Exploring associations between chronic stress, depression, and anxiety in people with aphasia

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Abstract

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The challenges people with aphasia face every day may be perceived as stressful. When perceived stressors persist over time, the neural structures and physiology important to memory, learning, and emotion can be negatively impacted. Additionally, the same neural structures affected by chronic stress are also affected by psychological disorders (e.g., depression and generalized anxiety disorder). In this project, we explored associations between measures of chronic stress, depression, and anxiety in people with aphasia. Self-report measures of depression and anxiety were collected and correlated with a self-report measure and biomarker of chronic stress. Results indicate people who report chronic stress are more likely to report symptoms of depression and anxiety. A biomarker of the stress hormone cortisol was not associated with self-report of mood symptoms. These findings suggest complicated underlying relationships between chronic stress, depression, and anxiety in people with aphasia. We anticipate these results will be useful given the converging evidence linking chronic stress and

psychological disorders to changes in neural structures required for successful rehabilitation (i.e., memory, attention, and executive function). The need to continue exploring these constructs in people with aphasia is critical.

I. INTRODUCTION

Per the Centers for Disease Control and Prevention, more than 795,000 Americans survive a stroke each year (CDC, NCHS). Of these 600,000 strokes, about one third will result in aphasia. Aphasia is a multi-modal impairment of language that more than one million people in the United States currently live with (National Aphasia Association). Given the negative effect aphasia has on an individual's ability to effectively communicate, this disorder can profoundly impact aspects of living. As communication skills can be vital in developing and maintaining relationships, employment, leisure activities, life goals and participation (Code & Herrmann, 2003).

The substantial challenges people with aphasia face every day could be perceived as stressful (DuBay, Laures-Gore, Matheny, & Romski, 2011; Laures-Gore, Hamilton, & Matheny, 2007). When perceived stressors persist over time, our body and brain adjust in ways that can be damaging to our health (Rice, 2011; McEwen & Gianaros, 2011; McEwen, 1998). Additionally, chronic stress is related to psychological disorders such as depression and anxiety (Mazure, 1998; Tafet & Bernardini, 2003). Depression is a common occurrence after stroke (Code & Herrmann, 2003) and the neurobiological adjustments our brain makes in response to chronic stress are similar to adjustments associated with psychological disorders (Bao, Meynen, & Swaab, 2008; Pittenger & Duman, 2008; Cramer, Borsboom, Aggen, & Kendler, 2012). That is, the same neural structures affected by chronic stress are also affected by depression.

To date, little is known about the impact of chronic stress and psychological disorders on aphasia rehabilitation. Issues of personal experience are often excluded or neglected in the assessment and treatment of aphasia. While emotional and psychosocial issues may be passively

acknowledged, too few rehabilitation programs make sufficient effort to incorporate psychosocial factors into rehabilitation. Given the converging evidence linking chronic stress and psychological disorders to changes in neural structures required for successful rehabilitation (e.g., memory, attention, and executive function), the need to understand these constructs in people with aphasia is critical.

The purpose of the current paper is to present a background of stress and psychological disorders and their interactions with relevant clinical populations, discuss the significance of exploring these constructs in people with aphasia, outline the methods for the current master's thesis project, and present the findings. We will begin by discussing chronic stress and psychological disorders separately, although, as implied above, the relationship between them is complicated and intertwined.

II. BACKGROUND & SIGNIFICANCE

A. Definitions of and Relationships Between Stress and Psychological Disorders

1. Stress

Stress is defined as the complex interconnected physiological and psychological responses a living organism experiences when faced with an internal or external disturbance (McEwen, 1998; 2006). As humans, we experience these disturbances to the equilibrium of our internal environment frequently. However, not all states of stress are equal and not all stress is necessarily harmful. Stressors can vary from brief and exciting to intense, relentless, and debilitating. Retirement, major personal injury or illness, and change in living conditions are all examples of life events – some positive, some negative – that could initiate a stress response

(Holmes & Rahe, 1967). When we experience stress, the regulatory centers of the brain respond in complex ways to calibrate our internal equilibrium. In a healthy stress response, the related systems in the body react in the moment when a stressor arises and return to homeostasis when the stressor is removed. Some of these regulatory centers include limbic structures (e.g., hippocampus and amygdala) and the hypothalamus-pituitary-adrenal (HPA) axis (Tafet & Bernardini, 2003). The HPA axis is responsible for the release and interactions of hormones responsible for activating and terminating the stress "alarm" response, like corticotropin-releasing hormone (CRH), adrenocorticotropin (ACTH), and cortisol. Given its role in mediating a stress response, cortisol is frequently used as a biological measure of an individual's stress level. Accordingly, elevated cortisol is frequently associated with increased HPA axis activity (McEwen, 2003).

A stressful experience can be identified as positive or damaging based on factors like genetics, general physical health, how much perceived control an individual has over the stressor, and individual coping style (Folkman & Lazarus, 1988). Perceived stress is related to coping resources (Cohen et al., 1983). Two major reaction patterns in response to stressful life events have historically been described: 1) problem-focused active coping (coping associated with perceived control and managing a challenge) and 2) emotion-focused coping (coping associated with feelings of helplessness and avoidance) which is associated with increased HPA axis activity (Tafet & Bernardini, 2003). Thus, one person's stressor could be another person's positive challenge.

Stressors that are judged by the individual to be mild, pleasant, or conquerable may have a positive influence on the body and behavior. For example, acute stress mobilizes the body to

"fight or flee;" overcoming the associated challenge can yield not only physical safety, but could lead to personal development and learning (McEwen & Gianaros, 2011). However, maladaptive responses to stress that are detrimental to the brain and body can occur. Specifically, pathophysiological adaptations can occur when 1) the individual faces persisting, repetitive, and/or unavoidable stressors, resulting in repeated "hits" of the stress response, 2) the stress alarm response will not terminate, resulting in maladaptive prolongation of the stress response, 3) the alarm response is not turned on when needed or "under-activated" (McEwen, 1998). These patterns of stress responses lead to cumulative changes we refer to as "chronic stress." The pathophysiological adaptations associated with chronic stress can lead to increased risk of stroke, heart disease, immunosuppression, depression, other illnesses and psychological disorders, and changes to the brain (Bao et al, 2008). The background presented will focus on the observed neural changes associated with chronic stress.

Specifically, adaptations to chronic stress appear to influence the neural structures and physiology important to memory, learning, and emotion. Increasing evidence including both translational animal studies and human studies demonstrates that chronic stress precipitates neuronal atrophy, especially in the prefrontal cortex (PFC) and the hippocampus (e.g., Bao et al, 2008; McEwen & Gianaros, 2011; Pittenger & Duman, 2008; Tafet & Bernardini, 2003). The hippocampus and PFC are both involved in the stress response system and contain a high concentration of cortisol receptors (Tafet & Bernardini, 2003). Logically, since chronic stress appears to interfere with an individual's neuroplastic capacity, it could impact learning in people with aphasia. Chronic stress may therefore limit the success of aphasia rehabilitation, though this association has yet to be explored.

The same stressors that result in suppressed neuroplasticity of the hippocampus and PFC affect the amygdala differently. Chronic stress appears to overactivate neural activity and produce neuronal growth in the amygdala (Pittenger & Duman, 2007). The amygdala is essentially involved in the analysis of the emotional significance of external stressors, as well as the emotional appraisal of internal stressors. Thus, chronic stress leads to the overactivation of the neuronal circuits that control fear, anxiety, and emotion. In other words, the structural remodeling of the brain under chronic stress may increase the likelihood of emotional dysregulation and vulnerability for the development of psychological disorders while impairing the systems necessary for successful rehabilitation.

2. Stress and Psychological Disorders

Depression is a psychological disorder characterized by emotional and somatic symptoms, such a loss of pleasure or interest in activities, feelings of excessive guilt or worthlessness and certain physiological changes such as change in sleep (i.e., insomnia or hypersomnia) or in movement (e.g., psychomotor agitation) (DSM-5). The link between stress and depression has long been observed in both research and clinical populations (e.g., Liu & Alloy, 2010). It is widely known stressful life events and chronic adverse conditions are among the most powerful catalysts to depressive episodes. This consistent finding has led some researchers to label depression and anxiety as “disorders of stress adaptation” (McEwen & Gianaros, 2011). A review, including 2,000 cases of major depression, found approximately 80% of depression diagnoses were preceded by stressors (Mazure, 1998). Additionally, depression has been associated with increased cortisol in otherwise healthy populations (Anton, 1987; Posener et al, 2000), though the evidence has been inconsistent (Stadler et al, 2017).

Like depression, exposure to stressors has also been implicated in the development of generalized anxiety disorder (GAD) and other anxiety disorders (Arborelius et al, 1999; Nemeroff, 2004). GAD is a chronic form of anxiety characterized by excessive and uncontrollable worrying. Patients experience symptoms such as restlessness, difficulty concentrating, muscle tension, irritability, and sleep disturbance (DSM-5). Some evidence of overproduction of cortisol in GAD exists, through research is not consistent (Tiller, Biddle, Maguire, & Davies, 1998; Stadler et al, 2017).

As mentioned previously, the same neurobiological processes we observe in chronic stress are also observed in individuals with psychological disorders. That is, the same structures affected by chronic stress are the structures that are functionally different in people with major depression and anxiety syndromes. Neural imaging of persons with major depression and anxiety disorders (e.g., GAD) show the hippocampus and PFC are both reduced in size and activity, and the amygdala's size and activity are increased. Amygdala hypertrophy is associated with elevated behavioral measures of anxiety in experimental animal studies (Pittenger & Duman, 2007). Structural changes in these brain regions are important for psychological disorders because the altered neurobiology is likely to contribute to impaired cognitive function (McEwen, 2004). Moreover, cognitive impairment is a core behavioral symptom of major depression (DSM-5) and one of the formal diagnostic criteria for the syndrome is a 'diminished ability to think or concentrate' (American Psychiatric Association, 2000). Patients with major depression often complain of difficulty with executive function (e.g., time management, attention, etc.) during everyday tasks and also exhibit prominent deficits in explicit memory (Pittinger & Duman, 2007).

Notably, the neural changes associated with chronic stress and depression may be modified by psychotherapy and medical management. There is growing evidence documenting cognitive therapy, pharmacological intervention, and certain forms of medication can enhance frontal lobe function and inhibit amygdala activation (DeRubeis, Siegle, & Hollon, 2008; Davidson & McEwen, 2012). That is, alterations in brain regions implicated in chronic stress and psychological disorders are sensitive to targeted intervention.

Logically, since psychological disorders interfere with the neurophysiology required for memory, attention, and executive function, they may limit the cognitive rehabilitation inherent in aphasia treatment. Indeed, in a longitudinal study conducted by Robinson, Lipsey, Rao, and Price (1986), it was revealed that depression negatively impacted post-stroke cognitive rehabilitation outcomes. To maximize therapeutic gains for people with aphasia, it is essential to address psychological symptoms.

B. Stress, Psychological Disorders and Clinical Populations

1. Stress, Psychological Disorders, and Stroke

The possible interactions of stress and psychological disorders in the aphasia population are not yet well understood though these constructs have been investigated separately and in other clinical populations. In fact, most literature to date has viewed aphasia and depression as separate outcomes of stroke (Døli, Helland, & Andersen Helland, 2017). A consistent finding in this literature is people who have suffered a stroke demonstrate a higher level of stress than the general population (Barugh, Gray, Shenkin, MacLullich, & Mead, 2014; Baune & Aljeesh, 2006; Hilari, Northcott, Roy, Marshall, Wiggins et al., 2010). This finding is reflected in both behavioral/self-report measures and in biological measures of distress. Specifically, both

elevated plasma, salivary, and/or urinary cortisol levels (Barugh, Gray, Shenkin, MacLullich, & Mead, 2014) and higher levels of psychological stress (Dennis, O'Rourke, Lewis, Sharpe, & Warlow, 2000) have been observed in acutely post-stroke patients. Notably, spontaneous elevation in cortisol occurs immediately following stroke, however, this elevation appears to subside after one year (Bustamante, Sobrino, Giralt, Garcia-Berrocoso, Llombart, Ugariza, Espadaler, et al, 2014).

Additionally, depression is frequently observed after stroke. In a systematic review including over 22,000 people conducted by the American Heart Association, the estimated proportion of stroke survivors suffering from depression was 33% (Hackett, Yapa, Parag, & Anderson, 2005). Though traditionally it was believed the greatest risk for depression is in the acute recovery phase following stroke, this study demonstrated the risk for depression remained stable even into long-term recovery (i.e., included participants up to 5 years post-stroke).

Emerging evidence suggests anxiety is nearly as prevalent as depression after stroke. Specifically, a longitudinal study found a prevalence rate between 22% and 28% at both the acute stage and chronic stage of recovery (Astrom, 1996). High anxiety is associated with reduction in concentration, attention, and sleep disruption (Kneebone, Neffgen, & Pettyfer, 2012). It is likely this could impact stroke rehabilitation.

Importantly, people with aphasia are systematically excluded from published studies of psychological disorders in post-stroke populations. Given the difficulties people with aphasia are likely to have in comprehending and responding to self-report measures designed for neurologically intact individuals, they are largely excluded from these reported research samples.

Consequently, the incidence of stress and psychological disorders in patients with language impairments resulting from stroke may be underestimated.

2. Stress, Psychological Disorders, and Aphasia

Individuals with aphasia specifically may experience more stress because of the presence and nature of language impairments. To date, studies suggest that people with aphasia report higher levels of stress than people without brain damage (e.g., Laures-Gore, Hamilton, & Matheny; Parr 1994; Hilari, Northcott, Roy, Marshall, Wiggins et al., 2010). However, these studies have primarily focused on the acute stages of recovery (e.g., hours to weeks post-stroke).

Laures-Gore and Buchanan propose a framework (Figure 1; 2015) for understanding how factors such as aphasia profile and personal coping style can mediate stress. They incorporate factors know to influence stress reactivity in healthy populations as well as those unique to people with aphasia. Specifically, they pose that moment-to-moment language difficulties associated with aphasia do not uniformly generate a stress response, but instead several individual factors, such as coping style and social support, interact with the perception of linguistic difficulties to generate biological and psychological stress symptoms.

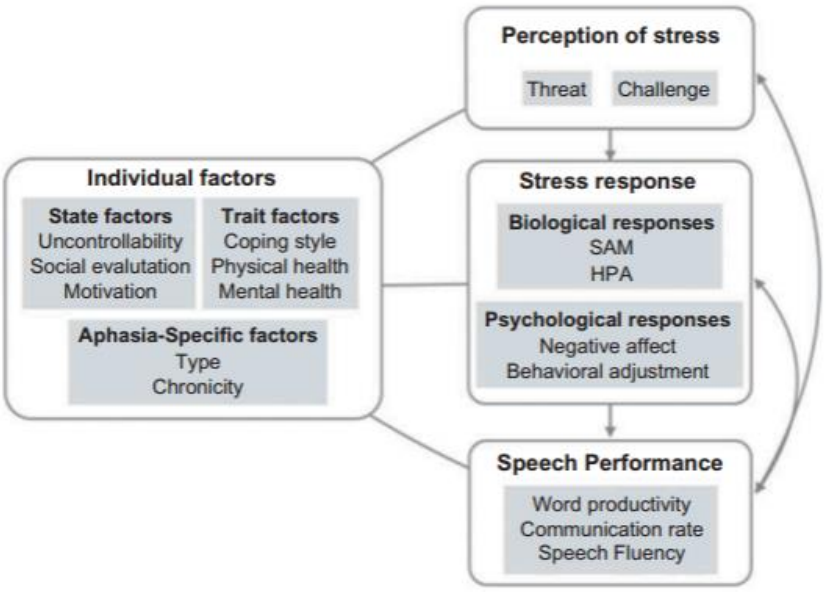


Figure 1: *A neuropsychobiological stress model in individuals with aphasia (Laures-Gore & Buchanan, 2015)*

However, little is known about the long-term impact on people with aphasia when these moment-to-moment stressors are chronic and persistent. Coping resources are thought to be factors that may mediate the effects of chronic stress (Wheaton, 1983). Specifically, the psychological resources of individuals to cope with stressors are important variables that contribute to the development of depressive symptoms. These factors are impacted in people with aphasia. DuBay et al (2011) found people with aphasia have fewer perceived coping resources than neurologically intact individuals or individuals with right brain damage (i.e., brain damage not resulting in aphasia).

Negative emotional symptoms such as depression and anxiety are often observed in people with aphasia (Code & Herrmann, 2003; Fucetola, Connor, Perry, & Leo, 2006; Spencer, Tompkins, & Schulz, 1997). Depression is a frequent reaction to the onset of aphasia (Code & Herrmann, 2003) and often persists into the chronic stage of recovery (Spencer, Tompkins, &

Schulz, 1997). Additionally, Fucetola et al determined that self-reported measures of depressive symptoms were predictive of functional communication (2006). That is, mood state was predictive of performance on a measure of communication in everyday life with angry, sad, tired, and tense mood states resulting in poorer performance.

C. Significance

This project is significant given the existing literature connecting chronic stress and psychological disorders and the limited evidence exploring this connection in post-stroke and aphasic populations. An improved understanding of the relationships between chronic stress, depression, and anxiety in people with aphasia may impact rehabilitation.

The relationship between stress, psychopathology, and cortisol has been explored in otherwise healthy populations. The link between chronic stress and psychological disorders has been well established. Given the current literature, it is highly likely that a large proportion of people with aphasia are experiencing chronic stress and/or symptoms of psychological disorders. These threats to emotional well-being could impact the neuroplasticity and neurobiology of brain regions involved in memory, attention, and executive function – the same constructs necessary for successful rehabilitation. However, study of the possible interactions of stress, depression, and anxiety in the aphasia population has not kept pace with research on these same constructs in other clinical populations. If these relationships are more deeply explored, it could have a significant impact on our understanding of aphasia and how it is treated clinically.

For this reason, the proposed master's thesis project sought to examine the relationship between chronic stress and psychological disorders (i.e., depression and generalized anxiety disorder) in people with aphasia. This project aligns with a larger study which seeks to validate a

measure of chronic stress in people with aphasia. We hypothesized people with aphasia who report experiencing chronic stress are also highly likely to experience symptoms of depression and anxiety. Moreover, we predicted a biological measure of stress would be positively associated with depression and anxiety measures. This master's thesis project sought to answer two research questions:

1. Is self-report of chronic stress associated with self-reports of depression and anxiety in people with aphasia?
2. Is a biological measure of chronic stress associated with self-reports of depression and anxiety in people with aphasia?

Table 1.
Summary of Independent Measures and Dependent Measures

Independent Measures	Dependent Measures
Self-Report of Chronic Stress: Modified Perceived Stress Scale (mPSS) Total Score	Self-Report of Depression: Patient Health Questionnaire-8 (PHQ-8) Total Score
Biological Marker of Chronic Stress: Scalp Hair Cortisol Level in Picograms/Milligram	Self-Report of Anxiety: Generalized Anxiety Disorder Scale-7 (GAD-7) Total Score

III. METHODS

A. Overview and Design

This correlational study investigated the relationship between behavioral and biological measures of chronic stress and psychological disorders. Data were collected using self-report measures and a single biological measure, scalp hair cortisol level. Participants provided this information through paper-based questionnaires and a hair sample.

B. Participants

Seventy-two individuals previously diagnosed with aphasia completed questionnaires that measure self-reported levels of chronic stress, anxiety, and depression after giving their consent to participate in the study. Hair scalp cortisol samples were collected from fifty-seven eligible participants. Participants were at least 21 years of age, and at least one year post-onset language-dominant hemisphere stroke. Individuals with all levels of severity were included in the study provided they could sufficiently demonstrate comprehension of and agreement to the IRB-approved informed consent process. Participants with a concomitant diagnosis of apraxia of speech and/or dysarthria were also included.

Stroke could have an impact on many areas of life including physical impairments, communication skills, and cognition (Sarre, Redlich, Tinker, Sadler, Bhalla, & McKevitt, 2013). Thus, subjects with concomitant communication and physical diagnoses were included in the project. Following stroke, individuals have complex and varied impairment profiles and the experience of aphasia brings different changes to function for everyone. Instead of limiting subjects to the very uncommon clinical presentation of aphasia in the absence of any other deficits (e.g., dysarthria, apraxia of speech, hemiplegia), participants more accurately represented the diversity clinical population.

Individuals who were excluded from participation are those with neurodegenerative impairment, active substance abuse, adrenocortical dysfunction (e.g., Cushing syndrome), and those currently using glucocorticoid medication (e.g., Prednisone).

C. Procedures

Participants were recruited from the IRB-approved University of Washington Aphasia Registry and Repository and the VA Puget Sound Health Care System. The examiner first reviewed the protocol and completed the IRB-approved informed consent process with each participant. After obtaining consent, the examiner collected demographic information (e.g., age, education level, and months post onset) and descriptive information (e.g., use of glucocorticoid medications, current substance abuse, and hair treatment types). Next, participants completed language and vision testing (Comprehensive Aphasia Test, comprehension and vision subtests; Howard, Swinburn & Porter, 2004), questionnaires, and had a hair sample taken (described below). The examiner administered the primary experimental measure (mPSS) after the completion of descriptive measures. To control for order effects, the examiner administered secondary and tertiary experimental measures in one of three different pseudo-random orders. Approximately thirty percent of participants (29.2%) completed a follow-up session with a selection of questionnaires to ensure reliability of responses.

D. Dependent Measures

1. Chronic Stress

The two primary ways stress is measured are behaviorally and biologically. In this project, self-report measures were collected using a modified version of the Perceived Stress Scale (PSS; Cohen & Janicki-Deverts, 2012; Cohen, Kamarck, Mermelstein, 1983; Cohen & Williamson, 1988), the Modified Perceived Stress Scale (mPSS; Hunting Pompon, in preparation) (See Appendix B). The original PSS has been validated for use with the general population. For the larger research study associated with the present project, the PSS had been

modified through expert panels and cognitive interviewing to make it maximally understood by people with communication limitations. To maintain the validity of the original PSS (Cohen & Janicki-Deverts, 2012; Cohen, Kamarck, Mermelstein, 1983; Cohen & Williamson, 1988), modification did not alter the tone or intent of the instructions, the number of items, the emphasis of each question, nor the number or structure of response options. The mPSS consists of ten questions about the participant's perceived stress within the last month. Participants respond, verbally or gesturally (i.e., pointing) on an ordinal scale with five response options from "Never" to "Very Often." The ordinal scale is supplemented with visual representations of the response options. While modifications supported understanding of the scale for some people with aphasia, people with more severe communication impairment still struggled with comprehension of the instrument. Therefore, the mPSS was administered with the communicative support hierarchy and independence rating scale created by Tucker, Edwards, Matthews, Baum, and Connor (2012) (See Appendix C).

Stress can be measured via a number of different systems including physiology, subjective report, and behavior (Laures-Gore & Buchanan, 2015). Given the key role cortisol plays in mediating the physiological stress response, it has often been used as a measure for assessing stress. However, traditional cortisol assessment (e.g., plasma, saliva, or urine analysis) reflects short-term cortisol levels. The assessment of scalp hair cortisol represents a relatively new methodological approach to measure long-term cortisol levels (Stadler & Kirschbaum, 2012).

Measurement of individual long-term cortisol levels provided a biological measure of chronic stress in participants. A scalp hair sample approximately 3mm in diameter (approximate

width of a pencil eraser) was collected from the posterior vertex of the scalp. The hair was clipped with an electric hair trimmer as close to the scalp as possible. The samples were cut to approximately 2 cm in length representing 2 months of hair growth (i.e., 2-3 months' worth of cortisol levels) (Stadler et al, 2012; Wennig, 2000). The sample was secured in aluminum foil and stored at room temperature until it was sent to the University of Washington Biobehavioral Health Informatics Lab for processing. Once in the lab, the hair was weighed, cut into small sections, then pulverized into a powder. The powder was poured into a vial, 3 ml of methanol was added, and the vial was sealed and placed in a tube rotator overnight. Next, the methanol, which then contained the extracted cortisol, was removed and put into a Speed-Vac lyophilizer. The resulting pellet was resuspended in a cortisol buffer (Salimetrics High-Sensitivity Cortisol EIA kit; Salimetrics, LLC, State College, PA) and the assay was carried out using the protocol set forth by the kit. Cortisol level determination is through extrapolation of sample values based on a standard curve generated with each EIA test kit. Sample values were compared against a reference range for neurologically typical adults (17.7-153.2 pg/mg; Sauve, et al, 2007).

2. Psychological Disorders

Psychological disorders were evaluated through psychological self-report measures, specifically the Patient Health Questionnaire (PHQ-8; Kroenke, Spitzer, & Williams, 2009) to measure depression (See Appendix D) and the General Anxiety Disorder scale (GAD-7; Spitzer, Kroenke, Williams, and Lowe, 2006) (See Appendix E). Both the PHQ-8 and GAD-7 are popular, valid measures of emotional symptoms often used with clinical populations. Items on these measures are relatively simply worded and derived from the DSM-IV criteria for depressive disorder and generalized anxiety disorder, respectively. For example, item 1 on the

PHQ-8 states “Little interest or pleasure in doing things;” item 2 on the GAD-7 states, “Not being able to stop or control worrying.” For both measures, the participant identifies how often in the past 2 weeks they have experienced a particular symptom. They select one of four options from: “not at all” to “nearly every day.” These measures were expected to provide evidence of a positive association between chronic stress and psychological disorders.

3. Secondary Measures

The mPSS, PHQ-8, and GAD-7 were administered with the Stress Visual Analogue Scale (Stress VAS; Lesage, Berjot, & Deschamps, 2012), and Connor Davidson Resilience Scale (CD-RISC; Connor & Davidson, 2003). These questionnaires served as different behavioral measures of stress in each participant for the larger study. That is, though these questionnaires were included in the testing session, their results will not be reported in the current master’s thesis project.

4. Communicative Support and Independence Ranking

The examiner administered all self-report measures (i.e., the mPSS, Stress VAS, CD-RISC, PHQ-9, and GAD-7) through simultaneous auditory and visual presentation by the examiner. All self-report measures were administered with the Tucker Support Hierarchy and Independence Rating Scale (Tucker et al, 2012). The Tucker Hierarchy and Scale allowed the examiner to modify environmental support systematically and rate the level of independence for participants’ performance on each measure. The Tucker et al (2012) hierarchy outlines specific environmental modifications for the examiner to offer the participant during test item administration, such as “2. Restate, simplify question format, review scale” and “3. Re-explain the choice scale.” The independence scale is a 7-point rating scale that allows the examiner to

identify the level of communicative support necessary for each participant ("1=does not produce response with maximal support" to "7=responds with no need for additional support") (pg. 45, Tucker et al, 2012). Use of the Tucker Hierarchy of Support and Independence Rating Scale allowed people with a broader range of aphasia severity to participate in the project.

E. Data Analysis

Data analysis involved a Pearson's product-moment correlation and simple linear regression. The total scores on the mPSS were used to measure self-report of chronic stress, total scores on the PHQ-8 were used to measure self-reports of depression, and total scores on the GAD-7 were used to measure self-reports of anxiety. Biological measurement of chronic stress was determined based on cortisol level (picogram/milligrams).

Research Question 1 - *Is self-report of chronic stress associated with self-reports of depression and anxiety in people with aphasia?*

Analysis - To determine the relationships among these variables, a Pearson's product-moment correlation was performed on mPSS, PHQ-8 and GAD-7 scores. A simple linear regression was completed on statistically significant correlations.

Research Question 2 - *Is a biological measure of chronic stress associated with self-reports of depression and anxiety in people with aphasia?*

Analysis - Correlational analyses were applied to cortisol level, PHQ-8 scores, and GAD-7 scores.

IV. RESULTS

A. Demographic Statistics

Across the 72 participants, age ranged from 33-84 years (*m*=64.53, *SD*=10.91). Participants were all classified in the chronic phase of recovery (i.e., at least one year post-onset language-dominant hemisphere stroke) and ranged from 12-228 months post injury, with an average of 81.10 months since onset (*SD*=54). The total for 5 Comprehensive Aphasia Test comprehension subtests (out of 125 points), ranged from 33-125 points (*m*=98.52, *SD*=21.9). Please see Table 2 for complete demographic statistics.

Table 2.
Demographic Data of Participants

Pt #	age	sex	ed yrs	months post	CAT comp total
001	72	F	17	228	112
002	65	F	17	71	114
003	48	F	16	39	116
004	72	F	18	69	111
005	66	F	14	45	116
006	56	M	14	31	123
007	66	F	12	112	106
008	63	M	16	30	115
009	56	M	16	94	123
010	67	F	18	32	125
011	63	M	19	60	72
012	75	F	15	18	76
013	64	F	15	46	109
014	70	F	12	63	95
015	67	M	16	23	117
016	66	M	13	96	118
017	67	F	16	26	98
019	65	M	14	15	106
020	79	F	20	120	113
021	84	F	18	56	110
022	70	M	12	45	102

023	68	M	16	131	66
024	60	M	12	23	87
025	53	F	13	92	94
026	61	M	14	106	111
027	79	F	16	24	123
028	65	F	18	168	70
029	70	M	16	141	124
030	79	M	15	60	106
031	75	M	14	63	103
032	56	M	16	37	107
033	71	M	15	78	116
034	61	F	20	132	79
035	78	M	13	73	33
037	71	F	16	220	119
038	60	F	12	203	97
039	69	M	26	128	90
040	63	M	14	16	86
041	52	F	16	70	108
042	67	M	16	124	85
043	79	M	18	144	104
044	60	M	18	148	88
045	56	F	13	75	85
046	65	M	12	173	50
048	63	M	16	100	104
049	33	M	14	114	89
050	64	M	16	64	86
051	62	M	25	72	116
052	66	F	16	153	78
053	59	F	14	88	52
054	73	M	16	175	102
055	63	M	19	139	102
056	55	M	16	14	118
057	74	M	25	86	126
058	63	M	19	116	125
059	79	M	25	149	92
060	37	M	16	156	113
061	73	M	20	48	77
062	70	M	13	136	107
063	71	M	16	29	107
064	55	M	16	22	107

065	46	M	14	27	103
066	62	M	16	54	102
067	64	M	20	34	101
068	84	F	19	27	87
069	75	M	20	12	91
070	40	F	13	61	92
071	57	F	12	35	100
072	74	F	18	57	117
073	42	F	16	38	102
074	40	M	12	52	85
075	83	F	15	33	103
mean	**64.53**	**29**	**16.17**	**81.10**	**98.52**
(*SD*)	**10.91**	**43**	**3.16**	**54**	**21.9**

B. Descriptive Statistics

Of the 72 participants, 57 were eligible for scalp hair cortisol sampling. That is, their hair was at least 2 cm in length, they had not used hair dye in the past 8 weeks, and they were not using any glucocorticoid medications. Participants who used hair color provided a sample, however, values were not considered in the statistical analysis. Cortisol values ranged from 3.2-60.0 picograms/milligram (*m*=22.2, *SD*=14.74).

Pt #	cortisol pg/mg	mPSS	PHQ-8	GAD-7
001	20.0	11	0	0
002	25.0	20	6	4
003	14.3	19	10	5
004	DNT	17	3	1
005	DNT	15	3	5
006	DNT	18	8	9
007	11.3	17	9	5
008	30.0	17	12	17
009	30.0	1	1	1
010	7.3	16	6	10

011	25.0	15	6	4
012	13.3	8	4	0
013	8.6	9	2	3
014	8.2	18	8	6
015	28.0	11	7	4
016	11.7	12	10	10
017	32.0	13	2	2
019	25.0	19	8	12
020	3.7	17	7	12
021	36.4	16	7	5
022	45.5	11	2	2
023	30.8	19	4	10
024	8.7	14	3	2
025	53.3	18	7	12
026	28.5	23	14	12
027	5.1	21	1	3
028	3.4	15	4	2
029	30.0	19	4	5
030	4.0	18	9	6
031	12.7	3	3	3
032	17.5	12	9	4
033	DNT	8	2	0
034	5.3	8	4	1
035	38.4	30	17	DNT
037	16.7	15	5	3
038	13.3	11	10	3
039	39.7	12	2	1
040	33.3	17	10	6
041	27.5	21	13	5
042	60.0	12	3	4
043	26.2	12	7	6
044	30.2	15	5	7
045	11.2	19	2	8
046	19.4	10	7	0
048	10.8	12	3	3
049	19.2	15	10	5
050	33.3	10	11	6
051	7.6	23	8	8
052	18.3	13	4	3
053	8.4	14	4	2

054	11.4	13	3	2
055	10.0	15	6	6
056	14.4	14	3	2
057	27.0	4	4	0
058	22.1	19	4	7
059	9.5	14	12	7
060	33.8	28	7	17
061	22.8	31	0	0
062	46.4	10	6	3
063	73.3	7	6	2
064	27.4	24	9	9
065	3.2	19	6	5
066	2.4	3	1	0
067	16.0	6	5	2
068	44.8	19	6	3
069	20.3	27	11	5
070	46.6	14	7	2
071	17.0	6	2	5
072	35.5	7	5	2
073	18.9	26	7	10
074	3.7	14	7	3
075	15.4	18	3	1
mean	**22.2**	**14.96**	**5.92**	**4.79**
(SD)	**14.74**	**6.17**	**3.52**	**3.87**

C. Correlation and Regression

RQ 1. To determine the association between self-reports of chronic stress and self-reports of depression and anxiety, tests of correlation were performed. A Pearson correlation test was conducted among mPSS and PHQ-8 scores for the entire sample (n = 72). This resulted in a statistically significant moderate positive correlation (r = .408, p < 0.01) (See Figure 1). A Pearson correlation test was conducted among mPSS and GAD-7 scores for the entire sample (n

= 72) and this resulted in a statistically significant moderate positive correlation (r = .520, p < .01) (See Figure 2).

Figure 1.
Significant positive correlation between self-report chronic stress (mPSS) and depression (PHQ-8)

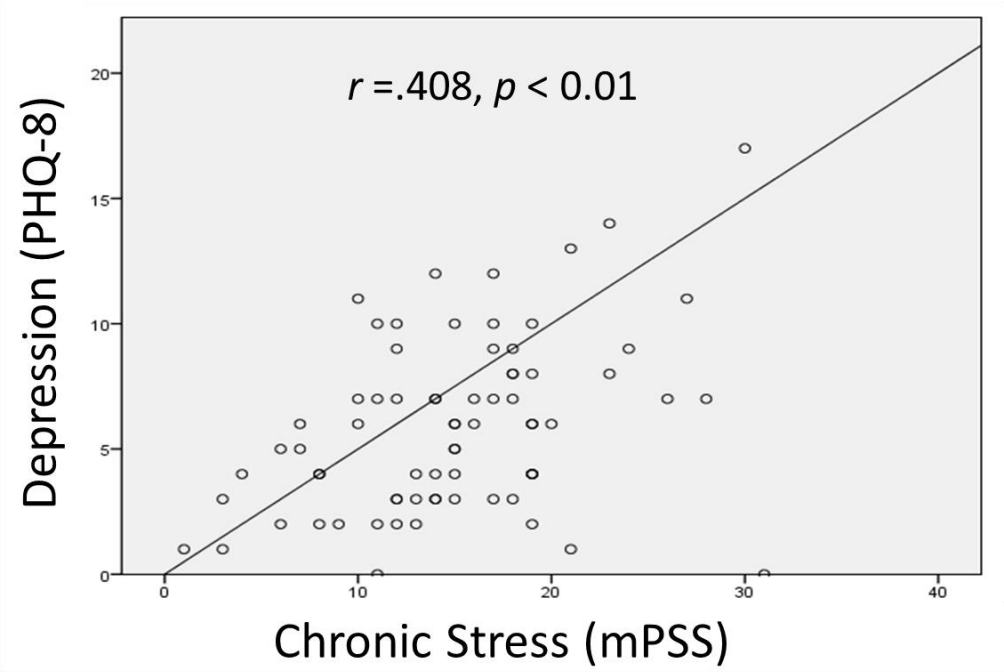
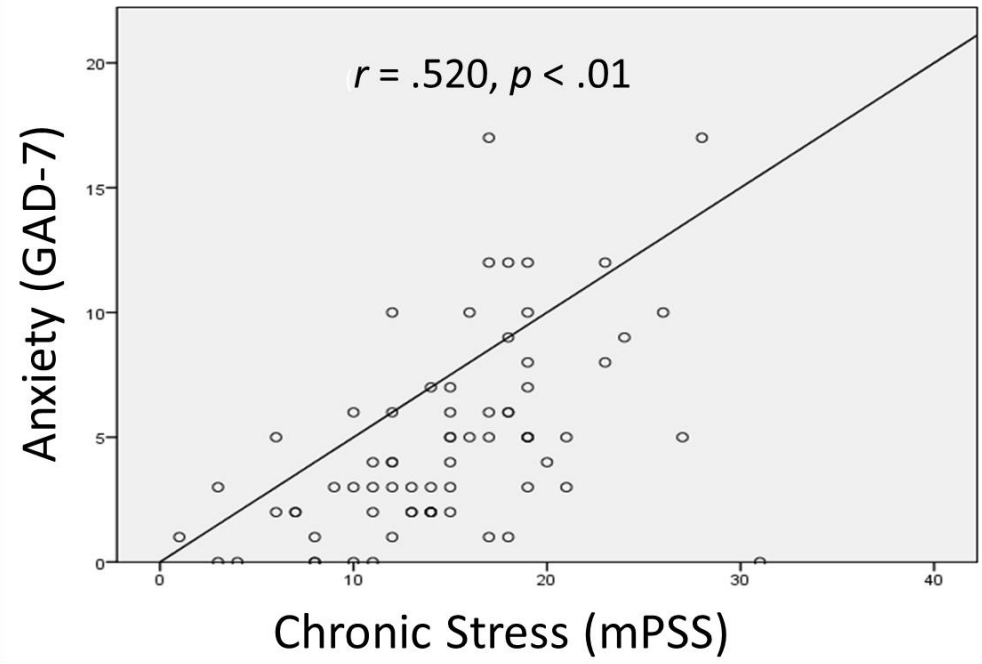


Figure 2.
Significant positive correlation between self-report chronic stress (mPSS) and anxiety (GAD-7).



A simple linear regression was calculated to predict PHQ-8 scores based on mPSS scores. A significant regression equation was found (F (1, 70) = 13.989, p < .01), with an R^2 of .167. Mean PHQ-8 score increased for each 0.232 points reported on the mPSS. A simple linear regression was calculated to predict GAD-7 scores based on mPSS scores. A significant regression equation was found (F (1, 69) = 25.632, p < .01), with an R^2 of .271. Mean GAD-7 score increased for each 0.339 points reported on the mPSS. See Figure 3 for full report of linear regression analysis.

Figure 3.
Simple linear regression for significant correlations only.

	R^2	*F*	*b*	*t*	*Beta*
PHQ-8	.167	13.989**	.232	3.740	.408
GAD-7	.271	25.632**	.339	5.063	.520

** p < .01

RQ 2. To determine the association between cortisol values and self-reports of depression and anxiety, tests of correlation were performed. A Pearson correlation test was conducted among PHQ-8 scores and cortisol values (pg/mg) for all eligible participants (n = 57). This did not reach statistical significance (r = .100, p = .457) (See Figure 4). A Pearson correlation test was conducted among GAD-7 scores and cortisol values (pg/mg) for all eligible participants (n = 57). This did not reach statistical significance (r = .076, p = .576) (See Figure 5).

Figure 4.
No correlation between hair scalp cortisol value (pg/mg) and depression (PHQ-8)

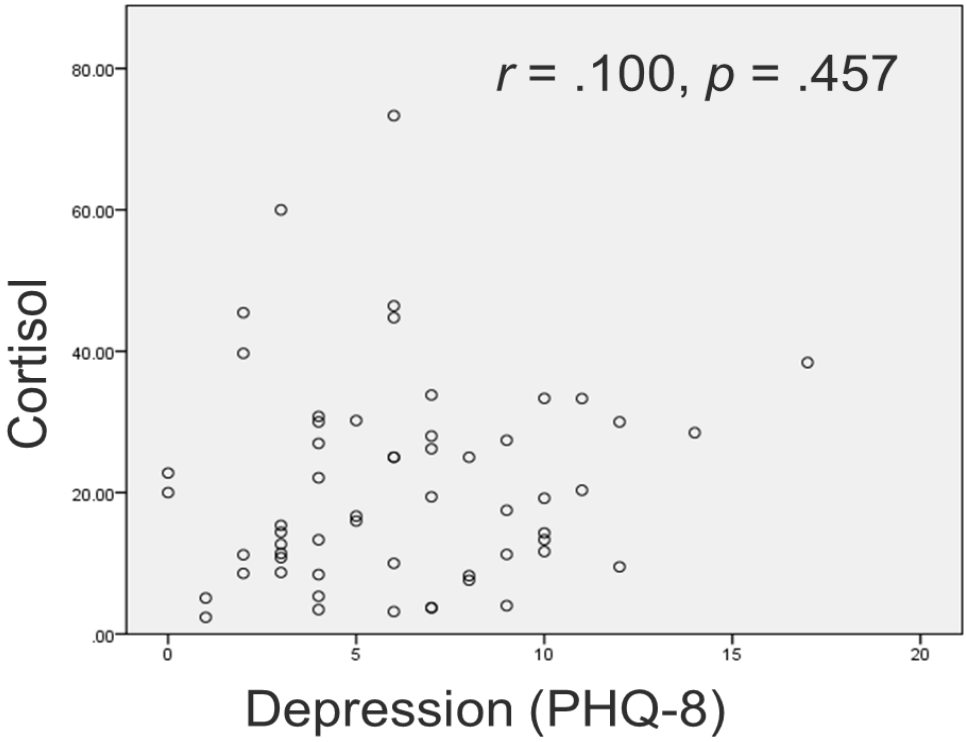
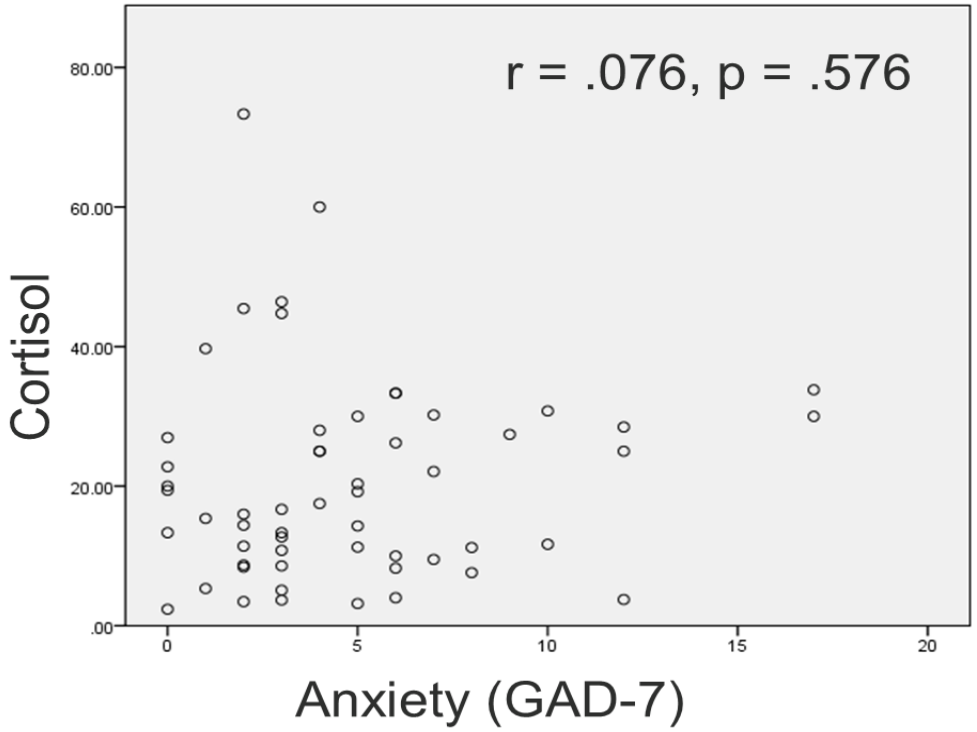


Figure 5.
No correlation between hair scalp cortisol value (pg/mg) and anxiety (GAD-7)



V. DISCUSSION

The purpose of this master's thesis project was to investigate the relationships between measures of chronic stress and self-report measures of depression and anxiety in people with aphasia. We explored associations between both self-report and biological measures of chronic stress and self-report of depression, and anxiety. Our results revealed 1) a measure of chronic stress was correlated with both a measure of depression and a measure of anxiety, and 2) self-report measures of depression and anxiety were not correlated to scalp hair cortisol levels in people with aphasia. In the following discussion, we will outline conclusions and clinical implications drawn from these findings. Finally, we will address limitations of the current project and propose future directions.

A. Stress and Anxiety

The first aim of this project was to determine the relationship between self-report measures of chronic stress, depression, and anxiety. We measured symptoms of chronic stress with a modified version of the PSS made to be maximally understood by people with aphasia, the mPSS (Hunting Pompon, in preparation). Symptoms of anxiety were measured using the GAD-7. A large review of the psychometric evidence of the PSS revealed PSS scores were consistently either moderately or strongly correlated with emotional variables, such as anxiety (Lee, 2012). In these studies, anxiety was measured using the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983), State-Trait Anxiety Inventory (Spielberger, 1983), Escala de Cansancio Emocional (Scale of Emotional Exhaustion; Ramos, Manga, & Moran, 2005), General Health Questionnaire (Goldberg & Williams, 1991), or Depression Anxiety Stress Scale-21 (Lyrakos, Arvaniti, Smyrnioti, & Kostopanahiotou, 2011). That is, no studies to date have examined the relationship between the PSS with the GAD-7. However, given the psychopathological nature of generalized anxiety disorder, we hypothesized the mPSS total score would be associated with measures of anxiety.

Data analysis revealed scores on the mPSS were moderately associated with the GAD-7. That is, people with aphasia who report chronic stress are more likely to report symptoms of anxiety. This finding supports the literature connecting valuations of chronic stress with measures of anxiety. In addition to correlating mPSS with GAD-7 scores, our results indicated a high proportion (14.1%) of subjects were experiencing symptoms of anxiety.

In our sample, the proportion of participants with aphasia over the GAD-7 cut-point of 10 was 14.1%. The proportion of participants who reported mild anxiety symptoms (i.e., GAD-7

scores 5-9) was 32.4%. There is an estimated 2.8% to 8.5% people with GAD in general medical practice (Olfson, Fireman, Weissman, Leon, Sheehan, & Kathol, 1997; Byrne & Wagner, 2004) and 1.6% to 5.0% in the general population (Wittchen, Zhao, Kessler, & Eaton, 1994; Kessler, Brandenburn, & Lane, 2005; Kessler, Keller, & Wittchen, 2001). That is, this sample reported a higher prevalence of anxiety symptoms on the GAD-7 than epidemiological estimates in either the general population or in general medicine. This is consistent with a prospective study conducted by Astrom (1996) that demonstrated a high prevalence of GAD that extends into chronic recovery after stroke (i.e., 11.8% at 3-years post stroke). Their sample included patients with aphasia and their findings suggest GAD was more frequent in people with communication impairment following stroke.

Our results demonstrating the relationship between chronic stress and anxiety are significant because anxiety can be distracting and disabling (Astrom, 1996). Individuals with generalized anxiety disorder report having difficulty focusing and feeling distracted (Faravelli, Castellini, Benni, Brugnera, Landi, Lo Sauro et al, 2012). A number of studies have demonstrated anxious people perform worse than people without anxiety on goal-oriented tasks and working memory tasks (Maloney, Sattizah, & Beilock, 2014; Vytal, Cornwell, Letkiewicz, Arkin, & Gillon, 2013). One current hypothesis is if cognitive resources (e.g., executive function) are used up by anxious thoughts, the individual has less cognitive resources to perform tasks (Vytal et al, 2013). This could have significant implications for aphasia rehabilitation. If chronic stress and anxiety interfere with a person's ability to attend to treatment, logically, these constructs may limit the success of intervention.

B. Stress and Depression

This project also sought to examine the relationship between self-reports of chronic stress and depression. Symptoms of chronic stress were measured using the mPSS and symptoms of depression were measured using the PHQ-8. Previous literature examining the convergent validity of the PSS report moderate positive correlations with measures of depression including the PHQ-8 (Wu & Amtmann, 2013; Mitchell, Crane, & Kim, 2008). This association has been demonstrated in a few different clinical populations, however, this relationship had yet to be investigated in people with aphasia. Given the substantial relationship of stress and depression, we hypothesized the mPSS total score would be associated with measures of depression.

Data analysis revealed scores on the mPSS were associated with the PHQ-8. Not surprisingly, people with aphasia who report chronic stress are more likely to report symptoms of depression. Our findings support and expand the compelling evidence supporting a link between major adverse life experiences and subsequent depressive symptoms. The notion that stressful life events contribute to psychological disturbance and psychological disorders is widely accepted today (Mazure, 1998) based on both clinical observation and empirical findings. This relationship has been consistently demonstrated in adults without stroke and our results suggest this association is observed in people with stroke and aphasia.

The PHQ-8 is one increasingly used measure for assessing depression (Kroenke et al., 2001). Kroenke et al (2008) demonstrated PHQ-8 severity scores are sensitive and specific for measuring depressive disorders. It has been used to effectively detect symptoms of depression in both clinical (Kroenke and Spitzer, 2002) and population-based settings (Martin et al., 2006). Specifically, older populations (Klapow et al., 2002), as well as in patients with cancer (Dwight-

Johnson et al., 2005), chronic kidney disease (Drayer et al., 2006), and neurological disorders like traumatic brain injury (Bombardier et al., 2006; Bombardier et al., 2004). However, this measure has not been used to measure depression in people with aphasia.

In a large epidemiological study, PHQ-8 scores detected a prevalence of major depression (greater than or equal to a score of 10) in 4.3% in their general population sample (Kroenke et al, 2008). This study also reported 9.1% prevalence of mild depression (a score of 5-9). The proportion of people with aphasia in our sample who reported a major depression using this same cut-point was 16.7%. The proportion of people with a mild depression was 32.4%. In other words, people with aphasia reported a relatively much higher prevalence of depression than the general population.

This finding is significant; depressive symptoms in people with aphasia could have considerable effect on rehabilitation outcomes. Depression is associated with poorer functional communication (Fucetola et al, 2006) and changes in cognitive and language processing (Code & Hermann, 2003) in stroke survivors. Moreover, clinicians, researchers, and healthcare institutions develop and initiate language-based treatments for aphasia that depend on new learning. Logically, since chronic stress and depressive symptoms appear to interfere with an individual's neuroplastic capacity, these constructs may therefore limit the success of aphasia rehabilitation.

C. Factors Influencing Depression and Anxiety

Simple linear regressions were completed using 1) mPSS and PHQ-8 scores and 2) mPSS and GAD-7 scores. As discussed previously, self-report of chronic stress has a positive relationship with both depression and anxiety self-report. Results of regression analyses indicate

chronic stress measured by the mPSS accounted for 16.7% of the variance in depression (i.e., PHQ-8) scores and 27.1% of the variance in anxiety (i.e., GAD-7) scores. This suggests while chronic stress uniquely predicts a proportion of these psychological disorders, there are other factors we did not measure in this project that contribute to depression and anxiety.

This is perhaps not surprising given the incredible number of factors, from within and without, that impact an individual's risk for psychological disorders. Factors in additional to chronic stressors that may predict psychological disorders include: individual differences like genetics, development, and experience; unique personal behavior like diet, smoking, drinking, and exercise; coping style; and being lesbian, gay, bisexual, transgender, or intersex in an unsupportive situation (McEwen & Gianaros, 2011; McEwen, 1998; Kelleher, 2009). Any number of these factors may account for a proportion of the variance in depression and anxiety scores.

D. Hair Cortisol and Self-Report of Depression and Anxiety

Contrary to our expectations, we found no relationship between a biological marker of stress (i.e., scalp hair cortisol levels) and depression or anxiety. There could be several explanations for why this association was not observed in our sample.

One possible explanation could be methodological issues with scalp hair cortisol sampling. This analysis represents a relatively new strategy for measuring cortisol in an individual's system over time. The earliest reports available indicating the overall validity reach back only to 2007 (e.g., Sauve et al, 2007; Stadler et al, 2010; Thomson et al, 2010). Though findings have indicated the overall validity (e.g., Short et al, 2016; Stadler et al, 2010) and test-retest reliability (Stadler et al, 2010) of hair cortisol assessments, researchers are still developing

the “gold-standard” approach. New studies are currently being developed and published at the time of this project. In other words, once we understand more about the methods of hair cortisol sampling, we may be more likely to observe a relationship between this biological marker of stress and psychological disorders.

An alternate explanation for why we did not observe an association between hair cortisol levels and psychological disorders could be there was in fact no relationship between hair cortisol levels and these measures. Some studies have demonstrated a relationship between measures of self-reported psychological disorders and hair cortisol samples, but others have not (Stadler et al, 2017; Russell et al, 2011). This conflicting evidence demonstrates the complexity of the stress system. That is, there are many variables contributing to mediating and propagating physiological stress responses and measuring these variables over time is an added level of complexity. Complex chronic stress and dysregulation of the systems involved in psychological disorders may be less clearly reflected in hair cortisol values. We need more information and need to continue collecting biological and behavioral markers of stress and psychological disorders to further understand this relationship.

An alternative explanation for our findings is there is a difference in long-term cortisol levels for people who experience chronic stressors, like what may arise from aphasia. People with more severe chronic stress may not mirror the biophysiological response patterns apparent in normal populations with less stress. This concept was reflected in our finding that descriptively, a large proportion of participants demonstrated lower than typical levels of cortisol (Sauve et al, 2007). In a recent meta-analysis (see Stadler, Steudte-Schmiedgen, Alexander, Klucken, et al, 2017) including 10,289 samples, a 17% lower scalp hair cortisol concentration

was observed in patients with anxiety disorders such as general anxiety disorder (GAD). The core emotional themes and features of a chronic stressor like aphasia may cause differences in physiological responses we do not yet understand. However, there is emerging literature connecting hypocortisolism and anxiety disorders. This may contribute to our complicated findings and is ripe for future exploration.

E. Implications

People with aphasia are often excluded from studies measuring psychological disorders following stroke (Spencer, Tompkins, & Schulz, 1997). Emerging evidence suggests people with aphasia are more vulnerable to developing depression following stroke than people with stroke without aphasia (Code & Hermann, 2003; Dubay et al, 2011; Hilari et al 2011). Consequently, the literature does not reflect the full picture of the incidence of stress and psychological disorders in stroke populations. Additionally, individuals with diagnosed psychological disorders are often excluded from clinical research (e.g., Kendall & Nadeau, 2016; Wambaugh et al, 2013). This means the effects of current widely used treatment programs have not been examined for people with psychological disorders such as depression or anxiety. When more is known about stress and psychological disorders and their role in aphasia, then more specific behavioral, pharmacological, and counseling interventions could be developed.

Understanding the neuropsychobiology of stress and psychological disorders in aphasia could shed light on clinically relevant issues including different recovery profiles of individual patients and potential health consequences of chronic stress. Moreover, any comprehensive account of the pathophysiology of psychological disorders in people with aphasia will include an important causal role for chronic stress. While reliable biological measures are still being

developed, questionnaires, diaries, visual analog scales depicting mood states could be used to collect basic information about stress levels and psychological disorders (Fucetola et al, 2006). It appears the mPSS, PHQ-8, and GAD-7 are feasible candidates for the identification of stress and emotional symptoms in people with aphasia. Kneebone et al (2012) also outline protocols and instruments available for commercial use recommended for use with people with aphasia and/or cognitive disability. It is important for clinicians to screen and assess for depression and anxiety in people with aphasia following stroke and understand the negative impact psychological disorders have on post-stroke cognitive rehabilitation (Robinson et al, 1986).

Though depression and anxiety syndromes frequently co-occur, it is important to consider these psychological constructs separately. In this system of continuous interaction, it may not be possible to isolate dependent and independent variables. However, importantly there is a clinical difference in the treatment and prognosis of depression and GAD (Astrom, 1996). Depression and anxiety-related disorders have different, distinguishing symptom profiles and different patterns of recovery (McEwen, 2003). Bragoni (2013) demonstrated anxiety impacted functional rehabilitation outcomes (i.e., mobility) after subacute stroke. In this study, they did not find other psychological features, such as depressive symptoms, impacted outcomes. This suggests anxiety symptoms and depressive symptoms may impact rehabilitation outcomes differently. Thus, it is important to measure these constructs separately and develop targeted behavioral treatment and supports for individuals with different psychological profiles.

F. Limitations

The present master's thesis project is subject to some limitations. First, our use of the mPSS, PHQ-8, and GAD-7 could be used for screening but not diagnostic purposes. The larger

study with which this project aligns seeks to validate the mPSS and thus, standardization and validity information are not yet available. The PHQ-8 and GAD-7 are both used as screening tools to collect information about symptomology associated with psychological disorders. Screening measures such as the PHQ-8 and GAD-7 are helpful for collecting relevant symptoms of depression and anxiety, though higher scores do not necessarily indicate the diagnosis of a psychological disorder and lower scores do not necessarily indicate the absence of a psychological disorder. While the standardized and reliable nature of these screening measures is an advantage, normative information for use with PWA is very limited (Kroenke & Williams, 2009). Consequently, the objective scores of these screening measures must be interpreted with caution in this population.

Second, the current project did not attempt to control for other life events, additional stroke sequelae impacting emotional symptoms, or premorbid psychological diagnosis. We did not collect information about depression diagnoses or current anti-depression use. In other words, participants may already have diagnosed psychological disorders and/or may already be treated pharmacologically for depression or anxiety. The use of anti-depressants in post-stroke depression populations is associated with a significant reduction in depressive symptoms (Chen et al, 2007). Thus, if individuals were actively being treated with anti-depressants, they may have been less likely to endorse depressive symptoms in self-report. Additionally, some anti-depressant medications act directly on hormones and neurotransmitters such as norepinephrine (e.g., selective noradrenaline reuptake inhibitors) and serotonin (e.g., selective serotonin reuptake inhibitors) (Chollet et al, 2013). However, their impact on cortisol values is not well understood (Pariante et al, 2004).

G. Future Directions

Even though there has been a growing interest in the psychological sequelae of stroke, there are still many outstanding questions and gaps in our knowledge that need to be addressed. First, rehabilitation therapists and researchers alike should work to develop protocols and assessment tools to capture psychological symptoms in people with aphasia. Assessing chronic stress, depression, and anxiety in people with communication impairment remains a complicated venture. The relatively poor level of evidence regarding the prevalence of psychological disorders and the lack of psychometric data for widely used measures for people with aphasia highlights this difficulty. Further exploration of how to assess these constructs in people with language impairment is likely to point to a deeper understanding and, hopefully, better measurement techniques.

Biological measures could contribute to accurate evaluation of psychological disorders in post-stroke aphasia populations. However, further investigation of biomarkers of chronic stress and psychological disorders in people with aphasia is warranted. In light of the mixed evidence in the literature and our surprising cortisol findings, scalp cortisol sampling should be subject to further investigation.

Finally, the impact of psychological disorders and emotional symptoms have emerged as important considerations in the course of stroke rehabilitation. Chronic stress, depression, and anxiety almost certainly impact aphasia treatment. However, the influence of these constructs on treatment outcomes is not often measured and is not yet well understood. Matters of personal experience, including emotional and psychological symptoms, are frequently overlooked as factors that may contribute to the success of rehabilitation. Especially given the current literature

linking chronic stress and psychological disorders to changes in neuroplasticity, future studies should investigate how these constructs impact new learning and intervention in people with aphasia.

H. Conclusions

In conclusion, this project sought to explore associations between chronic stress and psychological disorders in people with aphasia. Findings indicate a self-report measure of chronic stress is associated with both a self-report measure of depression and a self-report measure of anxiety. Hair scalp cortisol levels were not associated with self-report measures of psychological disorders. These findings suggest complex underlying relationships between chronic stress, depression, and anxiety in people with aphasia.

The convergence of literature of chronic stress and psychological disorders on an overlapping set of neural mechanisms is increasingly apparent and suggests a deep connection between these constructs. We anticipate the results of this project will be useful given the growing evidence linking chronic stress and psychological disorders to changes in neural structures required for successful rehabilitation (e.g., memory, attention, and executive function).

Additionally, the prevalence of depression and prevalence of anxiety were both high in our sample of people with aphasia. Given the demographics of the current sample, this finding suggests depression and anxiety after stroke are common and potentially long-lasting. Considering the difference in symptom profile and prognosis, it is important to measure symptoms of depression and anxiety separately. Our understanding of the emotional changes people with aphasia demonstrate, including how to assess them, has critical implications for

rehabilitation outcomes. That is, to provide patients with the maximum opportunity for therapeutic gains, it is essential to attend to psychological symptoms.

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Appendix A) Demographic, descriptive and experimental data

CAT comp total *is the total for 5 Comprehensive Aphasia Test comprehension subtests, we do not have normative data for these subtests alone;* cortisol pg/mg *is pictograms per milligrams in hair sample;* mPSS *is modified Perceived Stress Scale (range 0-40; higher score = higher stress);* StressVAS *is the Stress Visual Analogue Scale (range 0-100, higher score = higher stress);* CD-RISC *is the Connor-Davidson Resilience Scale (range 0-50, higher score = more resilient);* PHQ-8 *is the Personal Health Questionnaire Depression Scale (range of 0-24, higher score = higher level of depressive symptoms);* GAD-7 *is the Generalized Anxiety Disorder Scale (range 0-21, higher score = higher level of anxiety symptoms).*

DESCRIPTIVE INFORMATION						*EXPIMENTAL SCALES*			
Pt #	age	sex	ed yrs	months post	CAT comp total	cortisol pg/mg	mPSS	PHQ-8	GAD-7
001	72	F	17	228	112	20.0	11	0	0
002	65	F	17	71	114	25.0	20	6	4
003	48	F	16	39	116	14.3	19	10	5
004	72	F	18	69	111	DNT	17	3	1
005	66	F	14	45	116	DNT	15	3	5
006	56	M	14	31	123	DNT	18	8	9
007	66	F	12	112	106	11.3	17	9	5
008	63	M	16	30	115	30.0	17	12	17
009	56	M	16	94	123	30.0	1	1	1
010	67	F	18	32	125	7.3	16	6	10
011	63	M	19	60	72	25.0	15	6	4
012	75	F	15	18	76	13.3	8	4	0
013	64	F	15	46	109	8.6	9	2	3
014	70	F	12	63	95	8.2	18	8	6
015	67	M	16	23	117	28.0	11	7	4
016	66	M	13	96	118	11.7	12	10	10
017	67	F	16	26	98	32.0	13	2	2
019	65	M	14	15	106	25.0	19	8	12
020	79	F	20	120	113	3.7	17	7	12
021	84	F	18	56	110	36.4	16	7	5
022	70	M	12	45	102	45.5	11	2	2
023	68	M	16	131	66	30.8	19	4	10
024	60	M	12	23	87	8.7	14	3	2
025	53	F	13	92	94	53.3	18	7	12
026	61	M	14	106	111	28.5	23	14	12
027	79	F	16	24	123	5.1	21	1	3
028	65	F	18	168	70	3.4	15	4	2
029	70	M	16	141	124	30.0	19	4	5
030	79	M	15	60	106	4.0	18	9	6
031	75	M	14	63	103	12.7	3	3	3

032	56	M	16	37	107	17.5	12	9	4
033	71	M	15	78	116	DNT	8	2	0
034	61	F	20	132	79	5.3	8	4	1
035	78	M	13	73	33	38.4	30	17	DNT
037	71	F	16	220	119	16.7	15	5	3
038	60	F	12	203	97	13.3	11	10	3
039	69	M	26	128	90	39.7	12	2	1
040	63	M	14	16	86	33.3	17	10	6
041	52	F	16	70	108	27.5	21	13	5
042	67	M	16	124	85	60.0	12	3	4
043	79	M	18	144	104	26.2	12	7	6
044	60	M	18	148	88	30.2	15	5	7
045	56	F	13	75	85	11.2	19	2	8
046	65	M	12	173	50	19.4	10	7	0
048	63	M	16	100	104	10.8	12	3	3
049	33	M	14	114	89	19.2	15	10	5
050	64	M	16	64	86	33.3	10	11	6
051	62	M	25	72	116	7.6	23	8	8
052	66	F	16	153	78	18.3	13	4	3
053	59	F	14	88	52	8.4	14	4	2
054	73	M	16	175	102	11.4	13	3	2
055	63	M	19	139	102	10.0	15	6	6
056	55	M	16	14	118	14.4	14	3	2
057	74	M	25	86	126	27.0	4	4	0
058	63	M	19	116	125	22.1	19	4	7
059	79	M	25	149	92	9.5	14	12	7
060	37	M	16	156	113	33.8	28	7	17
061	73	M	20	48	77	22.8	31	0	0
062	70	M	13	136	107	46.4	10	6	3
063	71	M	16	29	107	73.3	7	6	2
064	55	M	16	22	107	27.4	24	9	9
065	46	M	14	27	103	3.2	19	6	5
066	62	M	16	54	102	2.4	3	1	0
067	64	M	20	34	101	16.0	6	5	2
068	84	F	19	27	87	44.8	19	6	3
069	75	M	20	12	91	20.3	27	11	5
070	40	F	13	61	92	46.6	14	7	2
071	57	F	12	35	100	17.0	6	2	5
072	74	F	18	57	117	35.5	7	5	2
073	42	F	16	38	102	18.9	26	7	10

074	40	M	12	52	85	3.7	14	7	3
075	83	F	15	33	103	15.4	18	3	1
Mean	**64.53**	**29**	**16.17**	**81.10**	**98.52**	**22.2**	**14.96**	**5.92**	**4.79**
(SD)	**10.91**	**43**	**3.16**	**54**	**21.9**	**14.74**	**6.17**	**3.52**	**3.87**