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Physiological Arousal, Emotion, and Word Retrieval in Aphasia: Effects and Relationships

Angela Lynne Johnson
Brigham Young University

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Master of Science

Tyson G. Harmon, Chair
Shawn L. Nissen
Garrett J. Cardon

Department of Communication Disorders

Brigham Young University

ABSTRACT

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Angela Lynne Johnson
Department of Communication Disorders, BYU
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People with aphasia are known to have poor word retrieval abilities in communicative tasks. It has also been reported that they have lower, non-optimal levels of physiological arousal, which may cause lower attention levels therefore contributing to poor performance on linguistic tasks. The purpose of this study was to investigate the relationship between physiological arousal and word retrieval in adults with aphasia and neurotypical adults when presented with emotional stimuli within a confrontational naming task. Participants included 6 people with aphasia and 15 neurotypical controls. All participants completed a confrontational naming task within 3 emotional conditions (neutral, positive, negative) and physiological measures (Heart Rate Variability, Skin Conductance) were taken simultaneously. No statistically significant results were found; however, numerical trends were identified in the data that may provide direction when designing future studies.

Keywords: aphasia, physiological arousal, emotion, heart rate variability, skin conductance

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DESCRIPTION OF THESIS STRUCTURE AND CONTENT

This thesis, *Physiological Arousal, Emotion, and Word Retrieval in Aphasia: Effects and Relationships* is part of a larger study investigating the relationship of emotion and physiological arousal in a confrontational naming task. It is presented as a journal article and portions may be submitted for publication. The literature review is included in Appendix A, Institutional Review Board approved consent forms used in the study are provided in Appendix B, SAM arousal and pleasure ratings are provided in Appendix C, and a list of stimuli for each condition is provided in provided in Appendix D.

Introduction

Two million people in the United States are affected by aphasia—a neurogenic language disorder most often acquired through stroke (Simmons-Mackie & Cherney, 2018). Aphasia is associated with damage to the left-hemisphere of the brain and therefore, results in deficits across language modalities (speaking, listening, reading, writing) that may be manifest by impaired spontaneous speech, language comprehension, verbal repetition, and naming (i.e., word retrieval). In addition to difficulties with language, people with aphasia (PWA) have shown generally low levels of physiological arousal (Laures et al., 2003; Laures-Gore et al., 2019). Physiological arousal (viz. stress response [Chih et al., 2020] or alertness level [Laures-Gore et al., 2010]) refers to changes that occur within the body (e.g., increased heart rate, skin conductance, increased respiration) in response to a threatening or demanding situation. Low physiological arousal correlates with poor attentional processing, which may contribute to poor language performance in PWA (Christensen & Wright, 2014; Laures et al., 2003; Riley & Owara, 2020). Despite their language deficits and seemingly low physiological arousal, however, PWA demonstrate relative strengths in right-hemispheric functions of the brain such as general intelligence, memory, prosody, and emotion (Metcalfe et al., 1995; Ross & Mesulam, 1979; Wan et al., 2014; Weddell, 1989).

Emotion can induce physiological arousal, which in turn, may affect language performance (Cahana-Amitay et al., 2015; Chih et al., 2020; Laures-Gore et al., 2007). To date, few empirical studies have investigated the effects of emotion on language in PWA and, to our knowledge, no study has included the direct relationship between emotion and physiological arousal. The purposes of this study are to learn (a) how emotional stimuli affect physiological arousal for PWA compared with healthy controls during a confrontational naming task and (b) how changes in physiological arousal relate to behavioral performance.

Naming, Emotion, and Physiological Arousal in People With Aphasia

The ability to name objects or abstract ideas plays an essential role in everyday communication (Chih et al., 2020; Gleichgerrcht et al., 2015). Words are used to convey meaning, provide information, and facilitate human connection. For these reasons, anomia can be one of the most distressing problems for PWA (Chih et al., 2020) and frequently leads to conversational breakdowns which correlate with common socioemotional symptoms (e.g., depression, anxiety, loss of self-identity, changes in interpersonal relationships, social isolation, reduction in employment or preferred activities; Code & Pertheram, 2011; Kirkevold et al. 2018). Treatment for anomia and other language difficulties will often rely on spared regions of the brain and capitalize on right-hemispheric strengths (e.g., melody, intonation, rhythm) to facilitate language recovery through compensatory strategies (Fujii & Wan, 2014; Lorch et. al., 1998; Reuterskiold, 1991; Schlaug et al., 2010; Wan et al., 2014; Wilson et al., 2006). It is unknown whether emotion, another relative strength in PWA (Lorch et al., 1998; Ross & Mesulam, 1979), could facilitate language production. It has been shown, however, that emotions have a correlation with physiological arousal and may facilitate physiological responses through the autonomic nervous system (Wehrwein et al., 2016).

Emotion and Physiological Arousal

Although emotions involve higher-order cognitive processes (Ledoux & Brown, 2017), they are governed by the autonomic nervous system (ANS; Levenson, 2014). The ANS is part of the peripheral nervous system, which regulates physiological stress responses involuntarily. It is comprised of two major divisions including the sympathetic (SNS) and parasympathetic nervous systems (PNS). These two systems have complementary roles: while one is activated, the other is inhibited. The SNS regulates what is commonly known as the “fight or flight” response. It prepares the body for emotionally heightened situations through a series of sudden, physiological changes. When triggered, the SNS response increases hormone release (adrenaline and cortisol) and raises the heart rate, perspiration levels (i.e., skin conductance), and respiration rate. Different patterns of physiological arousal are correlated with heightened emotions (e.g., fear, disgust, excitement) and trigger a response used to create defensive behaviors toward the stressor (Bauerly et al., 2019; Levenson, 2014; Wehrwein et al., 2016). These defensive behaviors could range from increased heart rate and heightened reflexes in a dangerous situation to something as simple as face blushing during an embarrassing moment (Wehrwein et al., 2016). Once the stressor is overcome, the PNS initiates a recovery response to bring the body back to a balanced, unstressed state. The main function of the PNS is commonly referred to as “rest and digest,” because it conserves energy and aids in digestion. Signs of increased PNS activity include decreased heart and respiration rate and low skin conductance levels. The SNS and PNS are not “all or nothing” responses (Wehrwein et al., 2016). Rather, they work together to achieve physiological stability. The ANS as a whole is integrated with behaviors and emotions and coordinates between organs, nerves, and tissues to maintain homeostasis within the body (Levenson, 2014; Wehrwein et al., 2016).

Although ANS responses leading to physiological change can reflect fluctuations in emotional states, emotion is difficult to quantify because it depends greatly on individual experience (Choi et al., 2017). Caicedo and van Beuzekom (2006) divided approaches to measure emotion into two categories: self-reporting and ANS methods. Self-reporting methods typically involve rating scales where individuals report their emotional state through a picture or description that matches how they feel (e.g., Self-Assessment Manikin; SAM; Bradley & Lang 1994). ANS measures, though, may better identify subtle changes in emotional arousal (Riley & Owara, 2020). ANS activity may be measured in a variety of ways including through (a) chemical and hormonal changes such as cortisol (Laures-Gore et al., 2019), (b) heart rate variability (Choi et al., 2017), (c) respiratory and heart rate (Chih et al., 2020), and (d) skin conductance (Baurley et al., 2019). Changes in these physiological responses may correlate with changes in cognitive or emotional states (Lane et al., 2011) and, theoretically, can support anecdotal evidence of a stress response (i.e., stress rating scales or questionnaires). Previous studies, however, have found that this is not always the case for PWA (Chih et al., 2020; Laures-Gore et al., 2019).

Physiological Arousal Response in People With Aphasia

The few studies that have investigated physiological arousal of PWA while performing linguistic tasks (Chih et al., 2020; Christensen & Wright, 2014; Laures et al., 2003; Laures-Gore et al., 2010; Laures-Gore et al., 2019; Marshall et al., 2018; Riley & Owara, 2020) generally take one of two perspectives. The first perspective suggests that there is a correlation between low physiological arousal and impaired attentional processing in PWA and that these deficits in attention could contribute to language difficulty such as anomia (Hunting-Pompom et al. 2011; Riley & Owara, 2020). However, another perspective proposes that physiological arousal, or stress response, caused from “linguistic anxiety” is the main contributor to poor language performance in PWA (Cahana-Amitay et al., 2015). A paucity of research remains regarding the relationship between physiological arousal and language performance in PWA.

Perspective 1: Impaired Attentional Processing. In a recent study that investigated the relationship between attention and arousal response in PWA, Riley and Owara (2020) measured behavioral signs of fluctuating attention levels and corresponding physiological changes that occurred during a communicative task. Attention levels were assigned a behavioral engagement score and physiological changes were monitored through electroencephalogram (EEG) measurements. The researchers found a correlation between low behavioral engagement scores and low levels of physiologically measured attention on the EEG. The lower levels of attention corresponded to poorer performance on the linguistic tasks, supporting the perspective that attention processing deficits, possibly caused by low physiological arousal, may relate to language difficulties in aphasia.

Similarly, Christensen and Wright (2014) and Laures et al. (2003) aimed to determine if attentional deficits caused by non-optimum arousal (i.e., too much or too little arousal) occur more during linguistic than nonlinguistic tasks. Both studies made inferences about the attention that PWA assigned to tasks varying in type and difficulty through different physiological measures: Christensen and Wright (2014) tracked changes in Heart Rate Variability (HRV) that occurred between a resting baseline and verbal or spatial memory tasks, while Laures et al. (2003) measured physiological arousal through blood pressure levels taken every two minutes and cortisol levels measured at the end of each condition (i.e., resting baseline, linguistic and nonlinguistic auditory recognition tasks). The physiological measurements from both studies revealed that participants with aphasia demonstrated non-optimum (low) arousal regardless of the type or difficulty of the assigned task. In another study, Marshall et al. (2018) also found that even after attempting to focus and reduce the amount of outside distraction through mindfulness meditation training, attention levels in PWA remained low for language performance when compared to controls.

Perspective 2: "Linguistic Anxiety". Two recent studies, Chih et al. (2020) and Laures-Gore et al. (2019) investigated physiological arousal in PWA compared to neurotypical adults during picture naming and picture description tasks. Physiological measures were taken through heart rate and respiratory rate (Chih et al., 2020) or salivary cortisol levels (Laures-Gore et al., 2019) and were compared to participants' perceived stress ratings. Chih et al. (2020) found significant differences in heart rate between resting and naming conditions for both aphasia and control groups. Only the aphasia group, though, experienced significant differences in respiratory rate between resting and naming conditions when compared to the control group. Laures-Gore and colleagues (2019) reported that their aphasia group had a significantly lower cortisol awakening response when compared to controls and that cortisol response was correlated with language performance. Both studies concluded that although PWA perceived language tasks as stressful, perceived stress ratings were not in agreement with physiological measurements.

As Lazarus et al., (1985) described, stress (i.e., physiological arousal) occurs when a person encounters a situation that, due to previous experience, is perceived as threatening, and coping resources are not accessible. Because stressors depend on previous experience, responses may differ for each person. Laures-Gore and Buchanan (2015) suggested, "one person's stressor may be another person's positive challenge" (p. 696). For example, if an adult with aphasia displays increased heart rate or skin conductance levels during a naming task, it may be an indication of increased vigilance resulting in better task performance, or it could have the negative association of "linguistic anxiety" as suggested by Chana-Amitay (2015). When a cognitively challenging task is seen as a positive challenge, an individual tends to expend more effort, leading to an increase in SNS control and inhibited PNS input. The question remains whether increased levels of emotional arousal would (a) improve attentional levels through increased physiological arousal in PWA leading to improved linguistic performance or (b) distract PWA from linguistic performance as they attend to emotional regulation. These ambiguities will only dissolve after further investigation.

Purpose

While investigating the two perspectives mentioned above, the present study aims to answer the following research questions:

1. Will participants experience a greater physiological stress response (i.e., skin conductance, heart rate, heart rate variability) across four experimental conditions (rest, neutral naming, positive naming, negative naming) and how does this response compare between aphasia and control groups?

We hypothesize that all participants will show greater physiological arousal response in naming conditions when compared to baseline; however, the control group will show a higher level of physiological arousal when compared to the aphasia group. We expect this result due to the non-optimum arousal levels suggested by the impaired attentional processing perspective. (Christensen & Wright, 2014; Laures et al., 2003; Marshall et al., 2018; Riley & Owara, 2020). Furthermore, we suspect that all participants will show increased physiological arousal in negative and positive conditions compared to neutral conditions.

2. What is the relationship between physiological stress response, perceived arousal, and naming accuracy and response time?

We hypothesize that that response time and accuracy will decrease in PWA as physiological arousal increases (Christensen & Wright, 2014). Similar to the results of previous studies (Chih et al., 2020; Laures-Gore et al., 2019), we expect that the physiological and self-perceived arousal ratings will not show a strong correlation.

Method

This thesis is part of a larger research project exploring the effect of emotion on confrontational naming in PWA. Behavioral measures (i.e., response time and accuracy) were obtained previously (Loveridge, 2020; Nielsen, 2020) and were compared against physiological data. This study used a repeated measures group design that involved the analysis of physiological measurements (i.e., heart rate, heart rate variability and skin conductance) during different emotional conditions using a repeated baseline (ABACA) design.

Participants

All participants were recruited from referrals and the Brigham Young University (BYU) Stroke and Brain Injury Registry. This study included 6 adults with aphasia and 15 neurotypical control participants. All participants were native English speakers over the age of 18 and passed a vision and hearing screening. Those with aphasia were included in the study based on the following criteria: (a) evidence of left hemisphere stroke, (b) a score of less than 93.8 on the Western Aphasia Battery revised (WAB-R), (c) a score between 1 and 9 on the WAB-R naming and word finding subtest, and (d) 6 months post-onset of aphasia. Control participants were included if they reported no evidence of neurological damage. Ten PWA and 18 control participants were initially recruited. Each aphasia participant was matched with two controls of the same gender and relative age (i.e., +/- 5 years). Four participants with aphasia were not included in the study; AE02 indicated possible severe depression on the Geriatric Depression Scale (GDS), AE07 did not meet qualification criteria, and AE03 and AE09 were excluded due to difficulty obtaining physiological measures. Three control participants (AEc12, Aec14, Aec16) were excluded due to difficulty obtaining physiological measures. See Tables 1 and 2 for complete participant demographic and assessment information for the participants ultimately included in the study.

Setting

Participants completed the study at the BYU Aphasia Lab, in a public community area, or in their own home according to their preference. The time and date of sessions were based on participant availability. Efforts were made to minimize environmental distractions during all sessions. Session recordings were done with a Canon Vixia HF R80 or HFR21 camera with a Sony ECM-AW4 microphone. Participants were seated at a table to view stimulus pictures displayed through Microsoft PowerPoint on a MacBook Pro.

Stimulus Development

Positive, negative, and neutral stimulus pictures were selected from a previously reported wordlist rated for valence and arousal on a scale from 1-9 (Warriner et al., 2013). Words with arousal ratings greater than or equal to 5 and valence ratings of greater than or equal to 6 were classified as positive, while negative words were defined as those with arousal ratings greater than or equal to 5 and valence ratings of 4 or less. Words with an arousal rating of 3.2 or less and a valence rating between 4 and 6 were categorized as neutral words (Bauerly & Paxton, 2017; Blackett et al., 2017). Each word was assigned a black and white image to be used in a naming task. Images were obtained from the International Picture-Naming Project (IPNP; Szekely et al., 2004) and royalty free clip art websites (vectorportal.com and clipart-library.com). Stimulus pictures were chosen through informal naming tasks. The images were presented to young adults who named each image using one word. Images were included in the study if they were consistently named accurately. Some stimulus pictures were modified to specify the target word (e.g., arrow pointing to specific detail in image).

All words were rated for five linguistic variables (i.e., concreteness, imageability, familiarity, frequency, and articulatory complexity). Concreteness, imageability, and familiarity ratings were acquired from the Medical Research Council (MRC) Psycholinguistic Database (Coltheart, 1981). When not obtainable through the MRC database from the Bristol norms list (Stadthagen-Gonzalez & Davis, 2006), word concreteness ratings were completed from a list of concreteness ratings for 40,000 English word lemmas (Brysbaert et al., 2014). Frequency ratings were acquired from the BYU iWeb corpus (Davies, 2018). Articulatory complexity was chosen through the Word Complexity Measure (Stoel-Gammon, 2010). Only words that were given a rating value for all of these categories were included in the experiment.

The chosen words were categorized into five lists: one positive, one negative, and three neutral. Each list consisted of 20 target words. ANOVAs revealed no statistically significant difference between wordlists in ratings of concreteness, familiarity, imageability, frequency, or articulatory complexity ($p > .05$). Two colored images were also presented at the beginning of each experimental condition to reinforce the emotional arousal and valence of each wordlist (Kurdi et al., 2017). Colored images were chosen from the Open Affective Standardized Image Set (OASIS).

Procedures

Research sessions were completed in two phases: a pre-experimental evaluation and an experimental session. Sessions were conducted by research assistants trained in supportive communication for people with aphasia. Before beginning the study, all participants provided informed consent. The consent form was organized to augment comprehension for individuals with aphasia through bolding of key words and use of supplementary pictures. Each participant was given a copy of the consent form and reviewed it with research assistants present. Research assistants were trained to summarize the key points of the form and ask questions to verify participant comprehension. All procedures were approved by the BYU Institutional Review Board (IRB).

Pre-Experimental Evaluation

Pre-experimental evaluation consisted of a series of assessments and questionnaires that provided (1) a verification of participant's eligibility and (2) a description of the participants speech, mood, and language function. All participants completed a hearing and vision screening and the Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986). Participants with aphasia also completed the WAB-R, the Boston Naming Test (BNT; Goodglass et al., 1983), and, with the exception of one participant, subtests 6 and 7 of the Test of Everyday Attention (TEA; Robertson et al., 1996). Participant hearing was screened in both ears at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz. All participants showed thresholds at 40 dB or below except AE04 (at 2000 Hz in the left ear [60dB] and 4000 Hz in both ears [R:50 dB, L:65dB]), AE08 (at 4000 Hz in the right ear [threshold not available due to researcher error]), and Aec10 (at 4,000 Hz in left ear [55 dB]). All participants passed a visual field test with the exception of AE06 who did not respond to stimulus in the upper and lower right side of the right eye and AE08 who did not respond to stimulus in the upper and lower left side of right eye.

Table 1

Control Participants' Demographic Information

Group Type	Gender	Number	Age (Mean, SD)
Control Group	Male	12	(53, 14)
	Female	3	(40, 4)

Note. Age reported in years.

Table 2

Aphasia Participants' Demographic and Assessment Information

PptID	Sex	Age	TPO (yy:mm)	WAB-AQ	Type	TEA 6	TEA 7	BNT %	GDS
AE01	M	52	6;01	81.8	Anomic	4.74	9.83	80	0
AE04	M	76	3;01	60.3	Wernicke's	6	2.56	60	3
AE05	F	40	1;01	83.4	Anomic	3.6	7.3	80	5
AE06	M	42	6;06	85.9	Anomic	5.4	10.1	73	0
AE08	M	58	14;10	66	Broca's	5.3	13.33	27	1
AE10	M	34	5;11	63.2	Broca's	-	-	2	7

Note. 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 percent correct; GDS= Geriatric depression screener.

Experimental Session

After completing the pre-experimental portion, participants who were eligible began the experimental session where participants completed a naming task under positive, negative, and neutral conditions. Each participant was asked to name black and white pictures using only one word and were instructed to do so as quickly and accurately as possible. Participants engaged in a practice naming task until they demonstrated understanding of their instructions. Before starting the naming task within each condition, participants were instructed to view a low-arousal, neutral image on the screen for the duration of three minutes. They were not asked to do anything while looking at this image so that their physiological levels could be measured at baseline. After 3 minutes, the participant began the naming task for the designated condition. During the task, 20 naming trials were presented as follows: (a) two colored images were presented for six seconds each, (b) a 1000 Hz, 500 ms tone signaled, (c) a black and white image was presented until it was named for up to 30 seconds. Both the colored and black and white images corresponded to the emotional arousal and valence of the designated condition (i.e., positive, negative, or neutral).

Immediately after the naming task for each condition, participants completed a Self-Assessment Manikin form (SAM; Bradley & Lang, 1994). The SAM is a visual analogue self-report rating scale used to determine an individual's perceived arousal. Participants were asked to mark the image that matched their arousal on a scale ranging from "relaxed, calm, or unaroused" to "stimulated, excited, or aroused". Between each condition, participants looked at a neutral image for 3 minutes to allow their physiological state to return to baseline. Participants were randomly assigned into one of two condition sequences: order one (neutral, positive, neutral, negative, and neutral) or order two (neutral, negative, neutral, positive, and neutral).

Physiological Measures

ECG and skin conductance recordings were obtained using the NeXus-10 system. Prior to electrode placement, a sterile alcohol skin swab was used to clean areas on which electrodes would be placed. ECG activity was recorded from three disposable silver-silver chloride (Ag/AgCl) electrodes, which were placed on the undersides of each wrist and the underside of the non-dominant forearm. The sampling rate for ECG recording was 256 samples per second. Skin conductance was measured using two Ag/AgCl electrodes, which were placed on the palmar surface of the second and fourth fingertips of the non-dominant hand. The sampling rate for skin conductance recordings was 32 samples per second. Participants were instructed to keep their arms and hands as still as possible with their palms facing upwards to reduce artifacts. Before being analyzed, physiological data were inspected visually for artifacts caused by undesired participant movement. Different researchers inspected each participant's data two times while using a strict protocol to ensure inter-rater reliability. Electrocardiography (ECG) and skin conductance recordings were taken continuously throughout the experiment. Researchers marked the beginning and end of each condition to facilitate data analysis. Mean skin conductance for each condition was calculated using BioTrace+ software (Mind Media, 2019). Artifacts in skin conductance data were identified through visual inspection. Inter-beat intervals (IBI) were extracted from ECG recordings and analyzed with Kubios HRV analysis software (Tarvainen et al., 2014). Segments containing artifacts, which were identified automatedly and through visual inspection (including comparison of the ECG signal with excessive movement detected during video recordings of the session) were excluded. Mean heart rate (HR) and the power (%) within the high frequency band (0.15-.4 Hz; Mackersie & Calderon-Moultrie, 2016) of heart rate variability (HRV) results were obtained using Kubios software.

Data Analysis

Descriptive statistics were obtained for raw data across all conditions including the resting baseline. Absolute difference scores for all physiological measures were then obtained by subtracting the value during each respective condition from the value during the resting baseline condition. Two-way mixed effects ANOVAs were then performed to analyze differences in physiological measures. The Group factor accounted for the two participant groups; The Condition factor accounted for the conditions: neutral, negative, positive; participants were included as a random factor. Correlation analyses were performed using Pearson's R for the following dependent variables: HR, HRV, SC, RT, accuracy, and SAM arousal. 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., 2021).

Results

Two main hypotheses were made at the start of this experiment. First, it was hypothesized that all participants would show greater physiological arousal in naming conditions when compared to baseline (R1) and that the control group would show a higher level of physiological arousal overall when compared to the aphasia group. We also expected all participants to show increased physiological arousal in negative and positive conditions when compared to neutral conditions. Second, in relation to perceived arousal, response time, and accuracy, we assumed that response time would decrease in PWA as their physiological arousal levels increased (Christensen & Wright, 2014). Due to the results of previous studies (Chih et al., 2020; Laures-Gore et al., 2019), we hypothesized that the physiological and self-perceived arousal ratings would not show a strong correlation. Both physiological responses and perceived arousal relationships will be discussed below.

Hypothesis #1: Physiological Arousal

Physiological arousal was measured via changes in HRV, HR, and SC levels. These measures are included in table 3. Consistent with our hypothesis, both groups generally showed increased physiological arousal (i.e., lower HRV levels and increased HR and SC) between baseline and naming conditions. However, the arousal levels did not demonstrate what we hypothesized in the different emotional conditions; no numerical trends were identified between the positive/negative and neutral conditions.

Table 3

Mean and Standard Error of Physiological Responses for All Participants

Variables		R1		N1		NEG		N2		POS		N3	
		Aphasia	Control	Aphasia	Control	Aphasia	Control	Aphasia	Control	Aphasia	Control	Aphasia	Control
HR	M	65.97	71.55	67.46	74.68	65.31	73.14	65.54	71.97	65.38	71.57	65.64	73.23
	SE	4.92	3.15	5.57	3.32	5.66	3.26	5.10	3.26	4.62	3.26	4.48	3.19
HRV	M	31.17	32.01	26.77	28.04	27.99	27.72	34.49	27.07	30.62	28.73	23.94	26.59
	SE	5.27	3.31	4.64	3.41	6.29	2.77	9.62	2.39	6.32	3.53	4.87	3.28
SC	M	1.89	2.34	2.35	3.00	2.41	3.21	2.41	3.27	2.35	3.25	2.59	3.39
	SE	0.27	0.31	0.32	0.41	0.36	0.53	0.42	0.48	0.39	0.45	0.41	0.53

Note. HR=Heart Rate, HRV=Heart rate variability, SC=Skin conductance. HR measured in BPM (beats per minute). HRV reported as the power (%) within the high frequency band (0.15-.4 Hz). SC measured in microSiemens (mS). M=mean; SE=Standard Error**.**

Physiological data were analyzed using two-way mixed effects ANOVAs and correlation coefficients. In relation to the ANOVAs, no main or interaction effects were found for HR, HRV, or skin conductance (see Table 4). Correlation analysis revealed moderate negative correlations between HR and HRV (r = -.31, p < .01).

Table 4

Inferential Statistics for Physiological Measures

Variables	Factor	dF	F	η^2_p	p
HRV	Group	1	.08	.00	.77
	Condition	4	.55	.03	.69
HR	Group	1	.31	.02	.58
	Condition	4	.98	.05	.42
SC	Group	1	1.03	.06	.31
	Condition	4	2.37	.12	.06

Note. HRV = Heart Rate Variability; HR= Heart Rate; SC= Skin Conductance; HR measured in BPM (beats per minute). HRV reported as the power (%) within the high frequency band (0.15-.4 Hz). SC measured in microSiemens (mS).

Hypothesis #2: Relationship Between Response Time, Accuracy, and Perceived Arousal

We hypothesized that response time would decrease in PWA as their physiological arousal levels increased (Christensen & Wright, 2014). While this was not the case in the present study, correlational analyses did reveal a moderate positive correlation between HR and naming accuracy (r = .31, p < .01). A strong negative correlation was also found between accuracy and RT (r = -.60, p < .01). In relation to perceived arousal and consistent with our hypothesis (Chih et al., 2020; Laures-Gore et al., 2019), we found no correlation between physiological and self-perceived arousal ratings. Perceived arousal was moderately correlated, though, with naming accuracy ($r = -.28$, $p < .01$).

Discussion

Two perspectives could potentially explain how physiological arousal interacts with language performance in aphasia. The first perspective, referred to as impaired attentional processing, suggests that poor language performance in PWA is partly caused from decreased attention due to non-optimum levels of physiological arousal (Laures et al., 2003; Marshall et al., 2018; Riley & Owara, 2020). Thus, if physiological arousal was increased, it would in turn improve attention, leading to fewer linguistic errors, decreased response time, and overall improved language production during linguistic tasks (Laures et al., 2003; Marshall et al., 2018; Riley & Owara, 2020). The perspective of linguistic anxiety, on the other hand, suggests that increased physiological arousal is associated with the stress elicited by language-based tasks and will lead to poorer performance due to the need to expend more effort on emotional regulation. Further research is needed to identify which of these two perspectives is most accurate. Although this study is exploratory in nature, it may provide insight and direction regarding future research investigating these perspectives.

Discussion of Hypothesis #1: Physiological Arousal

The findings regarding physiological arousal were not statistically significant; however, numerical trends may still provide useful information in relation to our hypotheses. We used the objective measures of HR, SC, and HRV to track the participants' changes in physiological arousal. HR and SC levels increase when attention improves in response to a stressor (Riley & Owara, 2020). During this study, PWA had a consistently lower HR than control participants. SC levels were also generally lower for PWA than controls. Although differences in these measures were not significant, this general trend may support the idea that the ANS is integral for improved language production in PWA (Laures-Gore et al., 2010; Marshall et al., 2018).

HRV for both groups dropped between the baseline and the majority of naming conditions, suggesting that the participants may have experienced a stress response while participating in the linguistic task. It is possible that the physiological arousal experienced by the participants was not robust enough to cause statistically significant differences between groups, given the small sample size. Second, when HRV levels were compared between groups, only one consistent trend was identified. During the positive and negative emotional conditions, the aphasia group demonstrated numerically higher HRVs than controls, suggesting that the aphasia group did not demonstrate as strong of a physiological response to the negative and positive stimuli as the control group. The reason for these decreased physiological responses is still unknown and more research regarding the physiological and neurological changes that PWA experience after their injuries is necessary.

Additional trends showed that the HRV levels in the aphasia group varied more than the control group overall. This may suggest inconsistent attention as proposed by Riley and Owara (2020). It is possible that the varying levels of physiological arousal correlate with lapses in attention. HRV will also drop when a cognitively challenging task is presented, requiring more effort from the individual, leading to an increase in attention and SNS activation (Christensen & Wright, 2014). People who have a higher HRV are typically more resilient to stress (Campos, 2019; Shaffer & Ginsberg, 2017); however, in this case, the higher HRV levels in PWA suggest agreement with findings that PWA have non-optimal SNS arousal levels which may cause either attention deficits (Laures et al., 2003) or undesired lapses in attention (Riley & Owara, 2020).

Results from previous research, which used similar physiological measures (e.g., skin conductance, heart rate, hormonal levels and respiration) were in line with the notion of undesired lapses in attention for PWA (Laures et al., 2003; Marshall et al., 2018). Although we attempted to increase attention and arousal input through images that were perceived as emotionally arousing, the PWA still did not demonstrate as strong of a physiological response as the control group in the positive and negative conditions. There are a variety of factors that may explain this trend.

First, the images we used may not have been emotionally robust enough to elicit a change in physiological arousal. This is inferred from the results of the study by Choi and colleagues (2017). They explored the use of HRV as an objective tool to measure emotion. They found that significant emotional changes were accurately reflected by HRV data when emotional stimulation was relatively strong. Therefore, they concluded that HRV is a plausible way to track emotional changes but only when there is a high level of emotion induced by stimuli. Even though, like in Choi et al.'s study, we attempted to elicit an emotional response through visual stimuli, the images we used had a lower arousal rating (5.58-5.87 for positive/negative v. 6.24-7.35 for positive/negative). The slight differences in arousal ratings may have affected the physiological responses of the participants, preventing significant changes in arousal.

Second, personal factors may have contributed to the difference in physiological responses. Like Laures-Gore and Buchanan (2015) stated, "one person's stressor can be another person's positive challenge" (p. 696). Although the images chosen were rated by a large group of individuals, the pictures themselves could have elicited different responses from each of the participants based on personal experience. For example, the image depicting a wedding may elicit positive emotional responses in the majority of participants; however, if one of the participants has not had a positive experience with weddings or marriage, their physiological responses may look different. We did not control for personal experience in this study, so it is important to note as these variables may diminish or intensify the perception of stress, impacting the individual's stress response, thereby affecting performance in linguistic tasks and overall success in communication (Laures-Gore & Buchanan, 2015). Future research should consider using emotional stimuli that are personally relevant, which may elicit a higher SNS response.

Discussion of Hypothesis #2: Perceived Arousal, Accuracy, and Response Time

Based on previous findings in other studies (Chih et al., 2020; Laures-Gore et al., 2019) we hypothesized that physiological and self-perceived arousal ratings would not show a strong correlation, which was the case. Thus, the question remains why the aphasia group reported feeling more stressed on the perceived ratings than objective measures showed. Because feelings of stress are based on previous experience, PWA may have reported feeling stressed after the linguistic tasks due to previous encounters with communication breakdowns from language difficulty. The mismatch of subjective rating scales and objective physiological data may stem from the idea that although PWA have non-optimum physiological arousal levels and do not show an evident, physical stress response, previous negative experiences with language tasks may elicit a perceived stress response (Laures et al., 2003; Riley & Owara, 2020).

We also hypothesized that there would be a decrease in RT and increase in accuracy as physiological arousal increased in PWA. Correlations regarding these variables provide insight into the comparison of the two perspectives of poor linguistic performance in PWA previously discussed (i.e., impaired attentional processing and linguistic anxiety).

First, the moderate negative correlation between accuracy and perceived arousal suggests that as participants perceived more stress, their accuracy rating decreased. This initially supports the theory of linguistic anxiety as proposed by Cahana-Amitay and colleagues (2015); however, when the perceived physiological arousal ratings and the objective physiological measures were compared, they were not consistent with each other. Chih et al. (2020) and Laures-Gore et al. (2019) found similar results: Although trends in perceived arousal levels did correlate with poor performance, the objective measurements did not show signs of stress.

Second, the moderate positive correlation found between HR and accuracy might suggest that a higher level of alertness was contributing to increased accuracy. Similar to our findings, Marshall and colleagues (2018) found that as HR increased, language accuracy and overall language output increased as well. These findings provide further support for the perspective of impaired attentional processing, proposing that increased input from the SNS (manifested by increased HR and SC) may lead to improved attention and language skills (Christensen & Wright, 2014)

Riley and Owara (2020) used physiological measurements (i.e., EEG) to complement observable changes in attention in PWA while they accomplished a language task. They found that when participants displayed observable signs of decreased attention, the more errors they produced on language tasks. The EEG data they obtained supported this finding. When EEG signals showed a moderate-high state of attention, the PWA performed better than when EEG signals showed signs of inattention; however, when EEG signals showed signs of a highly vigilant state, performance began to decrease again. This suggests that the linguistic anxiety perspective and non-optimal attention perspective may both be accurate and work hand in hand. Optimal performance may result when there is an “optimum level” of attentional engagement on the task. However, if the SNS input is excessive, the individual may feel linguistic anxiety and performance may again deteriorate. Because we found a positive correlation between HR and accuracy, the trends in the objective data of our findings were more indicative of the perspective of impaired attentional processing in PWA. This supports the idea that the physiological changes experienced in this study may be signs of increased attention rather than having the negative connotation of linguistic stress. Nevertheless, looking at individual responses across participants may help identify patterns between physiological and behavioral responses. These findings could prove valuable when designing future studies.

In summary, correlations and numerical trends found in the present study are supportive of the following notions: (a) Decreased attention levels, marked by decreased physiological arousal, relate to decreased language performance in PWA; (b) PWA often perceive more stress than their physiological arousal levels objectively show.

Limitations and Future Research

There were multiple limitations encountered in this study that could be improved upon in future research. The first limitation was the small sample size (i.e., 6 PWA and 15 controls). Given the small aphasia group, other analyses may have better captured significant differences between groups and among conditions. Future research should include a larger sample size to ensure more reliable results and findings that are more representative of the aphasia population. The second limitation was overgeneralized stimulus images. Although the images used in the study were categorized as negative, positive, or neutral based on their rating for arousal and valence levels, the fact that they were not personalized to each participant could have impacted their emotional response. Future research using a similar study may want to consider having each participant rate the emotionality of the images or find personalized images that elicit emotional responses based on one's own previous experience.

Third, limited research regarding physiological responses in PWA made it difficult to analyze and interpret the mismatch between perceived arousal ratings and objective measures. Although the trend we found was similar to those of other studies (Chih et al., 2020; Laures-Gore et al., 2019), it is possible that a variety of factors could have contributed to it. For example, the aphasia participants may not have understood the rating scale directions that were presented to them. Similar to Laures-Gore and Buchanan (2015), we propose that future research should identify or create the best self-rating methods for perceived stress in PWA, with decreased demand for linguistic processing. The combination of subjective and objective stress assessment measures would provide the best idea of how stress impacts language in PWA. Furthermore, future research could include the use of observable attention measures to provide additional subjective support for the perceived ratings and objective physiological measures.

Clinical Implications

PWA have been shown to have decreased attention skills that negatively affect their language performance (Riley & Owara, 2020; Laures et al., 2003). Trends in our data align with previous findings (Riley & Owara, 2020) and show that when their attention increases, PWA demonstrate fewer linguistic errors and improve language production overall. Furthermore, in order to receive the most benefit from treatment tasks, PWA are required to maintain attention for extended periods of time (Laures et al., 2003). Compromised attention can hamper the benefit of therapy, and therefore, therapy tasks should not only target language, but should aim to improve the cognitive aspects of attention processing as well. Attention levels may improve with increased physiological arousal (Riley & Owara, 2020); however, there are two barriers that may stand in the way of incorporating physiological arousal in clinical practice: (a) it is inconvenient to use objective physiological measures such as HRV, HR, SC, etc. to continuously track attention during therapy sessions and (b) it may be challenging for clinicians to find ways to ethically increase physiological arousal in the clinical setting.

In relation to the first barrier, there are more accessible heart rate monitors developing as apps on a phone or worn on one's wrist that could be integrated into therapy session to track physiological data (Laures-Gore & Buchanan, 2015). On the other hand, Riley and Owara (2020) instead suggested using observable, behavioral attention measures to track changes in attention during therapy sessions. When attention is properly tracked, the appropriate solutions can be provided for patients to be better able to address lapses in attention. For example, solutions may be provided through a change in activity or taking a break from treatment tasks (Riley & Owara, 2020). Other behavioral stress measures such as word productivity can be taken from language samples during a therapy session and overtime, could provide an efficacy measure for treatment (Laures-Gore & Buchanan, 2015). Understanding physiological arousal in PWA could explain poor linguistic performance and provide improved clinical treatments in the future.

The second barrier faced in the clinical application of this data is more difficult to resolve. Since attention increases when the SNS is activated, there needs to be a way to increase SNS activation without purposefully "stressing out" the patient. Trends in our data support the results from other studies (Choi et al., 2017) and show that emotional stimuli have been shown to increase the SNS response; however, the stimuli must be emotionally robust. Visual stimuli that fit this criterion may or may not be ethically appropriate in all clinical settings. Because SNS activation is based on previous experiences, stimuli that is more personally relevant may be a possible solution. However, further research would be necessary to investigate the use of personally relevant stimuli to elicit an SNS response. And even then, obtaining stimuli like this for each patient in the clinical setting may not be practical. Therefore, until further research has been done regarding SNS responses in the clinical setting, clinicians should focus their time in treatment on improving attentional processing in order to facilitate language production.

Conclusion

Previous research has shown that physiological arousal, or stress response, does affect naming ability (Cahana-Amitay et al., 2015; Laures-Gore & Buchanan, 2015); however, the reason behind this is still unknown. Limited work has been done regarding the relationship between physiological arousal and naming ability; and none to our knowledge has researched those variables with emotional stimuli. The purpose of this preliminary study was to identify the effect that emotions have on physiological arousal and during a confrontational naming task. Physiological measures (i.e., HRV, HR, and SC) were obtained while participants with aphasia and neurotypical controls named pictures in positive, negative and neutral conditions. In post-processing, no significant results were found. Nevertheless, the numerical trends that were identified support perspectives from previous studies (Chih et al., 2020; Laures et al., 2003; Laures-Gore et al., 2019; Riley & Owara, 2020) and may also provide direction for continued research on this topic. Expanded knowledge regarding this topic will lead to improvements in the clinical setting to target improved attention in conjunction with language therapy in PWA.

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APPENDIX A

Annotated Bibliography

Bauerly, K. R., Jones, R. M. & Miller, C. (2019). Effects of social stress on autonomic, behavioral, and acoustic parameters in adults who stutter. *Journal of Speech, Language and Hearing Research*, *62*(7), 2185-2202.

Objective: The authors of this study assessed the autonomic physiological responses, behavioral changes and acoustic measures of adults who stutter and those who do not when they are put under social stress.

Method: All participants were required to complete a stress-anxiety inventory, a social stress tests and then prepare and deliver a speech to a group of professional public speakers. Physiological responses were analyzed through skin conductance levels, beats per minute and heat rate variability analyzed through a high frequency band

Results/ Conclusions: Results showed that adults who stutter had higher self-reported stress levels and heart rate variability compared to adults with no stuttering. However, skin conductance levels and heart beats per minute were similar across all groups.

Relevancy to Study: This study uses the same physiological measures and analyses that I am interested in. Furthermore, heart rate variability was analyzed through a high frequency band.

Bauerly, K. R. & Paxton, J. (2017). Effects of emotion on the acoustic parameters in adults who stutter: An exploratory study. *Journal of Fluency Disorders, 54*, 35-49. https://doi.org/10.1016/j.jfludis.2017.09.006.

Objective: The aim of this study was to expand the knowledge of the effect that emotion has on speech-motor control in people who stutter. The researchers assessed the differences in adults who stutter and neurotypical adults while speaking in emotionally arousing conditions (both positive and negative).

Method: The participants were all males between the ages of 21 and 45 and included 10 AWS and 10 ANS. All participants completed three tasks. They viewed images shown on a computer screen, read words on a computer screen and self-rated their feelings in relation to the first two tasks. Pictures were selected based on their emotional valence and encompassed a variety of human emotion such as fear, sadness and joy. Self-reported emotion ratings were taken using the Self-Assessment Manikin. The three tasks were presented in three different emotional categories: negative, positive and neutral.

Results/Conclusion: results show that there are differences in the amount articulatory movement in the categories with greater arousal (positive and negative) compared to neutral conditions. Furthermore, the AWS showed greater changes compared to the ANS.

Relevancy to Study: This study suggests that positive and negative emotional stimuli provide increased arousal than neutral stimuli. In this study, skin conductance and HRV during naming tasks would be used instead of articulatory movement.

Cahana-Amitay, D., Oveis, A. C., Sayers, J. T., Pineles, S. L., Spiro, A., & Albert, M. L. (2015). Biomarkers of “Linguistic Anxiety” in aphasia: A proof-of-concept case study. *Clinical Linguistic and Phonetics*, *29*(5), 401-413. https://doi.org/10.3109/02699206.2015.1014572

Objective: Individuals with aphasia often feel stress or anxious while using language to communicate, but systematic, empirical studies of stress in aphasia are not common. The overall goal of the paper is to emphasize the importance of understanding the emotional effects of aphasia and how it plays a role in recovery and therapy treatment.

Method: This article reviews the current literature discussing language as a stressor in aphasia. Key issues and important gaps are identified, and a future plan of study is proposed.

Results/ Conclusions: The exact role that anxiety plays in aphasia is still undetermined. However, after reviewing the literature, the researchers proposed that language is a stressor for PWA and causes "linguistic anxiety."

Relevancy to Study: This study highlights one of the perspectives about why people with aphasia experience language difficulties and will be compared to other studies' perspectives about poor attentional processing deficits.

Cahana-Amitay, D., Oveis, A. C., Sayers, J. T., Pineles, S. L., Spiro, A., & Albert, M. L. (2015). Biomarkers of "Linguistic Anxiety" in aphasia: A proof-of-concept case study. *Clinical Linguistic and Phonetics*, May 2015, 401-413. https://doi.org/10.3109/02699206.2015.1014572

Objective: This article discusses the idea that people with mild aphasia experience Linguistic Anxiety, which is stress that stems from language use leading to poor language performance. The researchers designed the study as a "proof of concept" exploration, aiming to explore the feasibility of measuring the effects of stress on language performance.

Method: One participant with mild aphasia was given a linguistic and non-linguistic task and his ANS stress responses during the two tasks were measured through BPM, heart rate variability and skin conductance.

Results/ Conclusions: The researchers found heightened levels of anxiety in the language-based tasks compared to non-linguistic tasks, showing that the measurements in their research design were successfully able to measure changes in ANS anxiety levels.

Relevancy to Study: This study uses the same physiological measurements and stress response questionnaire chosen for my thesis study

Caicedo, D., & van Beuzekom, M. (2006). *How do you feel? An assessment of existing tools for the measurement of emotions and their application in consumer products research.* Academia. https://www.academia.edu/10653393

Objective: The aim of this article was to define emotions and discuss the best products available to objectively and subjectively measure them in research.

Methods: This article assesses the available tests and tools used to measure emotion to determine their validity and accuracy of quantifying and qualifying human emotions in experimental research.

Results/ Conclusions: They discussed a variety of assessments but stated that the SAM assessment appeared to be the more valid for subjective measurements.

Relevancy to Study: This study is important for my research as it discusses different ways to measure emotion and why the measures we chose are the most appropriate for our experiment.

Chih, Y. C., Tsai, M. J., Stierwalt, J. A. G., & LaPointe, L. L. (2020). Assessing physiological stress responses to word retrieval in individuals with aphasia: A preliminary study. *Folia Phoniatrica et Logopaedica*, *73*, 134-145. https://doi.org/10.1159/000506335

Objective: The authors of this study aim to measure the physiological response and perceived stress levels in individuals with aphasia during a naming task. Difficulty with word retrieval can cause a stress response in individuals with aphasia. However, little is known about the physiologic elements of the stress response (i.e., heat rate and respiratory rate).

Methods: Seven participants with aphasia and a group of 38 healthy individuals participated in 4 experimental conditions including rest, counting, high frequency and low frequency words. Their physiological measures and perceived stress levels were obtained throughout each condition.

Results/ Conclusions: The researchers found that compared to the rest condition, there were significant differences in heart rate while both groups were participating in language tasks. In the aphasia group, significant differences in respiratory rate were found between the rest and low frequency word conditions, which was different than the control group. No difference in heart rate was found between the two groups. The researchers noted some discrepancies between stress levels and physiological measures. The individuals with aphasia reported greater perceived stress levels, however, the stress levels did not show significant correlations to the physiological measures.

Relevancy to Study: This study included similar measurements (i.e., physiological data and perceived stress/emotional state) and tested a similar population in similar conditions.

Choi, K.-H., Kim, J., Kwon, O. S., Kim, M. J., Ryu, Y. H., & Park, J.-E. (2017). Is heart rate variability (HRV) an adequate tool for evaluating human emotions?—A focus on the use of the International Affective Picture System (IAPS). *Psychiatry Research, 251,* 192–196. https://doi.org/10.1016/j.psychres.2017.02.025

Objective: Emotions vary between individuals and are qualitative in nature, which makes it difficult to measure them with any degree of accuracy. The purpose of this study it to investigate whether or not heart rate variability could be an adequate tool for measuring human emotion objectively.

Method: Subjects consisted of 15 male and 15 female 19-35-year-old individuals with no medical issues that could impact the results. They were instructed to view 15 images of varying valence and arousal levels and complete SAM rating scales after each group of pictures. HRV measurements were taken simultaneously.

Results/Conclusions: There was a significant correlation between HRV and emotion only when the image's arousal level exceeded a high value. Therefore, the findings suggest that HRV measurements may be used accurate when only when a high level of emotion is induced.

Relevancy to Study: This study investigates the value of measuring emotions through HRV which is what we plan to do in our study. We will need to evaluate whether the images in our experiment induce enough emotion to create a strong enough response to be detected by HRV.

Christensen, S. C., & Wright, H. H. (2014). Quantifying the effort individuals with aphasia invest in working memory tasks through heart rate variability. *American Journal of Speech Language Pathology*, *23*(2), S361-S371.

Objective: This study analyzed the cognitive effort needed for people with aphasia to complete verbal and spatial memory tasks compared to the effort needed for neuro-typical individuals.

Method: The cognitive effort was quantified through the physiological measure of heart rate variability. All participants completed three verbal and three spatial memory tasks with varying levels of difficulty. The HRV was analyzed using a low frequency band.

Results/Conclusions: The results state that the individuals with aphasia did not put forth varying levels of cognitive effort for the different levels of difficulty, and that neither group differed their cognitive effort based on the type of memory task.

Relevancy to Study: This study includes the same physiological measure of heart rate variability. Although the HRV is analyzed with a low frequency band instead of high, the study involves the same population (i.e., individuals with aphasia).

Gleichgerrcht, E., Fridriksson, J., & Bonilha, L. (2015). Neuroanatomical foundations of naming impairments across different neurologic conditions. *Neurology*, *85*(3), 284-292. https://doi.org/10.1212/WNL.0000000000001765

Objective: This purpose of this article is to provide a review of the neurologic correlations involved in naming. The researchers review the cognitive processes involved in naming and provide clinical applications for them.

Results/Conclusions: The researchers explore the evidence of certain syndromes and disorders that disrupt neurological stages of naming and provide a guide to making an appropriate differential diagnosis between naming impairments.

Relevancy to Study: Anomia is the naming difficulty that many PWA experience and is the problem we are attempting to address in the study. This article gives physiological support to why naming is a difficulty for PWA.

Hunting-Pompon, R., Kendall, D., & Moore, A. B. (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: This study attempted to answer the following questions “Do people with mild anomia have impaired performance on tasks which require (a) automatic vs. controlled processing and/or (b) selective attention relative to neurologically typical controls?”

Method: 14 participants with mild anomia and 9 neurologically healthy individuals participated in this study. The participants were administered the Cover Orienting of Visuospatial Attention Tas (COVAT) at two intervals to test automatic and controlled process sing.

Results/Conclusions: the participants with anomia demonstrated significantly slower responses on the COVAT. They showed delayed response times when linguistic interference was presented. The individuals with anomia show the greatest delay times when inferences were presented, showing deficits in automatic processing and attention.

Relevancy to Study: This article stressed this importance of assessing non-linguistic aspects of cognitive function in people with naming difficulties.

Kousta, S.-T., Vinson, D. P., & Vigliocco, G. (2009). Emotion words, regardless of polarity, have a processing advantage over neutral words. *Cognition*, *112*(3), 473–481. https://doi-org.erl.lib.byu.edu/10.1016/j.cognition.2009.06.007

Objective: This study presents evidence to support the hypothesis that emotional valence in words facilitates cognitive processing for survival and reaching goals. It also provides evidence for the idea that emotions and cognitions are closely related.

Method: One hundred eight students participated in this study as part of a course requirement at the university college London. Only 79 participants were analyzed (72 women). The researchers collected valence and arousal norms for 1200 words 40 negative, positive and neutral words were selected. Each individual was shown a word on the screen and had to say whether it was a word or not.

Results/Conclusions: The researchers determined that positive and negative words were processed faster than neutral words. Valence was confounded with arousal and it was possible the response time was due to the difference in emotional vs neutral words instead of valence. The researchers analyzed the results and found that valence resulted in similar results, regardless of arousal. Positive and negative words give a processing advantage over neutral words.

Relevancy to Study: Significant stimuli regardless of polarity are processed faster and more efficiently than neutral stimuli, providing evidence compatible with mod- el of motivated attention and affective states in which the advantage is likely to come about at a preattentive level.

Laborde, S., Mosley, E., & Thayer, J. F. (2017). Heart Rate Variability and cardiac vagal tone in psychophysiological research - recommendations for, planning, data analysis and data reporting. *Frontiers in Psychology*, *8*, Article 213. https://doi.org/10.3389/fpsyg.2017.00213

Objective: This article reviews the increased interest in using heart rate variability as a measurement for parasympathetic and sympathetic activity. It provides recommendations for its use in future research.

Summary: HRV has many benefits including its low cost, noninvasive measure, and it is easily accessible to many researchers. However, the interpretation of HRV data can be difficult. This article includes factors that should be assessed before choosing HRV as the means of analysis and the different ways that HRV can be analyzed after data is recorded.

Relevancy to Study: This article was helpful as a guide in the decision to use HRV as a mode of measurement in this research experiment. It's guidelines and suggestions were taken into account for the analysis of the HRV data.

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), 1122-1152.

Objective: The purpose of this article was to study the arousal levels, or vigilance, of people with aphasia compared to nonbrain-damaged individuals.

Method: Vigilance was measured by the change in blood pressure and cortisol levels during tasks involving auditory processing of linguistic and nonlinguistic stimuli.

Results/Conclusions: The researchers found that the arousal levels differed between the two groups of participants but were similar across the different types of tasks, indicating nonoptimal arousal levels regardless of task type.

Relevancy to Study: This article will be beneficial in my thesis, because it provides a clear definition of arousal and vigilance in people with aphasia. It provides evidence that because arousal levels are lower in PWA, they may experience an impaired ability to maintain attention in linguistic-based activities. It also provides rationale for including attention tasks in clinical implications.

Laures-Gore, J. & Buchanan, T. W. (2015). Aphasia and the neuropsychobiology of stress. *J Clin Exp Neuropsychology*, *37*(7), 688-700. https://doi.org/10.1080/13803395.2015.1042839.

Objective: The purpose of this article was to review the current literature on the neuropsychobiology of stress in PWA and offer a proposal for future studies and provide clinical implications for future treatment.

Results/Conclusions: Literature suggests that further research about the impact of stress on PWA could provide insight on linguistic abilities and other difficulties that may stem from stress in PWA.

Relevancy to Study: This study provided a summary of the current literature on stress and aphasia, which is the main focus of my study.

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.

Objective: These researchers based their research off of the notion that individuals with aphasia have a connection between their stress levels and language abilities. This study focused on the cortisol (awakening response) levels in adults with and without aphasia along with their reported stress levels and language abilities.

Method: The cortisol was collected through saliva samples and stress and language were analyzed through questionnaires and narrative descriptions.

Results/Conclusions: Results showed that the participants with aphasia had an absence of the cortisol awakening response, unlike the neurotypical participants whose cortisol levels contributed to optimal performance in the language tasks. Furthermore, the study indicated the absence of awakening response in people with aphasia, which suggests a dysregulation of the HPA axis, although the degree to which is affects language needs further investigation.

Relevancy to Study: This study gives good reasoning for my hypothesis and provides evidence that will be included in the introduction of my thesis.

Laures-Gore, J., DuBay, M. F., Duff, M. C., & Buchanan, T. W. (2010). Identifying behavioral measures of stress in individuals with aphasia. *Journal of Speech, Language, and Hearing Research*, *53*(5), 1394-1400. https://doi.org/10.1044/1092-4388.

Objective: The purpose of this study was to develop valid signs of stress in PWA. They observed the relationship between language variables and the physiological measure of cortisol levels.

Method: Participants included 14 PWA and 10 control participants. Salivary cortisol levels were collected before and after the language tasks which included a language sample. Word productivity and error frequency were rated during the task.

Results/Conclusions: PWA demonstrated less word productivity and more errors than controls. Cortisol levels in the PWA were correlated with an increase word productivity whereas controls did not show this relationship. No correlation was found between cortisol levels and error frequency in either group.

Relevancy to Study: This study supports the idea that physiological measures are different in PWA than neurotypical individuals and that stress may be measured through those physiological measures or linguistic indicators such as word production.

Ledoux, J. E., & Brown, R., (2017). Emotions as a higher-order states of consciousness. *Proceedings of the National Academy of Sciences, 114*(10), E2016-E2025. https://doi.org/10.1073/pnas.1619316114

Objective: The writers of this article aimed to show why emotions are conscious experiences and described how neurological systems play a role in the creation and recognition of human emotion.

Method: Instead of gathering evidence through experimental designs, the researchers gave an explanation through known theories and concepts. They used the emotion of fear as an example throughout the article.

Relevancy to Study: This study provides details about why emotions and the nervous system are connected, which supports my hypothesis that physiological arousal of the nervous system may provide a change in emotion and vice versa.

Levenson, R. W. (2014). The autonomic nervous system and emotion. *Emotion Review*, *6*(2), 100–112. https://doi.org/10.1177/1754073913512003

Objective: This article reviews the ways that human emotion is organized within the autonomic nervous system and provides a description of the systems that create emotional responses.

Results/Conclusions: The researchers conclude that the relationship between emotions and ANS activity has profound implications for future testing of the influence of emotions and stress.

Relevancy to Study: This study provides evidence of why my hypothesis may work- the ANS and emotions would have to be connected in order for PWA to experience a change in physiological arousal from a change in emotion.

Mackersie, C. L., & Calderon-Moultrie, N. (2016). Autonomic nervous system reactivity during speech repetition tasks: Heart rate variability and skin conductance. *Ear and Hearing*, *37*, 118S-125S.

Objective: This study reviews the measures of skin conductance and heart rate variability in the analysis of sympathetic and parasympathetic activity during auditory tasks involving speaking rate.

Results/Conclusions: The researchers found that there was greater sympathetic nervous system arousal and less parasympathetic activity when the participants heard a speaking rate was fast, suggesting greater cognitive effort to perform and understand what was being said in fast rate conditions.

Relevancy to study: This study supports this idea that skin conductance and heart rate variability are valid measures of parasympathetic and sympathetic responses. People with aphasia may have similar physiological responses when put under the cognitive and emotional stress of word recall tasks, therefore, the same physiologic analyses will be performed in this study.

Marshall, R. S., Laures-Gore, J., & Love, K. (2018). Brief mindfulness meditation group training in aphasia: Exploring attention, language and psychophysiological outcomes. *International Journal of Language & Communication Disorders, 53*(1), 40-54. https://doi.org/10.1111/1460-6984.12325

Objective: The aim of this study was to investigate the use of mindfulness meditation training as a low-cost treatment for people with aphasia. However, it was also an exploration of taking physiological measures for people with aphasia in order to track attention and language abilities after physiological changes.

Method: Five adults with aphasia participated in a 5-day mindfulness meditation training. Physiological measures were taken before the training and 1week post-training to track changes in stress levels.

Results/Conclusions: The participants improved fluency ratings directly after mindfulness training, however attention, auditory comprehension and language tests did not improve. Physiological measures showed little different after training.

Relevancy to Study: Since one theory suggests that PWA have difficulties in language due to stress, this article can be part of the literature investigating that idea. However, it will be important in my paper to show that attempts to change physiological measures through calming meditation was not successful and therefore suggests that changes in arousal may.

Riley, E. A., & Owora, A., (2020). Relationship between physiologically measure attention and behavioral task engagement in persons with chronic aphasia. *Journal of Speech, Language, and Hearing Research*, *63*(5), 1430-1445.

Objective: PWA have demonstrated impaired attentional processing that may negatively impact their ability to communicate. The main goal of this study was to objectively measure fluctuations in attention through physiological measures (EEG) and compare them with observable behavioral signs.

Method: Ten people with aphasia and 10 neuro-typical individuals were included in this study. They completed a sentence reading task with 45 active and 45 passive sentences while EEG data was recorded. Video recordings were later watched trained assistants used behavioral rating scales to observe the attention levels of the participants.

Results/Conclusions: Results showed that behavioral engagements were significantly correlated with the participant's performance on tasks- higher engagement levels led to fewer errors. EEG recordings reported distracted/lower physiological states in the same instances of low engagement scores.

Relevancy to Study: This study provides evidence that physiological measures do related to attentional processing and may impact the ability to perform well on linguistic tasks.

Riley, E. A., Owora, A., McCleary, J., and Anderson, A. (2019). Sleepiness, exertion fatigue, arousal, and vigilant attention in persons with chronic aphasia. *American Journal or Speech Language Pathology, 28*(4), 1-18.

Objective: Because individuals recovering from acute and chronic stokes report more sleepiness and fatigue than what they had experienced pre-stroke, researchers in this study aimed to quantify the level of daytime sleepiness, exertion fatigue arousal and attention of individuals with aphasia.

Method: Ten people with aphasia and 10 neuro-typical individuals were included in this study. They were given a 72-minute language task; all measures were taken before and after the task.

Results/Conclusions: The results showed vigilant attention was the only measure that differed between the groups, suggesting that attention may explain why individuals with aphasia experience the feeling of fatigue.

Relevancy to Study: This study measures the levels of physical arousal that people with aphasia experience through stress. It includes HRV measurements to report these levels.

APPENDIX B

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.

<u>Video Recordings</u>

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**.

<u>Risks/Discomforts</u>

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.**

<u>Benefits</u>

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.

<u>Confidentiality</u>

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.

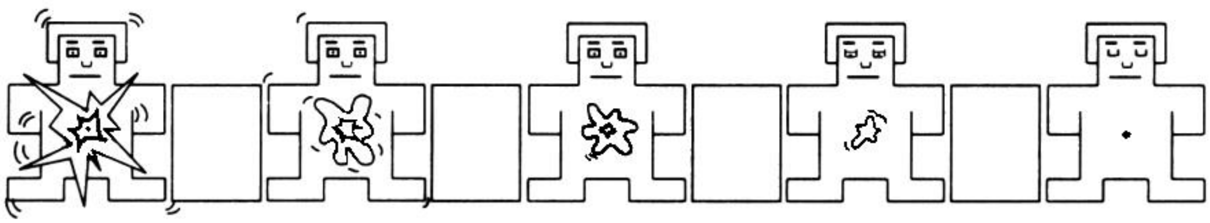
Statement of Consent
I have read, understood, and received a copy of the above consent and desire of my own free will to participate in this study.

Name (Printed):________________ Signature:__________________ Date:________

APPENDIX C

Self-Assessment Manikin Ratings

If you felt completely aroused, stimulated, excited, frenzied, jittery, or wide-awake while viewing the pictures, **you can indicate feeling aroused by pointing to the figure on the left**. If you felt completely relaxed, calm, sluggish, dull, sleepy, or unaroused, **you can indicate feeling unaroused by pointing to the figure on the right.**



Aroused ↔ **Unaroused**

APPENDIX D

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