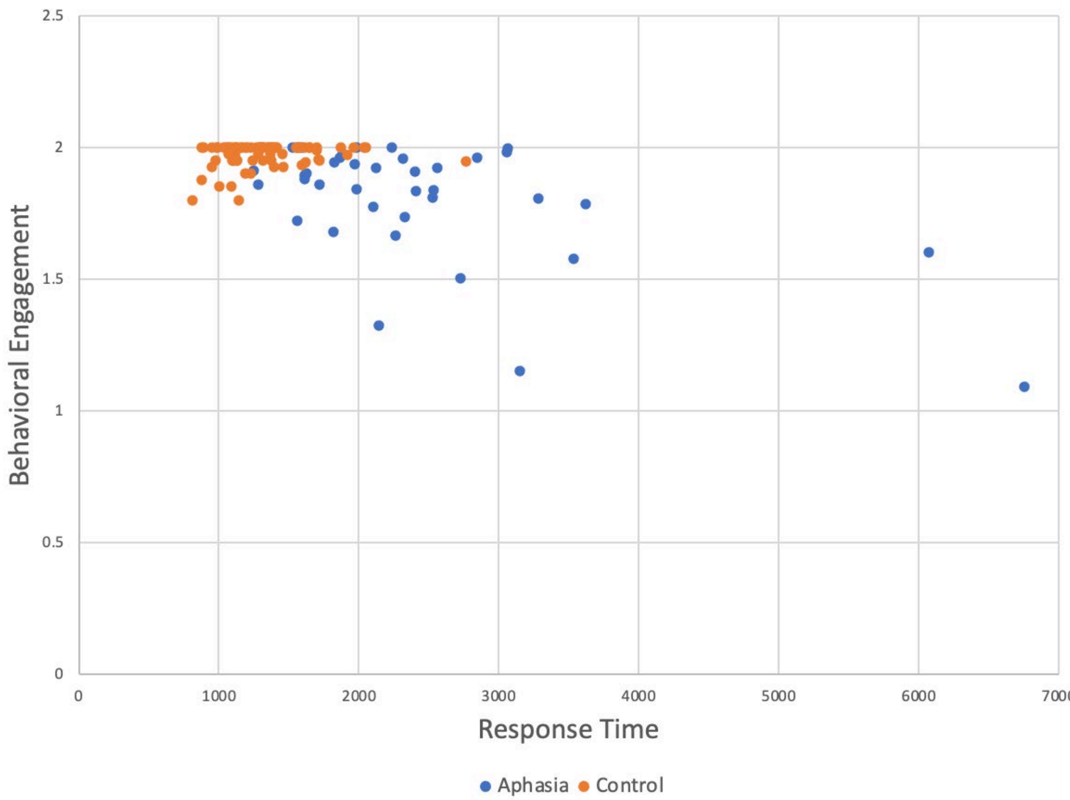
Note. Error bars indicate standard error from the mean.

Behavioral Engagement, Response Time, and Accuracy

Correlational analysis revealed a significant negative correlation between behavioral engagement and response time across the entire dataset (r = -.64, p < .001)(See Figure 2). When analyzed for each group independently, the significant correlation held for the aphasia group (r = -.59, p < .001) but not the control group (r = .2, p = .08). Correlational analysis also revealed a significant positive correlation between behavioral engagement and accuracy across the entire dataset (r = .65, p < .001)(See Figure 3). When analyzed for each group independently, the significant correlation held for both the aphasia group (r = .55, p < .001) but not the control group (r = .22, p = .06).

Figure 2

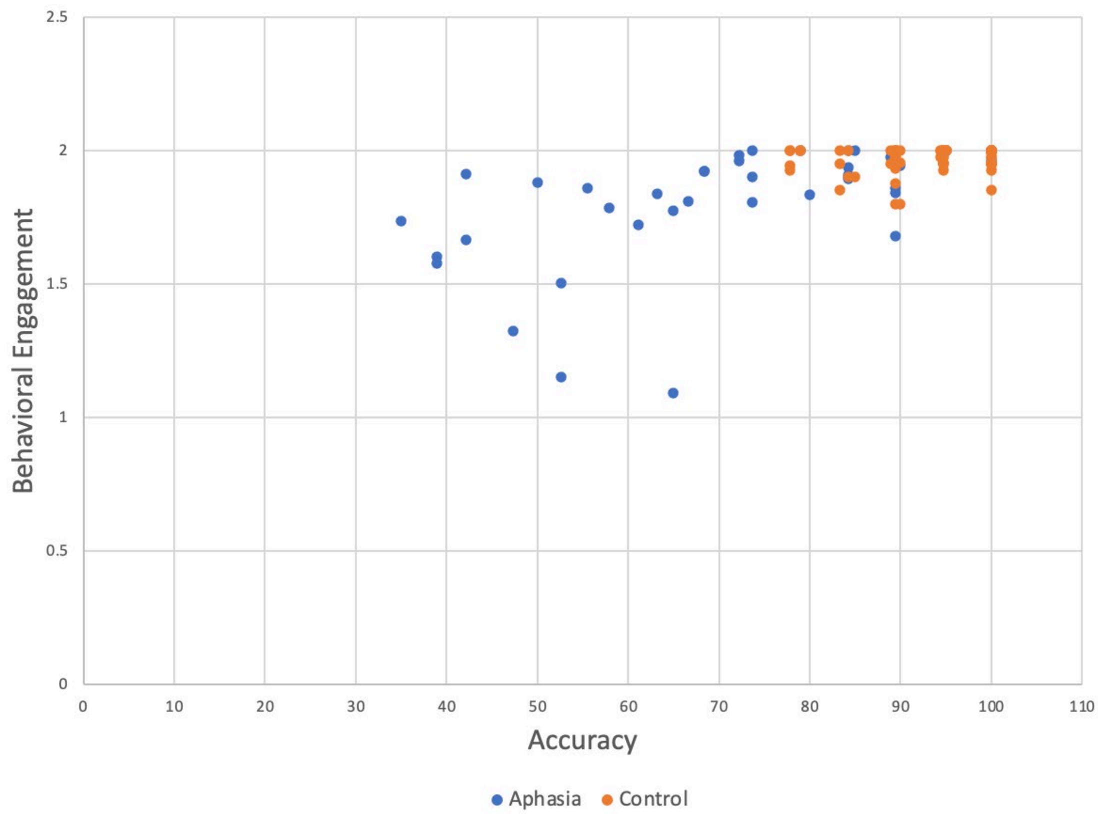
Relationships Between Behavioral Engagement and Response Time



Note. Each point on the graph represents the average response time for each participant across all trials.

Figure 3

Relationships Between Behavioral Engagement and Accuracy



Note. Each point on the graph represents the average accuracy for each participant across all trials.

Behavioral Engagement, Physiological Arousal, and Perceived Arousal

When looking at the entire dataset, no correlation was found between behavioral engagement and all measures of physiological arousal including heart rate variability (r = .03, p = .77), heart rate (r = .1, p = .26), and skin conductance (r = .03, p = .73). However, when looking at the aphasia group, behavioral engagement and skin conductance showed a low negative correlation (r = -.31, p = .10). When looking at the entire dataset, no correlation was found between behavioral engagement and perceived arousal (r = -.08, p = .38).

Discussion

This exploratory study examined the relationships between behavioral engagement, physiological measures, perceived arousal, response time, and accuracy. Results revealed differences between behavioral engagement in people with and without aphasia during a confrontational naming task as well as relationships between behavioral engagement and measures of language production.

Differences in Behavioral Engagement Between People With Aphasia and Control Participants

The finding that PWA had significantly lower levels of behavioral engagement than control participants corroborates previous research indicating that, during language tasks, PWA demonstrate more behaviors consistent with distraction and inattention than neurologically healthy controls (Riley & Owora, 2020). Although the current study and a previous study by Riley and Owora (2020) used similar scales to rate behavioral engagement, the language tasks during which behavioral engagement was measured were different. Riley and Owora (2020) found that PWA had significantly lower behavioral engagement ratings than control participants when completing a sentence reading task whereas the current study investigated behavioral engagement during a confrontational naming task. Despite the different tasks performed in these studies, behavioral engagement was lower for PWA than control participants. This could indicate consistently lower levels of behavioral engagement for PWA compared to control participants, regardless of the language task being completed. Possible explanations for this difference include differences between groups in attentional capacity and/or allocation, differences between groups in effort required for the task, or more time to exhibit inattentive behaviors for the aphasia group.

One explanation for why PWA demonstrated lower behavioral engagement ratings could be differences in attentional abilities between PWA and controls. Previous research indicates that PWA have decreased attentional abilities compared to neurologically healthy individuals as measured by worse performance on standardized tests of attention than controls (Hunting-Pompon et al., 2011; Laures et al., 2003; Murray, 1999). PWA also perform worse on tasks targeting sustained, selective, and divided attention than controls (Erickson et al., 1996; Murray, 2000; Villard & Kiran, 2015). Research done on other populations, including typically developing children and adults with communication disorders, suggests that behavioral engagement ratings can be a reliable method to measure attention (Rezazadeh et al., 2011; Whyte et al., 1996). Rezazadeh et al. (2011) successfully used a rating scale to identify inattentive behaviors in typically developing children and Whyte et al. (1996) successfully used a rating scale to quantify inattentive behaviors in people with TBI. Whyte et al. (1996) also compared levels of behavioral engagement in people with TBI and controls, finding that people with TBI had lower levels of behavioral engagement than controls. The findings of these studies suggest that the lower behavioral engagement ratings for PWA than controls may reflect decreased attentional capacity or ability to allocate attentional resources.

A second possible explanation for lower levels of behavioral engagement in PWA could be that confrontational naming tasks may require more effort for PWA than neurologically healthy individuals. Previous research has used self-rating scales to determine how much effort PWA perceive that a task will require (Harmon et al., 2019; Murray et al., 1997). No study that we know of, however, has compared perceived effort during a language task between PWA and controls. One study, though, did compare effort as measured objectively through pupillometry. In this study, pupillary responses were monitored as participants listened to semantically easy and difficult nouns while looking at pictures. This study concluded that both PWA and controls had increased pupil size as task complexity increased, indicating greater cognitive effort for the more linguistically complex task. There was no significant difference in the amount of change in pupil size in controls versus PWA. Although this study involved a different task than the current study, it is likely that pupillary response would mimic the same pattern of increasing in size when task complexity increased if monitored during a confrontational naming task (Chapman & Hollowell, 2015). Based on our study and the study by Chapman and Hollowell (2015), it may be beneficial to investigate the effects of increased effort on attention and behavioral engagement by having participants rate perceived effort of a task and using pupillometry to measure the amount of effort required to complete a task for PWA and controls to see if these measures correlated with each other. Control participants could also be given more challenging tasks to increase the amount of effort required to complete the task since it is often more difficult for PWA to complete tasks compared to neurologically typical individuals. We could then see if pupillometric responses correlated with ratings of perceived effort and levels of effort correlated with behavioral engagement and attention, or if levels of effort were more of a reflection of PWA difficulties with language processing.

A third possible explanation for lower levels of behavioral engagement in PWA could be the increased amount of time it took them to complete the confrontational naming task. Kim et al. (2018) determined that PWA required more time to complete a picture span task due to the increased amount of effort it took for them to complete the task. Evans et al. (2020) also investigated response time in PWA during a confrontational naming task, determining the average response time for optimal performance for PWA to be between 5 and 10 seconds.

Harmon et al. (2019) previously determined that participants with aphasia from the present study had significantly longer response times than controls.

Behavioral Engagement, Response Time, and Accuracy

In addition to differences in behavioral engagement between PWA and controls, the current study found a negative correlation between behavioral engagement and response time, which was driven by PWA, indicating that lower behavioral engagement ratings related to longer response time. We also found higher levels of behavioral engagement related to more accurate responses, also driven by PWA. This was consistent with our hypothesis, which was based on the idea that attention is required to complete therapy tasks, and the more engaged a participant is, the faster and more accurately they will respond (Villard & Kiran, 2017).

It is not surprising that when PWA had lower levels of behavioral engagement they had longer response times and more inaccurate responses. Since it is common for PWA to present with attentional deficits as measured by a standardized test, it can be difficult for them to focus on the task at hand, resulting in a longer response time. Our findings confirm previous research that deficits in attention can lead to longer response times (Erickson et al., 1996; Murray, 2000; Villard & Kiran, 2015). Previous research also indicates that attentional deficits in PWA can lead to inaccurate responses (Erickson et al., 1996; Murray, 2000; Murray, 2012).

One reason that these relationships may have been seen in PWA, but not controls, goes back to the idea of effort. A confrontational naming task may require more effort for PWA than it does for controls. Control participants may have been able to perform the confrontational naming task accurately and quickly while being less engaged simply because the task was much easier for them than PWA. Future research should investigate behavioral engagement of a neurologically healthy control group during a more difficult naming task (e.g., naming low frequency words).

Behavioral Engagement, Physiological Arousal, and Perceived Arousal

Although correlations were found in other areas, the current study found no relationship between levels of behavioral engagement, heart rate, heart rate variability, and skin conductance. There was also no relationship between levels of behavioral engagement and perceived arousal. The PWA group alone showed a weak relationship between behavioral engagement and skin conductance, but this was not statistically significant. Possible explanations for this include the type of tasks participants were asked to perform, the type of physiological measures used to measure attention, differences between behavioral engagement and cognitive engagement, or inaccuracies in the physiological measures.

We predicted that higher levels of behavioral engagement would relate to higher physiological responses as measured by heart rate, heart rate variability, and skin conductance. We made this predication based on research that found that physiological measures are a valid way to measure attentional responses (Ayres et al., 2021; Johannessen et al., 2020). In the current study, we used the same physiological measures used in the previously mentioned studies, including heart rate, heart rate variability, and skin conductance. Based on this research and the current use of physiological measures that had been determined to be valid measures of attention, the results of this study were surprising.

Possible explanations for the results of the current study could be the type of task that participants had to perform, the length of the intervals that were rated for behavioral engagement, and the types of physiological measures that were used. First, the type of task in the current study was different than that used in a previous study that did show correlations between behavioral engagement and physiological measures (Riley & Owora, 2020). Although the number of participants in both studies were comparable, the current study required participants to complete a confrontational naming task, whereas Riley and Owora (2020) required participants to complete a sentence reading task. It is possible that each trial of the confrontational naming task did not provide a long enough period of time to accurately determine behavioral engagement of participants, whereas a sentence reading task may have been enough time to accurately determine behavioral engagement. Additionally, Riley and Owora (2020) required participants to complete several tasks with each sentence, including silent reading while the clinician read the sentence out loud, choral reading the sentence with the clinician, reading one word at a time from each sentence when highlighted on the screen, and reading the sentence independently. The amount of time required to complete these tasks may have allowed more time to determine the attentional abilities of the participants compared to the present study in which participants were required to name a serious of 100 individual pictures.

Second, the current study rated different interval lengths than Riley and Owora (2020). The present study rated every two second interval of the confrontational naming task being completed, while Riley and Owora (2020) rated every 10 second interval of the sentence reading task being completed. The present study needed to rate such short intervals because the control group was able to complete the naming task very quickly. It could be that such a short interval was not enough time to accurate identify the level of behavioral engagement in the control group especially. This goes back to the previous point stating that a confrontation naming task may not have provided enough time to accurately determine behavioral engagement.

Third, the current study used different physiological measures than Riley and Owora (2020). In the current study, we used heart rate, heart rate variability, and skin conductance measures, whereas Riley and Owora (2020) used electroencephalography (EEG) measures. It is possible that some of these physiological measures are more accurate and reliable ways of measuring attention than others. Although, EEG and ECG measures have both been determined to be accurate measures of attention, it may be beneficial conduct a study similar to the present study using both measures so that the results from each could be compared. An additional measure that may be beneficial to add could be pupillometry and blink rate, which are the most accurate physiological measures of arousal and mental activity, according to Ayres et al. (2021).

Another possible explanation for our findings could be the subtle difference between behavioral engagement and cognitive engagement. Ben-Eliyahu et al. (2018) highlighted the difference between behavioral engagement and cognitive engagement, explaining that cognitive engagement "reflects the extent to which one is thinking about the learning activity, or attending and focusing on the task," whereas behavioral engagement is more focused on observable behaviors and what someone "would look like or be doing" (Ben-Eliyahu et al., 2018, p. 88). In the current study, we assumed that these terms could be used interchangeably, and attention would be manifest through how engaged or distracted participants were based on their behavioral responses. However, some participants may have appeared to be paying attention and fit the description set to receive a high behavioral engagement score of looking at the screen and not exhibiting any off-task behaviors, but were not cognitively engaged. In other words, it is possible that the current study did not capture subtle differences between how the participants were attending to the task cognitively and how they were manifesting their attentiveness behaviorally. Future studies may benefit from more sensitive measures, such as pupillometry, to capture these subtle differences.

The present study also found a weak relationship between levels of behavioral engagement and skin conductance. A possible explanation for this could be that if more effort is required to be engaged, then sweat gland activity increases, which causes higher levels of skin conductance (Ayres et al., 2021). This may suggest that skin conductance is a better measure of the effort that it takes to be engaged than how attentive a participant is. This could mean that skin conductance was not the best physiological measure to use when attempting to measure attention. On the other hand, if more effort is required to be attentive, then maybe it doesn't matter if skin conductance is more of measure of effort because the effort and attention go hand in hand. Regardless, further research needs to be done in this area to confirm our findings, due to our small sample size.

Limitations

Small sample size is a limitation to consider in this study. Data from eight PWA and 15 control participants were included. This was enough to gather preliminary data, but future research should consist of a larger sample size to confirm our findings. Another limitation of this study was the use of video recordings of participants. Raters were able to watch the videos as many times as necessary to obtain behavioral engagement ratings. If behavioral ratings of attention were to be used in real time during therapy sessions, this method will need to be further investigated to see if using a behavioral rating scale could be effectively done in real time. A third limitation could be the scoring of the behavioral engagement ratings. Although raters were trained and achieved a high level of interrater reliability, there is still room for differences in scoring since these behavioral engagement ratings were subjective. A final limitation could be that participants were able to choose the setting where they completed the confrontational naming tasks. Future studies may consider having all participants complete tasks in the same location to avoid possible external factors that may contribute to naming accuracy.

Clinical Implications

The relationship between behavioral engagement and naming performance for PWA may have important clinical implications. For example, if clinicians could improve task engagement, perhaps PWA would improve their performance during confrontational naming and possibly other language tasks. If clinicians can increase client motivation and monitor client engagement, they may be able to help PWA be more engaged and give their best effort during therapy tasks, resulting in improved accuracy and response time. However, due to the exploratory nature of this study, further research is needed to confirm whether this would indeed be the case.

Further research also needs to be done before behavioral rating scales replace physiological measures of attention. Behavioral rating scales may be a helpful tool to do a quick analysis of the difference in attention between PWA and controls during language tasks, but physiological measures may be needed for more in-depth analyses of attention. On the other hand, it is possible that physiological measures may be more accurately representing areas such as effort and stress as opposed to attention. If this is the case, behavioral engagement could be a more accurate measure of attention than physiological measures, which is an idea that should be more thoroughly investigated.

Conclusion

The purpose of this exploratory study was to investigate the relationships between behavioral engagement and physiological measures, perceived arousal, response time, and accuracy in people with aphasia (PWA) and neurologically healthy adults. In contrast with previous findings suggesting that behavioral engagement as a measure of attention correlates directly with physiological measures of attention, behavioral engagement was found to instead correlate with accuracy and response time during a confrontational naming task. We propose that behavioral engagement and physiological measures may be measuring different constructs. Further research should investigate the validity of physiological measures providing an accurate measure of attention.

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APPENDIX A

Annotated Bibliography

Erickson, R. J., Goldinger, S. D., & LaPointe, L. L. (1996). Auditory vigilance in aphasic individuals: Detecting nonlinguistic stimuli with full or divided attention. *Brain and Cognition*, *30*(2), 244–253. https://doi.org/10.1006/brcg.1996.0016

Objective: This study explores the idea that individuals with aphasia have deficits in attention and how dividing attention makes these deficits worse.

Method: 10 individuals with aphasia and 10 neurologically typical adults participated in this study. Each participant listened to two 10-minute sets of nonlinguistic stimuli while having divided attention in one set and focused attention in the other set. They were asked to identify target sounds amid nontarget sounds.

Results: The participants with aphasia performed much worse on the task with divided attention than the control participants.

Relevance to Study: This study is relevant to our study because it shows that attention deficits in PWA may be magnified when attention is divided. In the present study, we interpret extraneous behaviors as an indication of decreased attention to determine whether there are differences in these behaviors between people with and without aphasia and whether they are affected by emotional conditions.

Fulmer, S. M., D’Mello, S. K., Strain, A., & Graesser, A. C. (2015). Interest-based text preference moderates the effect of text difficulty on engagement and learning. *Contemporary Educational Psychology*, *41*, 98–110. https://doi.org/10.1016/j.cedpsych.2014.12.005

Objective: The purpose of this study was to see if interest-based text preferences have an effect on motivating individuals to be more engaged and have better comprehension, even if the text is difficult. The researchers wanted to see if reading non-preferred texts resulted in lower engagement and learning and if preferred texts would result in higher engagement and learning, possible even more so in difficult texts as opposed to easy ones.

Method: There were 84 undergraduate students from the Psychology department at a university, between 18 and 49 years of age. Participants were given a list of 4 research articles and asked to rate them based on which ones they thought were the most and least interesting. There were easy and difficult versions of each text, and each participant received 2 easy texts and 2 difficult texts. The participants then self-reported affect, attention, and learning.

Results: The results indicated that moderately difficult texts can promote learning, as long as the reader is given the opportunity to choose a text that they are interested in.

Relevance to Study: This article talks about different kinds of engagement (emotional, behavioral, and cognitive) which could be beneficial information for our study. This information can help us better understand the behavioral engagement in our participants.

Hula, W. D., & McNeil, M. R. (2008). Models of attention and dual-task performance as explanatory constructs in aphasia. *Seminars in Speech and Language*, *29*(3), 169–4. https://doi.org/10.1055/s-0028-1082882

Objective: This article is a discussion about how language mechanisms may be preserved in PWA and language difficulties may be from impairments of cognitive processes instead. They also talk about how attention appears to have a relationship to language processing. This study highlights the central bottleneck theory and the single resource model.

Relevance to Study: This article is important to our study because it discusses how language processing seems to have a relationship with attention. This can help us understand why language processing can be difficult for PWA.

Hunting-Pompon, R., Kendall, D., & Bacon Moore, A. (2011). Examining attention and cognitive processing in participants with self-reported mild anomia. *Aphasiology*, *25*(6–7), 800–812. https://doi.org/10.1080/02687038.2010.542562

Objective: The purpose of this study was to see if people with mild anomia have impaired performance on tasks that require automatic versus controlled processing. It also looks at whether or not people with mild anomia have impaired selective attention relative to neurologically typical controls.

Method: There were 14 patients with mild anomia and 9 patients that were neurologically typical. These participants were tested using the Covert Orienting of Visuospatial Attention Test (COVAT). This test was administered at two interstimulus intervals: 100 ms (automatic processing) and 800 ms (controlled processing).

Results: The participants with mild anomia had much slower responses than the typical neurological patients on the automatic processing test, but there was not much difference in the scores on the controlled processing test. The participants with mild anomia demonstrated slower response times the most when there were interfering stimuli present.

Relevance to Study: This study is important because it explores some of the strengths and difficulties related to attention in patients with anomia, which will be beneficial to our research study because it will give us some background on the patients that are participating. It also shows that when a PWA is distracted, their response time is delayed, which suggests a relationship between attention and language performance in PWA.

Laures, J. S., Odell, K. H., & Coe, C. L. (2003). Arousal and auditory vigilance in individuals with aphasia during a linguistic and nonlinguistic task. *Aphasiology*, *17*(12), 1133–1152. https://doi.org/10.1080/02687030344000436

Objective: The purpose of this study was to see if there is nonoptimal arousal in PWA that might affect auditory processing. They also wanted to see if nonoptimal arousal impaired vigilance or linguistic processing.

Method: 10 individuals with aphasia and 10 neurologically typical control participants were part of this study. Physiologic arousal was measured through cardiovascular measures and neuroendocrine measures.

Results: The PWA had decreased levels of overall vigilance, or attention. They also had nonoptimal arousal in both linguistic and nonlinguistic tasks.

Relevance to Study: This study is important because it teaches us more about how attention is impaired in some way in PWA and these attention deficits cause underperformance in both linguistic and nonlinguistic tasks.

Laures, J. S. (2005). Reaction time and accuracy in individuals with aphasia during auditory vigilance tasks. *Brain and Language*, *95*(2), 353–357. https://doi.org/10.1016/j.bandl.2005.01.011

Objective: This research explores auditory vigilance performance in PWA. The researchers wanted to know about reaction time and accuracy in PWA during a vigilance task with both linguistic and nonlinguistic stimuli.

Method: Ten individuals with aphasia and 10 neurologically typical participants were part of this study. They were each presented with linguistic and nonlinguistic tasks in two blocks of 32 minutes. They were required to push a button with their left hand when a specific stimuli was heard.

Results: The individuals with aphasia did not necessarily take longer than the control participants to answer. However, the individuals with aphasia were much less accurate than the control participants in their answers.

Relevance to Study: This study is important because it explores more about attention in PWA, in this case the main focus being reaction time and accuracy. This helps us understand more about how attention plays into the responses of PWA.

Laures-Gore, J., Cahana-Amitay, D., & Buchanan, T. W. (2019). Diurnal cortisol dynamics, perceived stress, and language production in aphasia. *Journal of Speech, Language, and Hearing Research*, *62*(5), 1416–1426. https://doi.org/10.1044/2018_JSLHR-L-18-0276

Objective: The purpose of this study is to look at the effects of diurnal, or daytime, cortisol in PWA and neurologically typical adults. The researchers also looked at measures of stress and language production. The researchers wanted to learn more about the effects of stress-induced cortisol disturbances for PWA.

Method: There were 19 participants who had aphasia in this study and 14 age matched neurologically typical adults. Each participant collected saliva samples on their own at home each day when they woke up to measure cortisol levels for an average of about 5 days. Each participant completed 2 stress questionnaires and participated in 3 discourses where they described pictures.

Results: The PWA had much higher cortisol levels that the control participants. The neurologically typical patients performed significantly better on the language task than the PWA. The PWA also reported the language tasks to be stressful. This indicates that PWA have a dysregulation of cortisol production, but the researchers recognized that further studies need to be done to investigate how this relates to language.

Relevance to Study: This is important to our study because it examines another area of attention and explores other explanations for attention deficits in PWA.

Murray, L (1999). Review Attention and aphasia: Theory, research, and clinical implications, *Aphasiology*, *13*(2), 91-111. https://doi.org/10.1080/026870399402226

Objective: This review article discusses attention in PWA. It talks about how adults with aphasia often exhibit attention deficits and how these attention deficits seem to be related to language difficulties, both with comprehension and production.

Relevance of Study: This article is important to our study because it reviews the literature on how aphasia, attention, and language are related.

Murray, L. L. (2000). The effects of varying attentional demands on the word retrieval skills of adults with aphasia, right hemisphere brain damage, or no brain damage. *Brain and Language*, *72*(1), 40–72. https://doi.org/10.1006/brln.1999.2281

Objective: The purpose of this study was to compare adults with mild aphasia, adults with right hemisphere brain damage, and neurologically typical adults when completing phrases under conditions of divided attention, focused attention, and isolation.

Method: Adults with mild aphasia, adults with right hemisphere brain damage, and neurologically typical adults were presented with word retrieval tasks in various conditions, including isolation, focused attention, and divided attention. Different types of phrases were used in the word retrieval tasks.

Results: The adults with right hemisphere brain damage and aphasia performed less accurately than the adults that were neurologically typical. The adults with aphasia were the only group whose accuracy was affected by the phrase type. The aphasic adults and the adults with right hemisphere brain damage performed more poorly on semantic and phonological aspects of word retrieval when the attentional demands were higher, indicating that there is a relationship between attention and word finding.

Relevance to Study: This article is relevant to our study because it links attention and word finding. This directly related to our study in which the participants are performing naming tasks. We are observing the relationship between attention and word finding as well.

Murray, L. L. (2012). Attention and other cognitive deficits in aphasia: Presence and relation to language and communication measures. *American Journal of Speech-Language Pathology*, *21*(2), S51–S64. https://doi.org/10.1044/1058-0360(2012/11-0067)

Objective: The purpose of this study was to explore in more detail the relationship between aphasia and cognition, specifically attention.

Method: Thirty-nine control patients and 39 patients with aphasia from left hemisphere strokes were tested using the Test of Everyday Attention. The researchers used subtests targeting attention, executive function, and short-term and working memory.

Results: It was found that the group of aphasia patients performed much more poorly than the control group. There was great variability in the results between the aphasia patients, and there were significant correlations found between the patients' attention abilities and language and communication abilities.

Relevance to Study: This study is important because it explores the relationship between aphasia and deficits in attention. This is important to our study because it helps us have an understanding of attention in PWA.

Oken, B. S., Salinsky, M. C., & Elsas, S. M. (2006). Vigilance, alertness, or sustained attention: Physiological basis and measurement. *Clinical Neurophysiology*, *117*(9), 1885–1901. https://doi.org/10.1016/j.clinph.2006.01.017

Objective: This article discusses vigilance, and defines it as sustained attention. This article reviews the literature on vigilance and goes into detail about the neurologic basis of vigilance and how to assess vigilance. It talks about how EEG is the most common measure of vigilance.

Relevance to Study: This article is pertinent to our study because it discusses attention, how it works, and how it is most commonly measured. In our study, we are trying to find a new way to measure attention, so it is helpful to be aware of the ways that attention is already measured.

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual Review of Neuroscience*, *35*(1), 73–89. https://doi.org/10.1146/annurev-neuro-062111-150525

Objective: This is an informational article that goes into detail about the attention system, what it consists of, and how it works.

Method: The authors used an article that they had written 20 years ago and updated it.

Results: There are still a lot of things that we don't know about the attention system, but we have learned a lot in the last 20 years and will continue to learn more in the future.

Relevance to Study: This study is important because it goes into detail about the attention system in the brain. This is important to our study because the more we know about the details of the attention system, the better we will be able to understand what is happening in the patients we are looking at.

Ponsford, J., & Kinsella, G. (1991). The use of a rating scale of attentional behavior. *Neuropsychological Rehabilitation*, *1*(4), 241–257. https://doi.org/10.1080/09602019108402257

Objective: The purpose of this study was to design an attentional behavior rating scale, look at the correlation between the rating scale's results and neurophysiological results, check inter-rater reliability, and look at how raters used the scale in different contexts.

Method: Two separate studies were completed. In the first one, there were 36 TBI patients that had had over 24 hours of post traumatic amnesia (PTA). Each subject's Occupational Therapist (OT) completed the rating scale during the same week that the subject received a neurological test. The OT rated them based on their performance on a variety of tests. In the second study, the same methods were used on 50 subjects with TBI and PTA. However, in Study 2, the patients were also rated by a Speech and Language Pathologist.

Results: The scale was determined to have validity. The results of the scale correlated with neurophysiological measures and had good inter-rater reliability. However, the correlations between the scores given by different raters were low.

Relevance to Study: This article is important because it shows us that it is evidence based to use a behavioral rating scale.

Rezazadeh, S. M., Wilding, J., & Cornish, K. (2011). The relationship between measures of cognitive attention and behavioral ratings of attention in typically developing children. *Child Neuropsychology*, *17*(2), 197–208. https://doi.org/10.1080/09297049.2010.532203

Objective: The purpose of this study was to explore the relationship between cognitive measures of attention and behavioral ratings of inattention in typically developing children. This study also explores the relationship between task performance/behavior ratings and IQ/chronological age.

Method: 31 typically developing boys between the ages of 3 and 7 participated. All of their parents completed the Conners' Parent Rating Scale-Revised. The children were administered the Wechsler Preschool or Primary Scale of Intelligence, the Wilding Visual Search Task, and the Conners' Continuous Performance Task.

Results: The results showed that the most accurate way to measure inattentiveness and hyperactive behaviors was the Visearch dual search task. There were frequent errors in things that were associated with poor attention from the parent ratings. This study suggests that attentional competence and speed are related to hyperactivity.

Relevance to Study: This article is important because it explores the relationship between behavioral ratings of attention and cognitive measures of attention, which is similar to what we are doing in our research study.

Riley, E. A., & Owora, A. (2020). Relationship between physiologically measured attention and behavioral task engagement in persons with chronic aphasia. *Journal of Speech, Language, and Hearing Research, 63*(5), 1430–1445. https://doi.org/10.1044/2020_JSLHR-19-00016

Objective: This article explores the idea that impaired attention skills can negatively interfere with therapy for patients with aphasia. Often, these fluctuations in attention are measured through electroencephalography (EEG). However, using EEG in therapy can be impractical. This article compares EEG results to observable behaviors changes.

Method: 10 people with aphasia and 10 healthy adults participated in an activity where they read 45 active sentences and 45 passive sentences. EEG data was taken and recorded during these tasks and each patients' level of attention was rated on a behavioral rating scale.

Results: The results of this study show that behavioral engagement was significantly correlated with task performance, suggesting that behavioral observation may be an alternative method of detecting lapses in attention during therapy.

Relevance to Study: This article is important because it shows that behavioral observation can be a way to detect inattentiveness in aphasia patients.

Riley, E. A., Owora, A., McCleary, J., & Anderson, A. (2019). Sleepiness, exertion fatigue, arousal, and vigilant attention in persons with chronic aphasia. *American Journal of Speech- Language Pathology*, *28*(4), 1491–1508. https://doi.org/10.1044/2019_AJSLP-18-0301

Objective: This article reports on research that looked at daytime sleepiness, exertion fatigue, arousal, and vigilant attention in persons with chronic aphasia. Many people with aphasia frequently report fatigue and daytime sleepiness. This study was designed to quantify daytime sleepiness, exertion fatigue, arousal, and vigilant attention in people with aphasia.

Method: 10 people with aphasia and 10 healthy adults participated in an activity where sleepiness, exertion fatigue, arousal, and vigilant attention using EEG, measuring heart rate, and using various rating scales.

Results: The results of this study show that people with aphasia did not show a significant difference from the controls in daytime sleepiness, exertion fatigue, arousal, and vigilant attention.

Relevance to Study: This article is important because it shows the attention can be measured through psychological measures. The researchers in this article used heart rate and ECG to measure arousal. This is beneficial to our study because we are using the same physiological measures.

Robertson, I. H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1996). The structure of normal human attention: The Test of Everyday Attention. *Journal of the International Neuropsychological Society*, *2*(6), 525–534. https://doi.org/10.1017/s1355617700001697

Objective: The purpose of this article is to describe the development of the Test of Everyday Attention. It looks at sustained attention, selective attention, attentional switching and auditory verbal working memory. The subtests in this assessment were shown to successfully identify between types of brain injuries, including closed head injury, Alzheimer's, and individuals with progressive brain diseases.

Relevance to Study: This article describes more about attention, which is helpful to our study. This article provides an interesting perspective from an assessment point of view, which may provide useful information.

Villard, S., & Kiran, S. (2015). Between-session intra-individual variability in sustained, selective, and integrational non-linguistic attention in aphasia. *Neuropsychologia, 66*, 204–212. https://doi.org/10.1016/j.neuropsychologia.2014.11.026

Objective: The purpose of this study is to look at the effect of task complexity on reaction times in both control patients and in people with aphasia. The researchers also looked at inter-individual variability between sessions.

Method: 18 participants with aphasia and 5 age-matched control participants were part of this study. They each participated in a non-linguistic attention task that was designed to measured 5 pre-determined areas of attention: memory, language processing, executive function, learning and therapy outcomes, and reasoning.

Results: They found that tasks with increased complexity had longer response times in both control participants and participants with aphasia. They also found that increased task complexity had increased inter-individual variability between sessions in PWAs but not control participants.

Relevance to Study: This is important to our study because it teaches us about task complexity and response times, which has to do with attention in PWA. This can help us better understand attention in PWA and how it may affect the participants in our study.

Villard, S., & Kiran, S. (2017). To what extent does attention underlie language in aphasia? *Aphasiology*, *31*(10), 1226–1245. https://doi.org/10.1080/02687038.2016.1242711

Objective: The purpose of this article is to review the current understanding of attention in people with aphasia. It also discusses how attention may influence language in aphasia.

Relevance to Study: This article teaches us more about attention in people with aphasia. Understanding attention in aphasia can help us understand more of what is going on in our study.

Villard, S., & Kiran, S. (2018). Between-session and within- session intra-individual variability in attention in aphasia. *Neuropsychologia, 109*, 95–106. https://doi.org/10.1016/j.neuropsychologia.2017.12.005

Objective: The purpose of this study is to examine between-session intra-individual variability (BS-IIV) and within-session intra-individual variability (WS-IIV) in PWA and how various attention tasks impact performance.

Method: 20 people with aphasia and 20 control participants were given two linguistic tasks and 3 nonlinguistic tasks. Each task got increasingly more difficult.

Results: PWA had higher levels of WS-IIV, but BS-IIV levels were similar in both groups. Tasks that were more difficult increased BS-IIV and WS-IIV in both groups as well. It was concluded that PWA have more fluctuations in their attention than neurologically typical people.

Relevance to Study: This study is important to our study because it helps us understand more about the fluctuations in attention in PWA. This can help us better understand how the attention system works in PWA, which can help us better understand what is happening with our participants.

Whyte, J., Polansky, M., Cavallucci, C., Fleming, M., Lhulier, J., & Coslett, H. B. (1996). Inattentive behavior after traumatic brain injury. *Journal of the International Neuropsychological Society*, *2*(4), 274–281. https://doi.org/10.1017/S1355617700001284

Objective: This article discusses how little is known about the observable behaviors of traumatic brain injury patients in daily and work environments when processing information. The researchers wanted to find a reliable method to quantify behavioral inattentiveness in a relatively naturalistic context. This study is a continuation of Whyte et al. 1994.

Method: A quantitative assessment of behavioral inattentiveness was developed and used on 20 TBI patients and 20 control patients. Each subject was given 3 tasks on 3 separate occasions on the same day, ranging from structured to unstructured. Each task was introduced for 2 minutes and then the patient had 15 minutes to complete the task. During the task, the researcher performed 12 natural distracting behaviors. Off task behavior from the subject was observed.

Results: The researchers concluded that they had successfully developed a method to quantify behavioral inattentiveness in a relatively naturalistic context.

Relevance to Study: This article is important because it uses a behavior rating scale that could be useful in our research study. It also looks at behavioral engagement, which is what our study is looking at as well.

Whyte, J., Rose, T., Glenn, M. B., Gutowski, W., Wroblewski, B., & Reger, J. (1994). Quantification of attention-related behaviors in individuals with traumatic brain injury. A pilot study. *American Journal of Physical Medicine & Rehabilitation*, *73*(1), 2–9.

Objective: The purpose of this study was to develop a way to quantify specific behaviors in patients with traumatic brain injury.

Method: 4 subjects that had suffered a severe TBI and were in long term rehabilitation were asked to make a collage, participate in a sorting task, and complete a block puzzle. The subjects were given cues based on whether or not they were on task. There were also various distractions that were delivered throughout the tasks.

Results: The method they used to measure on task behavior, extraneous motor activities, and presence of distractors was highly reliable and had high interrater agreement. They found that all subjects were the most attentive during the sorting task, fidgeting was the most common extraneous behavior when a subject was off task, and external distractors had different effects on all of the clients. They found that patients with TBI were much more off task than the control participants regardless of whether there was a distractor or not.

Relevance: This article is important because it is the beginning of the behavior rating scale that will be used in our study.

Whyte, J., Schuster, K., Polansky, M., Adams, J., & Coslett, H. B. (2000). Frequency and duration of inattentive behavior after traumatic brain injury: Effects of distraction, task, and practice. *Journal of the International Neuropsychological Society*, *6*(1), 1–11. https://doi.org/10.1017/S1355617700611013

Objective: The purpose of this research was to further the research done in Whyte 1994 and Whyte 1996. In this research, they used more precise measures to measure inattentiveness in patients with TBI. They wanted to find out if the increase in off-task behavior induced by the distractors was constant throughout the interval and if the disruptive impact of the distractors last beyond their termination.

Method: 20 subjects with moderate-to-severe- TBI and 20 control participants performed tasks while being distracted in various ways.

Results: TBI patients are much less attentive in the presence of distractions than control patients. They found that for both groups, the data revealed that there was a high probability of off-task behavior at the onset of the distractor. They also found that the off-task behaviors caused by the distractors lasted after the termination of the distractor. Patients had the most difficulty staying on task during the unstructured tasks.

Relevance to Study: This article is important because it further explores the rating scale that will be used in our study.

APPENDIX B

Institutional Review Board Consent Form

Consent to be a Research Subject

Introduction

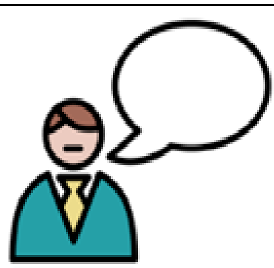
This research study is being conducted by Tyson Harmon, Ph.D., CCC-SLP at Brigham Young University. The purpose of this study is to determine how positive and negative emotions affect naming in aphasia. You were invited to participate because you have aphasia, which affects your ability to find words.

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 screenings, tests and questionnaires, and an experimental protocol.

The screening, tests, and experiment will involve:

Screening	Hearing screen Vision screen
Tests and Questionnaires	Language test Naming test Mood questionnaire
Experiment	View and name pictures Answer questions



During the experimental task, you will see and name a variety of pictures, some of which have been designed to make you feel happy or sad. You will have sensors placed on your wrists and finger to monitor your heart rate and sweat glands. We will also ask you to occasionally answer two questions about how you feel. You can choose whether the evaluation session is held in your home or the Aphasia Lab on BYU campus (John Taylor Building room 111).

Medical Records
Strokes and brain injuries can affect different areas of the brain. With your authorization, we would like to obtain **medical records** to help us describe what area of your brain was damaged.

_____YES _____NO I give the study investigators permission to request copies of previous brain scans.

Video Recordings
Several tests and the experimental naming task will be **video recorded** to check scores and 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 video in the ways that you agree to. In any use of the video, you will not be identified by name.

____YES _____NO Video recordings can be studied by the research team for use in the **research project.**

_____YES _____NO Short excerpts of video recordings can be used for **scientific publications, conferences, or meetings.**

____YES _____NO Short excerpts of video recordings can be shown in **university classes.**

Risks/Discomforts
During the experiment, you will see several **pictures that are designed to create an emotional response** (e.g., make you feel happy or sad). Examples of pictures designed to make you feel sad include scenes of natural disasters such as fires or tornadoes, injured animals, and explosions. Examples of pictures designed to make you feel happy include beautiful vistas, cute and content animals, and celebrations. For some people, these pictures may cause emotional distress. Some of the test items may also be difficult for you causing you to become frustrated, tired, or embarrassed. **You can take a break or discontinue your participation at any time.**

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 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., video 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 a **$15 gift card** 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

Stimuli

Neutral 1	Positive	Neutral 2	Negative	Neutral 3
cup	gold*	clarinet*	bomb	oar
elbow	wedding	pen	witch	box
chair	breakfast	rock	tornado	tie
newspaper	beach	foot	(hurricane)	cross
suit	dance	shirt	mosquito	nail
dustpan	candy	monk (friar,	hospital	forehead
hole	chocolate	priest)	rat	cube (box)
chalk*	star	table	gun	compass
card (8 of	swimming	match	ambulance	cow
heart)	money	hay	punch	toe
pigeon (bird)	fairy	lock	traffic*	stool
spatula	(video) game	jar	cry	pan
camel	leopard	dresser	skunk	pencil
nun	(cheetah)	(drawer)	devil	chess
rice	kiss	beard	bee	door
tire	football	sheep	spider	envelope
net	queen	straw	robber	accordion
desk	mermaid	fence	whip	lamp
cane	cake	lungs	angry*	moth
apron	tiger	seal	bullet	typewriter
nose	music	shoe	poison	
		asparagus	(alcohol)	

Note. * = items that were excluded; Parenthesis indicate acceptable alternative responses.