# Emotional Diathesis, Emotional Stress, and Childhood Stuttering

By

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This dissertation is dedicated to …

My husband, Heechun, who encouraged and supported my research so that I could achieve my dream,

My son, Ray who had to learn to do without a mother's care from a very tender age while I was working on this dissertation,

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# CHAPTER I

# INTRODUCTION

## The Relation between Emotion and Childhood Stuttering

For some time, researchers have empirically studied and/or speculated about the association between environmental or exogenous emotional stress (e.g., parents' negative evaluation) and childhood stuttering (e.g., Adams, 1992; Bloodstein, 1949; Johnson, Boehmler & Dahlstrom, 1959; Yairi, 1997). Although not all of these researchers appeared to assume that emotion contributes to childhood stuttering, they do seem to assume that if emotion is associated with stuttering, exogenous emotional stress would play a salient role.

While exogenous factors are certainly of import to our understanding of the association of emotion and childhood stuttering, others have recently begun to consider whether children who stutter (CWS) more actively process exogenous or environmental emotional stress and whether such processing (e.g., temperamental vulnerability) may be associated with their stuttering (Conture, Kelly, & Walden, 2013; Conture & Walden, 2012; Conture, Walden, Arnold, Graham, Harfield, & Karrass, 2006; Kefalianos, Onslow, Block, Menzies, & Reilly, 2012; Seery, Watkins, Mangelsdorf, & Shigeto, 2007). One example of such consideration is Conture and Walden's (2012) Dual Diathesis-Stressor (DD-S) account of childhood stuttering. In brief, this model suggests that variable emotional stressors (i.e., challenges) may intermittently activate CWS's relatively stable (endogenous) emotional or temperamental diathesis (i.e., vulnerability). Activation of such a diathesis, the model suggests, is associated with disruptions in these children's fluent speech and language planning and/or production.

Nonetheless, not a great deal is known about *how* emotional stress and children's emotional or temperamental diathesis affect their stuttering. One could speculate, for example, that heightened sympathetic arousal, which is known to be associated with emotional response to emotional stress, diverts attentional resources away from speech-language processes and thus disrupts speech fluency. In the same vein, Weber and Smith (1990) suggested that respiratory function or reflex pathways involved in speech production may be disrupted by alterations in sympathetic arousal and contribute to speech disfluency. Prior to testing such speculations, however, further empirical assessment of the association between emotional stress, emotional/temperamental diathesis, sympathetic arousal, and stuttering appears warranted.

Therefore, what follows is a brief review of extant information regarding the associations between emotional/temperamental diathesis, emotional stress, sympathetic arousal and childhood stuttering. Based on this review, as well as a theoretical account of the association between emotion and childhood stuttering, the potential impact of emotional diathesis and emotional stress as well as their interaction on childhood stuttering is discussed. Subsequently, the possibility is raised that these variables and their interaction influence childhood stuttering through sympathetic arousal. Following this discussion, the present author explicates several theory-driven, empirically-testable hypotheses seemingly pertinent to the role that emotion may play in childhood stuttering.

## Overview of Existing Empirical Studies

*Emotional Diathesis and Stuttering*

A diathesis (sometimes referred to as a disposition, proclivity or vulnerability) is typically conceptualized as a relatively stable predisposing factor open to environmental influences, endogenous to individuals, and usually latent in nature (Ingram & Luxton, 2005). Specifically, the DD-S model proposes that high emotional reactivity and/or low emotional regulation represent maximal diathetic loading. Given Rothbart and Derryberry's (1981) definition of temperament as constitutionally- (or biologically-) based individual differences in reactivity and self-regulation, it seems possible that the emotional diathesis described in the DD-S model is related to children's temperament.

Empirical studies of the association of children's emotional or temperamental diathesis and stuttering, based on parental report, indicate that young CWS, when compared to children who do not stutter (CWNS), were less successful in maintaining attention and adapting to their environment (Embrechts, Ebben, Franke, & Van de Poel, 2000), more reactive to environmental stimuli (Karrass et al., 2006; Wakaba, 1997). Likewise, Anderson, Pellowski, Conture, and Kelly (2003) reported that preschool-age CWS were less adaptive than CWNS, suggesting that CWS may be less able to adapt to novelty, change, and differences. Eggers, De Nil and Van den Bergh (2010) also reported that CWS, when compared to CWNS, exhibited significantly lower inhibitory control and attention shifting as well as significantly higher anger/frustration, approach and motor activation. Another study, based on behavioral observation, suggested that CWS, compared to CWNS, were less able to ignore changes in irrelevant stimuli (Schwenk, Conture, & Walden, 2007). In contrast, based on parental report, others have reported that CWS, when compared to CWNS, were less negative and more adaptable (Lewis & Goldberg, 1997) and more likely to exhibit the temperamental constellation of an "easy child" (Williams, 2006).

Based on a review of these empirical findings, Kefalianos et al. (2012) cautiously concluded that preschool-age CWS, when compared to preschool-age CWNS, appear to exhibit (1) lower adaptability (2) lower attention span/persistency, (3) more negative quality of mood and (4) greater activity. In another review of the association of temperament and speech-language processes, however, Conture et al. (2013) suggested that the "directionality of effect" (e.g., temperamental characteristics → stuttering vs. temperamental characteristics ← stuttering) regarding temperament and speech-language disorders/processes remains unclear. More recently, Choi, Conture, Walden, Lambert and Tumanova (2013), based on behavioral observation, reported a significant association between preschool-age CWS's behavioral inhibition and their percentage of stuttered disfluencies. A similar behavioral observation study (Arnold, Conture, Key and Walden, 2011) reported that decreased frequency and duration of regulatory strategies is associated with more stuttering in preschool-age CWS.

The above empirical findings regarding the association between children's emotional diathesis and stuttering would appear to provide insights into the possible role that emotion plays in childhood stuttering. However, these findings, which are based on children's relatively *stable* temperamental characteristics, may not readily account for the *variable* nature of stuttering across contexts. Perhaps, considering variations in emotional stress across contexts along with their emotional diathesis may help us to better account for changes in stuttering associated with changes in contexts.

*Emotional Stress and Stuttering*

In general, *stress* typically refers to exogenous factors that "interfere with the system's physiological and psychological homeostasis" (Ingram & Luxton, 2005). Within the DD-S model, one important *emotional* stressor is thought to be change, difference and novelty in the child's environment (Conture & Walden, 2012).

When environmental or exogenous emotional stress was examined in a non-experimental research design based on parental report, Yairi and Ambrose (1992) reported that 43% of preschool children experienced environmental emotional stress (e.g., divorce of parents, moving to another house, excessive sibling rivalry, or difficult day care arrangements) prior to stuttering onset. In one recent study, when environmental emotional stress was experimentally manipulated, Johnson, Walden, Conture and Karrass (2010) reported that CWS were more disfluent after receiving a desired gift than after receiving a disappointing gift. This finding was taken to suggest that positive emotional stimulus is associated with percentage of stuttered disfluencies more than negative emotional stimulus. In contrast, based on results of an experimental study, Arnold et al. (2011) reported no significant differences in percentage of stuttered disfluencies among neutral, happy and angry emotion conditions (i.e., emotionally valenced overheard conversations between adults) for CWS. Similarly, Ntourou, Conture, & Walden (2013) reported no main effect of condition (i.e., a neutral versus a frustrating task using "an attractive toy in a transparent box" procedure; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999) on percentage of stuttered disfluencies for preschool-age CWS. Likewise, Walden, Frankel, Buhr, Johnson, Conture, & Karrass (2012) reported no main effect of emotion eliciting conditions (i.e., emotionally valenced overheard conversations between adults) on stuttered disfluencies for preschool-age

CWS. However, Walden et al. also reported that when the first emotion condition was positive or negative compared to neutral, CWS stuttered significantly more during all three emotional conditions (e.g., positive, negative and neutral).

At present, it is unclear how comparable the quantity and quality of environmental emotional stress (e.g., divorce of parents) reported by Yairi (1997) is to that of experimentally-induced emotional challenges employed in the empirical studies of Arnold et al. (2011) and Walden et al. (2012). Similarly, it is unclear how comparable the aforementioned studies' participants' emotional or temperamental diatheses were to one another. Perhaps, taking into account children's emotional diathesis along with emotional stress may help explain why not all children's stuttering was associated with the emotional stress they experience.

*Sympathetic Arousal and Stuttering*

As suggested before, one key variable, with potential for connecting variance in emotional stress or emotional diathesis with variance in percentage of stuttered disfluencies, is thought to be sympathetic arousal[1]. This is because sympathetic arousal is a rapid physiological reaction known to be associated with changes in emotional stress (Reiff, Schwartz, & Northridge, 2001). Indeed, emotional responses to positive or negative emotional stimuli have been reported to be associated with increased sympathetic arousal (Kreibig, 2010). Specifically, in most studies, heightened tonic skin conductance level (SCL) – an index of sympathetic arousal – has been reported to be associated with high-arousal negative emotions such as anger (Christie & Friedman, 2004; Palomba & Stegagno, 1993;

[1] Sympathetic arousal refers to "excitatory activity that is commonly associated with acute emotional states, such as fear, anger, elation, or distress" (Mundorf, Zillmann, & Drew, 1991). It is usually measured in peripheral manifestations, such as increased heart rate, blood pressure, and electrodermal activity.

Marci, Glick, Loh, & Dougherty, 2007), anxiety (Blechert, Lajtman, Michael, Margraf, & Wilhelm, 2006; Ritz, Steptoe, Wilde, & Costa, 2000), disgust (Hofmann, Moscovitch, & Kim, 2006.), and fear (Williams et al., 2005) as well as high-arousal positive emotion[2] such as amusement (Foster, Webster, & Williamson, 2003; Tsai, Levenson, & Carstensen, 2000). In the same vein, Fowles, Kochanska and Murray (2000) reported that preschool-age children's (specifically 4 years olds) electrodermal activity (e.g., SCL) was associated with their fearfulness (i.e., negative emotional reactivity) and inhibitory control.

Furthermore, sympathetic arousal has been studied in relation to stuttering. To date, most studies of sympathetic arousal exhibited by people who stutter have involved adults. However, when the sympathetic arousal of adults who stutter (AWS) has been compared to that of adults who do not stutter (AWNS) during speech and non-speech conditions, findings have been equivocal. Some have reported significant differences in sympathetic arousal (Ickers & Pierce, 1973[3]) whereas others indicated no significant differences in sympathetic arousal (Peters & Hulstijn, 1984[4]) between AWS and AWNS. Similarly, findings have also been mixed regarding the association of AWS' sympathetic arousal and their stuttering. For example, Weber and Smith (1990) reported that AWS's disfluent utterances are associated with greater SCL than fluent utterances in reading condition. Conversely, Adams and Moor (1972) indicated no significant relation between sympathetic arousal (indexed by Palmar sweat measures) and stuttering frequency for AWS in auditory masking and non-masking

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[2] In contrast, studies on the physiological response of low-arousal positive emotion such as contentment (e.g., pleasure, serenity, calmness, peacefulness, relaxation) indicate decreased SCL (Christie & Friedman, 2004; Palomba & Stegagno, 1993). Similarly, low-arousal negative emotion such as sadness was reported to be associated with decreased SCL (Kreibig, 2010).

[3] Ickers and Pierce (1973) reported that AWS exhibited a significant decrease in blood volume when they approached the stuttered words, but exhibited a significnat increase in blood volume following the speaking of the words compared to AWNS.

[4] Peters and Hulstijn (1984) found no difference between AWS and AWNS in heart rate, elctrodermal activity (i.e., SCL), and vasomotor responses before and during speech tasks (i.e., reading and conversation) and non-speech tasks (i.e., motor an intelligence task).

condition. At present, it is unclear why there are equivocal findings on the relation between sympathetic arousal and stuttering for adults. Possibly, as Weber and Smith (1990) suggested, some AWS have better established emotion regulation and relatively more successful avoidance behaviors (e.g., circumlocutions), and thus exhibit less association between sympathetic arousal and stuttering.

On the other hand, in an experimental study of preschool-age children who stutter, Jones, Buhr, Conture, Tumanova, Walden, and Porges (in press) reported that CWS, when compared to their CWNS peers, exhibited less parasympathetic tone (i.e., respiratory sinus arrhythmia; RSA) in a neutral or baseline condition and greater sympathetic arousal (i.e., SCL) in an emotionally arousing condition (i.e., film viewing/listening). Considering a relative paucity of research on preschool-age CWS's sympathetic arousal in relation to their stuttering, the present study seeks, in part, to determine whether the relation between sympathetic arousal and stuttering exists in preschool-age CWS.

## Further Questions

As reviewed above, to date, most published empirical studies of the association of emotion and childhood stuttering have either investigated (1) *whether* there are differences between the two talker groups (i.e., CWS vs. CWNS) in emotional diathesis or sympathetic arousal or (2) *whether* CWS's emotional diathesis or emotional stress is associated with their stuttering frequency. Our understanding of the relation between emotion and stuttering, however, may be furthered by asking not only "whether" but also *"when"* or *"how*" the relations exist (Hayes, 2013).

*When does the Relation between Emotion and Stuttering Exist?*

As mentioned above, some have studied whether emotional stress *or* emotional diathesis independently[5] contribute to stuttering (Arnold et al., 2011; Walden et al., 2012). In contrast, there has been no apparent empirical assessment of whether emotional stress *and* emotional diathesis *interact* with one another to affect CWS's stuttering.

Theoretically, the aforementioned DD-S model (Figure 1) attempts to explain whether nature (i.e., emotional diathesis) and nurture (i.e., emotional stress) might singularly as well as jointly be associated with childhood stuttering (Conture & Walden, 2012). Walden et al.'s (2012) empirical assessment of the DD-S model indicated that for all children (CWS and CWNS), there was an interaction between negative emotional reactivity and emotion regulation, suggesting that children who exhibited high negative emotion and high emotion regulation stuttered less compared to those who exhibited high negative emotion and low emotion regulation. These findings, while providing at least partial empirical support for the DD-S model, do not indicate how the *interaction* between *emotional diatheses* and *emotional stress* may impact CWS's stuttering.

Therefore, a reasonable next step in testing the DD-S model would be to evaluate one of its salient predictions, that is, the interaction between CWS's emotional diathesis and emotional stress is associated with their stuttering. Specifically, empirical assessment of *when*[6] (e.g., under greater vs. lesser emotional stress*)* CWS's emotional diathesis is associated with their stuttering appears warranted.

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[5] As Ingram and Luxton (2005) suggested, it seems possible that considering emotional diathesis and emotional stress *separately* may restrict researchers' ability to thoroughly describe potentially key associates of childhood stuttering.

[6] One salient feature of the DD-S model is its attempt to account for the fact that not all individuals with high emotional diathesis exhibit more stuttering. For example, the DD-S model predicts that the positive relation

*How are Emotion and Stuttering Related?*

As discussed by Walden et al. (2012), the possible mechanisms[7] underlying the occurrence of stuttering are underspecified in the DD-S model. Specifically, the DD-S model does not clearly address *how* activation of emotional diathesis is associated with disruptions in fluent speech. Nevertheless, the model suggests that when a latent emotional diathesis is activated by emotional stress, a behavioral and/or physiological change might occur. Such changes, it may be further speculated, serve as one possible *mediator* between emotional diathesis or emotional stress and stuttering. Given that sympathetic arousal has been reported to be associated with emotional reactivity (Fowles et al., 2000; Jones et al., in press) as well as emotional stress (Kreibig, 2010) and that sympathetic arousal has been studied in relation to stuttering, such arousal seems to be one good candidate for a mediator[8] that accounts for, at least in part, how emotional diathesis and/or emotional stress may be associated with stuttering.

## Purpose

Therefore, it was the purpose of the present study to empirically test two seemingly salient issues pertaining to the emotional diathesis-stressor aspect of the DD-S account of childhood stuttering. To empirically assess these issues, the present writer developed six a priori hypotheses. Figure 2 provides an overview of the relation of this study's independent,

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between children's emotional diathesis and percentage of stuttering will be stronger *when* they are under greater rather than lesser emotional stress.

[7]To better understand the mechanism accounting for the impact of an independent variable on a dependent variable, the analytical methodology of *mediation* has been commonly used (Cohen, Cohen, West, & Aiken, 2003; Wood, Goodman, Beckmann, & Cook, 2008). In general, a mediational model is "operative when an independent variable affects a dependent variable indirectly, through a third variable called a mediational variable" (Cole & Turner, 1993, p.271).

[8] Given the possibility of several mediators relative to changes in percentage of stuttered disfluencies, it presently seems most prudent to both conceptually as well as analytically consider sympathetic arousal as a *partial* rather than *full* mediator.

dependent, and mediator variables to each of the six a priori hypotheses to be described immediately below.

The first salient issue (relating to hypotheses 1 – 3) addressed whether preschool-age CWS's *emotional diathesis* (e.g., emotional reactivity), *emotional stress* (e.g., emotional stress condition), and their interaction affect their stuttering. Specifically, hypothesis 1 predicted that preschool-age CWS's *emotional reactivity (i.e., emotional diathesis)* would affect their percentage of stuttered disfluencies per 100 words. Findings pertaining to hypothesis 1 were thought to shed light on the role, if any, that an emotional diathesis plays in changes in their stuttering. Similarly, hypothesis 2 predicted that *emotion stress (condition)* would affect preschool-age CWS's percentage of stuttered disfluencies per 100 words. Results relating to hypothesis 2 were believed to provide insights into whether emotional stress impacts their stuttering. Likewise, hypothesis 3 predicted that the *interaction* between preschool-age CWS's emotional reactivity and emotional stress condition would affect their percentage of stuttered disfluencies per 100 words. Findings pertaining to hypothesis 3 were believed to help evaluate whether interactions between emotional diathesis and emotional stress were associated with changes in their stuttering.

The second salient issue (relating to hypotheses 4 – 6) addressed whether those associations above are mediated by a mediator (i.e., sympathetic arousal) variable. Specifically, hypothesis 4 predicted that preschool-age CWS's *emotional reactivity* would affect their percentage of stuttered disfluencies per 100 words through (i.e., mediated by) their *sympathetic arousal*. Results relating to hypothesis 4 were thought to help determine whether activation of CWS's emotional diathesis in turn activates sympathetic arousal which leads to changes in their stuttering. Similarly, hypothesis 5 predicted that *emotion stress* *(condition)* would affect preschool-age CWS's percentage of stuttered disfluencies per 100 words through their *sympathetic arousal*. Testing of hypothesis 5 was believed to provide insights into whether emotional stress activates sympathetic arousal which in turn leads to changes in their stuttering. Likewise, hypothesis 6 predicted that the *interaction* between preschool-age CWS's emotional reactivity and emotional stress condition would affect their percentage of stuttered disfluencies per 100 words through their *sympathetic arousal*. Testing of hypothesis 6 made possible, it was thought, the evaluation of whether the interaction between emotional diathesis and emotional stress activates sympathetic arousal leading to changes in their stuttering.

# CHAPTER II

# METHOD

## Participants

Participants were 49 preschool-age CWS (38 boys and 11 girls, typical of preschool-age CWS[9]), all of whom were monolingual, native speaker of Standard American English. All forty-nine participants were between the ages of 36 - 71 months of age. No child had received any known or reported formal treatment for stuttering or other communication disorders prior to participation in the present study. Also, participants also had no known or reported hearing, neurological, developmental, academic, intellectual, or emotional problems.

Participants were paid volunteers referred to the Vanderbilt Bill Wilkerson Center (Nashville, TN) by their parents or other speech-language pathologists. Caregivers were informed of the study via (a) a free, widely read parent-oriented magazine, (b) local health care provider, or (c) self/professional referral to the Vanderbilt Bill Wilkerson Hearing and Speech Center. Participants were part of an ongoing series of empirical investigations of linguistic and emotional contributors to developmental stuttering (e.g., Arnold et al., 2011; Choi et al., 2013; Johnson et al., 2010; Jones, Conture, & Walden, 2014; Karrass et al., 2006; Ntourou et al., 2013; Walden et al., 2012) conducted by Vanderbilt University's Developmental Stuttering Project (DSP). This study's protocol was approved by the Institution Review Board of Vanderbilt University, Nashville, Tennessee. For each participant, parents signed informed consent, and their children gave their assent.

[9] Gender was controlled for as a covariate in all statistical analyses models to account for possible alternative explanations for findings.

## Classification and Inclusion Criteria

*Children Who Stutter (CWS)*

A preschool-age participant was considered a CWS if he or she (a) exhibited three or more stuttered disfluencies (i.e., sound/syllable repetitions, monosyllabic whole-word repetitions[10], and sound prolongations) per 100 words of conversational speech based on a 300-word sample (Bloodstein, 1995; Curlee, 2007) and (b) received a total overall score of 11 or above (i.e., a severity equivalent of at least "mild") on the *Stuttering Severity Instrument-3* (SSI-3, Riley, 1994).

*Speech, Language, and Hearing Criteria*

All participants scored at the 16$^{th}$ percentile (i.e., -1.0 SD) or higher on the (a) *Peabody Picture Vocabulary Test-Fourth Edition* (PPVT-4 A or B; Dunn & Dunn, 2007), (b) *Expressive Vocabulary Test-Second Edition* (EVT-2 A or B; Williams, 2007), (c) *Test of Early Language Development-3* (TELD-3 A or B, Hresko, Reid, & Hamill, 1999), and (d) "Sounds in Words" subtest of the *Goldman-Fristoe Test of Articulation-2* (GFTA-2; Goldman & Fristoe, 2000). Furthermore, each participant passed a bilateral pure tone hearing screening, with all speech, language and hearing tests administered to each child during his or her visit to the Vanderbilt Bill Wilkerson Center.

[10] For the present study, based on the SSI-3 manual, (Riley, 1994, p. 4) only perceptually "abnormal (shortened, prolonged, staccato, tense, etc.)" single-syllable whole-word repetitions were counted as stuttered disfluencies. Conversely, perceptually effortless, non-tense repetitions of single-syllable whole words—such as those produced for emphasis (e.g., the child says, "it was a **big, big** dog," while gesturing how large the dog was)—were *not* counted as stuttered or nonstuttered disfluencies.

*Excluded Participants*

From an initial group of 70 CWS who passed the above criteria, 21 CWS were excluded for the following reasons: incomplete narrative data due to either noncompliant behavior during the experimental procedure (N=13) and incomplete Children's Behavior Questionnaires (CBQ, Rothbart, Ahadi, Hershey, & Fisher, 2001) data (N=8). This resulted in 49 CWS who served as participants for the final data analyses.

Race

Each participant's race was obtained via parental interview. Participants included 82% (N=40) Caucasian, 8% (N=4) African American, and 10% (N=5) multi-racial children.

Socioeconomic Status (SES)

Each participant's SES was determined through application of the Four-Factor Index of Social Status (Hollingshead, 2011)[11]. This index takes into account both parents' educational levels and occupations based on self-report. Computed total scores range from 28 to 66 (M=49.83, SD=11.17), with a higher total score indicating a higher socio-economic status (see Richels, Johnson, Walden, & Conture, 2013, for possible associations between SES, parental education and childhood stuttering).

[11] As per Hollingshead (2011) test administration instructions, the SES score of each child/participant in the present study was calculated by multiplying the scale value for her parent's *occupation* by a weight of five and the scale value for *education* by a weight of three. Specifically, if both mother and father were gainfully employed, the scores for each parent are summed and the total was divided by two. If one parent, mother or father, was gainfully employed, the child's SES score was calculated on the basis of the employed parent's education and occupation. Hollingshead suggested Social Strata based on total SES scores as follows: 55-66=Major business and professions; 40-54=Medium business, minor professional, technical; 30-39=Skilled craftsmen, clerical, sales workers; 20-29=Machine operators, semiskilled workers; 8-19=Unskilled laborers, menial service workers.

## Procedures

Participants and their parents visited the Vanderbilt Developmental Stuttering Laboratory twice: the second visit approximately 1-2 weeks after the first visit. The first visit involved speech, language and temperament assessment as well as a hearing screening. The second visit involved experimental testing in which participants were exposed to relatively emotionally-neutral (i.e., baseline video clip) and emotionally-arousing stimuli (i.e., positive and negative video clips) and asked to produce a narrative from a storybook after each video clip.

Specifically, during the second visit, a participant was led into a room and seated in a car safety seat situated directly in front of a computer monitor. For collection of skin conductance level (SCL), this study's index of sympathetic arousal, two electrodes were applied on the participant's index and ring fingers of the right hand. A lapel microphone was placed on the participant's clothing near his/her mouth.

Each child participated in three emotional stress conditions: baseline (i.e., relatively neutral), positive and negative. For the *baseline* emotional stress condition, the participant viewed an animated screensaver of a three-dimensional fish tank for four minutes. This screensaver contained minimal action and therefore was assumed to be suitable for establishing participants' baseline level of emotional arousal. After the baseline emotional stress condition, the participant was presented with *negative* and *positive* video clips taken from one of five G-rated movies, including *Snow White, The Lion King, The Little Mermaid, The Wizard of Oz*, and *The Princess and the Frog*. These video clips, each approximately four minutes in duration, were intended to elicit negative or positive affective states, with their order of presentation counterbalanced. After each baseline, positive and negative emotional stress condition, the participant performed a speaking task, in which he or she was asked to produce a narrative[12] while watching pictures from one of six storybooks about a boy, a dog, and a frog by the author Mercer Mayer[13].

## Psychophysiological Data Acquisition

Tonic skin conductance level (SCL)[14] was acquired using the Biopac MP150 system (Biopac Systems, USA). Tonic SCL was defined as an average level of skin conductance in a given epoch exclusive of phasic (i.e., moment-by-moment, wavelike increases) skin conductance responses (SCRs) (Lykken & Venables, 1971). Tonic skin conductance levels are considered to vary over time in individuals depending on their psychological state (Rani, Sarkar, & Liu, 2005).

The Biopac MP150 system and a microphone were connected to a Macintosh computer. Data were recorded using Acknowledge software (ver. 4.1 for Mac, Biopac). Tonic SCL was recorded with a pair of Ag-AgCl electrodermal electrodes (Model TSD203; Exosomatic measurement[15]) filled with Biopac GEL101 electrode paste placed on the palmar surface on the distal phalange area of the index and the fourth fingers of the participants' right hand. The electrodes were connected to a Biopac GSR100C skin conductance amplifier, with tonic SCL data sampled at 500 Hz, with the gain set at 10 μS/V and a low-pass filter at 1 Hz.

[12] These speaking tasks could technically best be described as "picture-assisted narrative storytelling." However, for the purpose of brevity, they were described as"narrative" throughout the report of this study.
[13] The six story books included *a Boy, a Dog, and a Frog (Mercer Mayer, 2003a), a Boy, a Dog, a Frog, and a Friend (Mercer Mayer, 2003b), Frog Goes to Dinner (Mercer Mayer, 2003c), Frog on His Own (Mercer Mayer, 2003d), One Frog Too Many (Mercer Mayer, 2003e), and Frog Where Are You (Mercer Mayer, 2003f).*
[14] SCL was chosen because, "unlike most autonomic nervous system responses, it provides a relatively direct and undiluted representation of sympathetic activity" (Dawson, Schell, & Filion, 2007, p.167).
[15] The exosomatic measurement involved applying direct, very low-level, current via electrodes on the skin.

Following data acquisition, the "Connect Endpoints" math function of the Biopac Acknowledge 4.1 software was used to correct any data artifacts[16]that occurred during data collection. Data presented in this study's Results section are expressed in microSiemens (μS).

## Description of Independent, Dependent and Mediator Variables

The present study's *independent* variables were emotional reactivity, emotional stress condition and their interaction terms. The study's *dependent* variable was percentage of stuttered disfluencies per 100 words. The study's *mediator* variable was sympathetic arousal indexed by tonic SCL (see Table 1 and 2 for details pertaining to the six a priori hypotheses tested and their related independent, dependent and mediator variables).

### *Independent Variables*

#### *Emotional Reactivity (i.e., Emotional Diathesis)*

Emotional reactivity was defined as a tendency to experience frequent and intense emotional arousal in response to emotionally valenced stimuli (Bylsma, Morris & Rottenberg, 2008; Karrass et al., 2006). As Rothbart et al. (2001) suggested, emotional reactivity includes emotional reactions related to both *negative* and *positive* affect. Furthermore, Conture and Walden (2012) suggested that both positive and negative emotion "should be considered in any study of emotional contribution to stuttering, particularly in children." (p.109) Therefore, for the purpose of the present study, both positive and negative emotional reactivity – this study's index of emotion diathesis - were measured by using the

[16] Possible sources of recording artifacts include mechanical pressures on the electrodes, loose electrodes, wire drag, gross body movements, speech, irregular breathing, and/or ambient noise (Boucsein et al., 2012).

standard version (195 items) of the Children's Behavior Questionnaire (CBQ) (Rothbart, Ahadi, Hershey, & Fisher, 2001).

The CBQ is a well-established instrument for the measurement of temperament in children from three to seven years of age. The test is based on parents' reports and has been widely used to study the temperament of young children who stutter (e.g., Eggers, De Nil, & Van den Bergh, 2009; Eggers et al., 2010; Walden et al., 2012). The standard CBQ consists of 195 items across 15 scales that include: Activity Level, Anger/Frustration, Approach/Positive Anticipation, Attentional Focusing, Discomfort, Falling Reactivity/Soothability, Fear, High-intensity Pleasure, Impulsivity, Inhibitory Control, Low-intensity Pleasure, Perceptual Sensitivity, Sadness, Shyness, Smiling and Laughter.

Scale-level factor analyses of the 15 CBQ scales for children between 3 and 7 years old (Rothbart et al., 2001) indicated that scores from each of the 15 scales may be collapsed into three broad, latent factors: (1) Surgency, (2) Negative Affectivity, and (3) Effortful Control. For the purpose of the present study, the Surgency score was used as an index of *positive reactivity*, and the Negative Affectivity score was used as an index of *negative reactivity*. These two factor scores served as independent variables in the present study. Specifically, the Surgency score was calculated by averaging the scale scores for Approach, Activity Level, High-intensity Pleasure, Impulsivity, and Shyness (with shyness making a negative contribution to the Surgency construct). Similarly, the Negative Affectivity score was calculated by averaging the scale scores for Anger/Frustration, Discomfort, Fear, Sadness, and Soothability (with soothability making a negative contribution to the negative affectivity construct)[17]. The Effortful Control score – thought to be associated with emotional

[17] As noted in Discussion, the Surgency score does not include low-arousal positivity (Putnam, 2012) such as agreeableness or affiliation, rather it is seemingly more associated with high-arousal positivity. Unlike

regulation – was used as a covariate[18] for purposes of statistical analysis, consisting of an average of the scale scores for Low Intensity Pleasure, Smiling/Laughter, Inhibitory Control, Perceptual Sensitivity, and Attentional Control.

*Emotional Stress Condition (i.e., Emotional Stress)*

As described above, emotional stress conditions included baseline, positive and negative emotional stress conditions. The positive emotional stress condition was a 4 min. presentation of video clips taken from one of five G-rated movies intended to elicit positive emotion (e.g., amusement). Similarly, the negative emotional stress condition was a 4 min. presentation of video clips taken from one of five G-rated movies intended to elicit negative emotion (e.g., fear). The baseline emotional stress condition was a 4 min. presentation of an animated screensaver of a three-dimensional fish tank intended to elicit relatively neutral emotion.

Since the emotional stress condition has three categories (i.e., baseline, positive emotion & negative emotional stress conditions), two "dummy-coded"[19] variables were created and served as independent variables of the present study: (1) positive versus baseline emotional stress condition and (2) negative versus baseline emotional stress condition. These two independent variables allowed comparison of percentage of stuttered disfluencies per

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Surgency, the Negative Affectivity score does include both high-arousal (e.g., Anger/Frustration and Fear) and low-arousal (e.g., Sadness) negative emotion.

[18] Given previous findings that changes in emotional regulation are associated with changes in percentage of stuttered disfluencies (Arnold et al., 2011; Walden et al., 2012), it appeared prudent to statistically control for emotional regulation.

[19] Dummy coding refers to a process of coding a categorical variable into dichotomous variables (e.g., 0 and 1). Two variables were created from this dummy coding process in the present study. In the first dummy variable (i.e., positive versus baseline emotional stress condition), "0" was assigned to the baseline and negative stress conditions and "1" was assigned to the positive stress condition. Similarly, in the second dummy variable (i.e., negative versus baseline emotional stress condition), "0" was assigned to the baseline and positive stress conditions and "1" was assigned to the negative condition.

100 words during positive versus baseline emotional stress conditions as well as negative versus baseline emotional stress conditions. Comparison of percentage of stuttered disfluencies per 100 words during positive versus negative emotional stress conditions, however, was not conducted because it was not considered within the purpose and scope of the present study.

*Emotional Reactivity × Emotional Stress Condition Interaction Terms*

To examine the potential interactions between emotional reactivity and emotional stress condition, 4 interaction terms were created and served as independent variables: Surgency score (i.e., positive emotional reactivity) × positive versus baseline emotional stress condition, Surgency score × negative versus baseline emotional stress condition, Negative Affectivity score (i.e., negative emotional reactivity) × positive versus baseline emotional stress condition, and Negative Affectivity score × negative versus baseline emotional stress condition.

*Dependent Variable: Percentage of Stuttered Disfluencies per 100 Words*

The present author and three independent trained coders measured the percentage of stuttered disfluencies per 100 words[20] during a narrative after viewing each baseline, positive and negative video clip. As mentioned above, and based on Vanderbilt University's Disfluency Count Sheet (Conture, 2001), stuttered disfluencies included sound/syllable repetitions, monosyllabic whole-word repetitions, and sound prolongations.

[20] The percentage of stuttered disfluencies per 100 words was calculated by dividing the number of stuttered disfluencies by the total number of words and multiplying by 100.

*Mediator Variable: Sympathetic Arousal*

Each participant's sympathetic arousal was indexed by a mean tonic skin conductance level (SCL) [21] exclusive of phasic SCRs[22] measured during a narrative following each baseline (i.e., screensaver), positive and negative video clip, as the sympathetic nervous system is known to exclusively regulate skin conductance (i.e., electrodermal activity of the sweat glands; Boucsein, 1992; Jones et al., in press).

## Data Analyses[23]

To assess hypotheses 1 - 3, a Generalized Estimating Equation (GEE) with the Poisson distribution and a log-link function was used. Specifically, independent variables included Surgency and Negative Affectivity scores from the CBQ, dummy coded emotional stress condition, and their interaction terms, with the dependent variable being percentage of stuttered disfluencies per 100 words. Additionally, CWS's gender, language composite score[24], mean length of utterance (MLU) and Effortful Control score from the CBQ were included in the model as covariates due to their potential influence on the child's pecentage of stuttered disfluencies.

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[21] Dawson, Schell, and Filion (2007) suggests that SCL is the most useful electrodermal measure in the context of continuous stimuli (e.g., video viewing/listening) because it can be measured on an ongoing basis over relatively long periods of time.

[22] Phasic skin conductance response (SCR) was not assessed in the present study because for this initial moderator/mediator assessment of the association between emotional stress, emotional diathesis and sympathetic arousal, more general or overall indexes of sympathetic arousal (i.e., tonic SCL) were deemed of interest. Neither was it the purpose of the present study to determine associations between specific instances of stuttering and specific occurrences of sympathetic arousal (i.e., phasic SCR). Instead, it was the focus of the present study to assess the association of overall percentage of stuttered disfluencies per 100 words and overall or mean tonic sympathetic arousal during narratives after emotionally-challenging conditions (e.g., tonic SCL).

[23] In order to avoid multicollinearity issue, variables (i.e., Surgency, Negative Affect, Effortful Control, gender, & MLU) used in the analyses were centered around the mean prior to forming product terms (Howell, 2002). Multicollinearity occurs when "strong relationships exist between independent variables and can be problematic for regression analysis especially in the estimation of regression parameters" (Mueller & Pierce, 2003)

[24] A language composite score was calculated by averaging three different language scores (i.e., PPVT-4, EVT-2, TELD-3 standard scores). The language composite score was controlled for (i.e., served as a covariate) due to its potential influence on the child's percentage of stuttered disfluencies per 100 words.

To assess hypotheses 4 - 6, a path analysis[25] using Mplus (Muthén & Muthén, 2012) with adjusted standard error and chi-square[26] (Asparouhov, 2006; Muthén & Muthén, 2012) was conducted. Specifically, independent variables were participants' Surgency and Negative Affectivity scores on the CBQ, dummy coded emotional stress condition, and their interaction terms. The mediator was tonic SCL measured during narratives and the dependent variable was log-transformed percentage of stuttered disfluencies per 100 words. Additionally, CWS's gender, language composite score, MLU, and Effortful Control score from the CBQ were included as covariates in the mediation model (regarding hypotheses 4-6).

Baron and Kenny (1986) recommended that the overall association between independent and dependent variables (i.e., total effect) should be established to conduct a mediation analysis.  Recently, however, other researchers have stated that such a criterion is no longer a requirement when the total effect is likely to be affected by competing causes[27] or random effect or suppression is a possibility (Collins, Graham & Flaherty, 1998; MacKinnon, Krull & Lockwood, 2000; Shrout & Bolger, 2002). Thus, regardless of the statistical significance of the analysis of the association between independent variables (i.e., emotional reactivity, emotional stress condition and emotional reactivity × emotional stress condition interaction terms) and the dependent variable (i.e., percentage of stuttered

[25] Indirect effects were specified by using the MODEL INDIRECT command.
[26] Corrections to the standard errors and chi- square test of model fit, that take into account non-independence of observations, were obtained by using the TYPE=COMPLEX option of the ANALYSIS command in conjunction with the CLUSTER option of the VARIABLE command in Mplus.
[27] For example, one possible competing factor that could suppress the influence of the sympathetic arousal on stuttering would be a child's parasympathetic activity (i.e., physiological correlates of emotional regulation) that may occur concurrently or overlap with the child's sympathetic arousal (Alm, 2004; Berntson, Cacioppo & Quigley, 1991; Joneset al., in press).

disfluencies per 100 words), the mediation analysis[28] was performed on the basis of the aforementioned theoretical accounts as well as empirical evidence.

## Inter- and Intra-judge Measurement Reliability

*Speech Disfluencies*

Intra-class correlation coefficients (ICC; McGraw & Wong, 1996; Shrout & Fleiss, 1979) using the absolute agreement criterion were computed to assess inter- and intra-judgment reliability for the measurement of stuttered disfluencies, non-stuttered disfluencies, and total disfluencies.

*Inter-judge* measurement reliabilities for stuttered, non-stuttered and total disfluencies were accomplished by the first author and three trained coders independently judging stuttered disfluencies for 33 participants while watching video-recorded speech samples. The 95% Confidence Interval (CI) ranged from .981 to .994, with average measures of ICC of .989, $p<.001$, for identification of stuttered disfluencies; with a CI from .921 to .977, with average measures of .955, $p<.001$, for identification of non-stuttered disfluencies; and a CI from .975 to .993, with average measures of .987, $p<.001$, for identification of total disfluencies.

Assessment of *intra-judge* reliability for the speech disfluencies was based on 11 participants that each coder initially coded. At least 3 months passed between the first and second disfluency counts. ICCs ranged from .967 to .997 (M=.985) for identification of stuttered disfluencies, from .864 to .952 (M=.912) for identification of non-stuttered

[28] Although mediation relates to a causal explanation (Hayes, 2013), Hayes suggests that "one can conduct a mediation analysis even if one cannot unequivocally establish causality given the limitations of one's data collection and research design…(because) it is our brains that interpret and place meaning on the mathematical procedures used, not the procedures themselves" (p.89).

disfluencies, and from .952 to .985 (M=.974) for identification of total disfluencies. These inter- and intra-judge ICC reliability values exceeded the popular criterion of .7 (Yoder & Symons, 2010).

*Tonic SCL*

Intra-class correlation coefficients (ICC; McGraw & Wong, 1996; Shrout & Fleiss, 1979) using the absolute agreement criterion were computed to assess inter- and intra-judgment reliability for the measurement of mean tonic SCL during narratives.

*Inter-judge* measurement reliability for mean tonic SCL was accomplished by the first author and one independent trained coder independently judging mean tonic SCL for approximately 20% of the total final data corpus (N= 10). The 95% CI ranged from .999 to 1.00, with average measures of ICC of 1.000, $p<.001$, for identification of mean tonic SCL during narratives.

Assessment of *intra-judge* reliability for mean tonic SCL was based on approximately 20% of the total data corpus (N=10) that the first author initially coded. At least 3 months passed between the first and second coding. The 95% CI ranged from 1.00 to 1.00 (M=1.00) for identification of tonic SCL during narratives. The above inter- and intra-judge ICC reliability values exceeded the popular criterion of .7 (Yoder & Symons, 2010).

## Manipulation Check

A manipulation check was conducted by two trained coders – blind to emotional valence of the three conditions – to determine whether each video clip elicits positive, negative or baseline emotion as intended.  Based on 16 children's video clips (randomly selected), results indicated that overall percentage of correct identification[29] (PCI) of the video clips by the two raters for all children regardless of emotional stress conditions was 78.9%. "Correct identification" in the context of this study, refers to the coder accurately identifying the emotional valence that the video clip was intended to elicit. Specifically, PCI of the video clips for positive emotional stress condition was 68.8%, 65.6% PCI of the video clips for negative emotional stress condition, and 90.64% PCI of the video clips for baseline emotional stress condition.

## Statistical Power

A power analysis for an interaction model, similar to that described by Diggle, Heagerty, Liang, and Zeger (2002, p. 1665), was used to estimate how much regression coefficient (i.e., beta) of a slope changes, assuming a correlation of individuals' repeated measurements is $r$=0.5. The outcome slope that could be detected would be beta=1.51. When this slope is standardized, it becomes a Cohen's *d* at the end of the sloping line, d=0.45.

Based on the above analysis and using Cohen's cut points for *d*, it was possible to detect medium to large effect sizes with the study's sample size (N=49). However, small effects may not be detected due to low power.

[29] Percentage of correct identification (PCI) was computed by dividing the number of video clips that were correctly identified by the coders by the total number of video clips.

# CHAPTER III

# RESULTS

## Characteristics: Speech Fluency and Speech-Language

This section describes the preschool-age CWS's (N = 49) speech fluency and speech-language characteristics.

### *Speech Fluency*

Table 3 provides descriptive information regarding preschool-age CWS (N=49) participants' speech (dis)fluency. Participants exhibited a mean (M) of 7.45% stuttered disfluencies (standard deviation, SD=4.76), 4.89% (SD=2.59) non-stuttered disfluencies, and 12.34% total disfluencies (SD=5.72). Participants' mean chronological age was 51.04 months (SD=10.28). Consistent with gender distributions reported for children who stutter (e.g., Bloodstein & Bernstein-Ratner, 2008, Table 3-1), the present sample contained more preschool-age boys (N=38) than girls (N=11) who stutter.

### *Speech and Language Ability*

As part of this study's participant inclusion criteria, all participants scored at the 16$^{th}$ percentile (-1.0 SD) or higher on the (a) *Peabody Picture Vocabulary Test-Third Edition* (PPVT-III A or B; Dunn & Dunn, 1997; Standard score mean, M=115.65, SD=11.46), (b) *Expressive Vocabulary test-Second Edition* (EVT-2; Williams, 1997; M=116.31, SD=11.04), (c) *Test of Early Language Development-3* (TELD-3, Hresko et al., 1999; receptive subscale

M=118.85, SD=14.48, expressive subscale M=112.27, SD=15.54), and (d) "Sounds in Words" subtest of the *Goldman-Fristoe Test of Articulation-2* (GFTA-2; Goldman & Fristoe, 2000; M=108.41, SD=11.72). Furthermore, each participant passed a bilateral pure tone hearing screening.

## Pre-hypotheses Testing Analytical Considerations

Three issues – gender differences, relation of emotional reactivity to percentage of stuttered disfluencies per 100 words during a conversation, and normality of distributions of dependent and mediator variables – were considered prior to testing of the present study's six a priori hypotheses.

### *Gender Differences in Emotional Reactivity, Tonic SCL and Stuttered Disfluencies*

A series of Mann-Whitney U tests were conducted to examine whether, for the preschool-age CWS participants, there were gender (boys vs. girls) differences in (1) Surgency and Negative Affectivity scores (as described in Method), (2) percentage of stuttered disfluencies per 100 words and (3) mean tonic SCL during narratives. As shown in Table 3, there were no significant differences between boy and girl CWS in Surgency (U =173.00, z=.863, $p$=.397, $r$=.12, 95% CI=-.17 to .39), Negative Affectivity (U=141.50, z=1.617, $p$=.108, $r$=.23, 95% CI=-.05 to .48), percentage of stuttered disfluencies per 100 words (U=169.50, z=.949, $p$=.351, $r$=.14, 95% CI=-.15 to .41) and mean tonic SCL during narratives (U=.1771, z=.054, $p$=.959, $r$<.001, 95% CI=-.16 to .16).

*Relations of Emotional Reactivity to Stuttered Disfluencies during Conversation*

Another pre-hypothesis assessment - association of positive, negative emotional reactivity and percentage of stuttered disfluencies per 100 words observed in children's conversational speech sample (collected prior to experimental testing) - was also conducted. This analysis employed a Generalized Linear Model with the Poisson (non-normal) distribution and log-link function[30]. For this assessment, the statistical model's independent variables included Surgency and Negative Affectivity scores and the dependent variable was percentage of stuttered disfluencies per 100 words. Additionally, CWS's gender, composite language score, MLU during conversation, and Effortful Control score from the CBQ were included in the model as covariates.

Findings of the Generalized Linear Model indicated that there was no significant association between percentage of stuttered disfluencies per 100 words (observed during the pre-experimental conversational sample) and Surgency score (Wald $\chi^2$ =.014, df=1, $p$=.906; effect size: $\beta$=-*.108*, 95% CI=-.465 to .349) or between percentage of stuttered disfluencies per 100 words and Negative Affectivity score (Wald $\chi^2$=1.329, df=1, $p$=.249; effect size: $\beta$=*.155*, 95% CI=-.156 to .532).

*Distribution of Each Investigated Dependent and Mediator Variables*

The final pre-hypothesis consideration related to the normality of the distributions of dependent variables.  Specifically, the Shapiro-Wilk W test was used to assess the normality of distribution of investigated dependent and mediator variables, a well-regarded, powerful

[30] The Generalized Linear Model with the Poisson (non-normal) distribution and log-link function was used because the distribution of percentage of stuttered disfluencies per 100 words during a conversation with an examiner was not normal (skewness=1.081, W=.821, df=49, $p$<.001), displaying a high level of positive skew (i.e., values skewed to the right).

analytical test of distribution normality (Razali & Wah, 2011). Results of the Shapiro-Wilk W test (Shapiro & Wilk, 1964) indicated that the tonic skin conductance level during each narrative was normally distributed. In contrast, and consistent with the findings of Tumanova, Conture, Lambert & Walden (2014),[31] the Shapiro-Wilk W test indicated that percentage of stuttered disfluencies per 100 words (skewness = 2.335, W[32]=.781, df = 147, $p$ <.001) was not normally distributed, displaying a high level of positive skew[33]. Therefore, two statistical procedures that take non-normality of the dependent variable's (i.e., percentage of stuttered disfluencies per 100 words) distribution into account were used for statistical analyses. Specifically, to address research hypotheses 1-3, Generalized Estimating Equations (GEE) with the Poisson distribution and log-link function were used and to address research hypotheses 4-6, and Mplus (Muthén & Muthén , 2012) with log-transformed dependent variable (i.e., percentage of stuttered disfluencies per 100 words) was employed.

## Findings related to a priori Hypotheses

### *Hypotheses 1-3*

*Singular (Hypotheses 1 and 2) and Joint (Hypothesis 3) Effect of Emotional Reactivity and Emotional Stress Condition on Stuttered Disfluencies*

For the test of Hypotheses 1 to 3 (employing GEE with the Poisson distribution and a log-link function), independent variables included Surgency and Negative Affectivity scores

[31] Based on a relatively large representative sample of preschool-age boys and girls who stutter, Tumanova et al. (2014) reported that the distribution of stuttered disfluencies was not normal, but took the shape of a Poisson distribution (i.e., values skewed to the right).
[32] W is the test statistic associated with the Shapiro-Wilk W test. If W is significantly smaller than 1, the distribution of the variable of interest is considered to be non-normal.
[33] Skewness greater than zero indicates that the distribution of the variable has a longer right tail (i.e., the distribution is skewed or displaced towards higher values); skewness less than zero indicates that the distribution has a longer left tail (i.e., the distribution is skewed or displaced to lower values).

from the CBQ, dummy coded (as mentioned in the analytical section of Methods) emotional stress condition, and their interaction terms (i.e., product terms), with the dependent variable being percentage of stuttered disfluencies per 100 words. Additionally, CWS's gender, composite language score, MLU, and Effortful Control score from the CBQ were included in the model as covariates.

*Effect of Emotional Reactivity (i.e., Emotional Diathesis) on Stuttered Disfluencies (Hypothesis I)*

Consistent with hypothesis 1, findings of GEE analysis indicated that preschool-age CWS's Surgency score from the CBQ (i.e., positive emotional reactivity) was significantly positively associated with percentage of stuttered disfluencies per 100 words (during a narrative),Wald $\chi^2$=31.662, df=1, *p*<.001; effect size: *β=.602*, 95% CI=.473 to .717. Specifically, the follow-up regression analyses with Surgency as an independent variable and the percentage of stuttered disfluencies predicted from the GEE model as a dependent variable indicated significant correlations between Surgency and the predicted percentage of stuttered disfluencies per 100 words during a narrative after each baseline (*β=.608,* 95% CI=.357 to .781, *p<.001*), positive (*β=.619,* 95% CI=.391 to .790, *p<.001*), and negative (*β=.584,* 95% CI=.313 to .769, *p<.001*) emotional stress condition (See Figure 3-A). Conversely, preschool-age CWS's Negative Affectivity score from the CBQ (i.e., negative emotional reactivity) was not significantly associated with the percentage of stuttered disfluencies per 100 words, Wald $\chi^2$=1.820, df=1, *p*=.177; effect size: *β=.126*, 95% CI=-.054 to .315.

*Effect of Emotional Stress Condition (i.e., Emotional Stress) on Stuttered Disfluencies (Hypothesis 2)*

Findings based on the GEE analysis did not support the hypothesis 2 that the emotional stress conditions would affect preschool-age CWS's percentage of stuttered disfluencies per 100 words. Specifically, participants' percentage of stuttered disfluencies per 100 words during a narrative following positive emotional stress condition was not significantly different from that following baseline emotional stress condition (Wald $\chi^2$=1.194, df=1, $p$=.274, effect size: $\beta$=-*.053*, 95% CI=-.251 to .152). Similarly, participants' percentage of stuttered disfluencies per 100 words during a narrative following negative emotional stress condition was not significantly different from that following baseline emotional stress condition (Wald $\chi^2$=.026, df=1, $p$=.871, effect size: $\beta$=-*.012*, 95% CI=-.209 to .201).

*Interaction Effect of Emotional Reactivity (i.e., Emotional Diathesis) and Emotional Stress Condition (i.e., Emotional Stress) on Stuttered Disfluencies (Hypothesis 3)*

Findings of the GEE analysis indicated that there was a significant interaction between Negative Affectivity score (i.e., negative emotional reactivity) and positive versus baseline emotional stress condition, Wald $\chi^2$=5.358, df=1, $p$=.021; effect size: $\beta$=*.205,* 95% CI=.025 to .383. Specifically, the follow-up regression analyses with Negative Affectivity score as an independent variable and the percentage of stuttered disfluencies per 100 words predicted from the GEE model as a dependent variable indicated a significant positive correlation between Negative Affectivity score and the predicted percentage of stuttered disfluencies per 100 words during a narrative following positive emotional stress condition

($\beta$=*.292,* 95% CI=.002 to .593, *p=.042*). However, no such significant relation was found during narratives following negative ($\beta$=*.112,* 95% CI=-.179 to .421, *p=.444*), as well as baseline ($\beta$=*-.049,* 95% CI=-.335 to .315, *p=.741*) emotional stress conditions (See Figure 3-B). This finding suggests that preschool-age CWS's negative emotional reactivity is more associated with their percentage of stuttered disfluencies per 100 words during a narrative after positive, when compared to baseline, emotional stress condition. However, there was no interaction between Negative Affectivity score and negative versus baseline emotional stress condition (Wald $\chi^2$=.194, df=1, *p*=.660; effect size: $\beta$=*.079,* 95% CI=-.078 to .231) or between Surgency score and positive versus baseline emotional stress condition (Wald $\chi^2$=2.194, df=1, *p*=.139; effect size: $\beta$=*.079,* 95% CI=-.091 to .253) or between Surgency score and negative versus baseline emotional stress condition (Wald $\chi^2$=.054, df=1, *p*=.816; effect size: $\beta$=*-.016,* 95% CI=-.182 to .144).

### *Hypotheses 4-6*

*Sympathetic Arousal (as Indexed by Tonic SCL) as a Mediator through which Emotional Reactivity (i.e., Emotional Diathesis), Emotional Stress Condition (i.e., Emotional Stress) and their Interaction would Affect Stuttered Disfluencies (Hypotheses 4-6)*

As described in the Method section, to test Hypotheses 4 to 6, a path analysis (e.g., does Surgency impact stuttered disfluencies "through" sympathetic arousal?, i.e., Surgency →SCL→stuttered disfluencies) was conducted using Mplus (Muthén & Muthén , 2012) with adjusted standard error and chi-square (Asparouhov, 2006; Muthén & Muthén , 2012). Specifically, for this analysis, independent variables were participants' Surgency and Negative Affectivity scores from the CBQ, dummy-coded emotional stress condition, and their interaction terms (i.e., product terms). The mediator was mean tonic SCL during narratives and the dependent variable was log-transformed percentage of stuttered disfluencies per 100 words[34] Additionally, CWS's gender, MLU, composite language score, and Effortful Control score from the CBQ were included as covariates in the model.

*Indirect Effect[35] of Emotional Reactivity (i.e., Emotional Diathesis) on Stuttered Disfluencies through Sympathetic Arousal (Hypothesis 4)*

Findings did not support the hypothesis 4, indicating no indirect effect of emotional reactivity on stuttered disfluencies through sympathetic arousal: Surgency score: $\beta$=-*.015,* p=.633, 95% CI=-.075 to .046, Negative Affectivity score: $\beta$=-*.005,* p=.662, 95% CI=-.026 to .016. Interestingly, however, the path analysis indicated that Surgency score ($\beta$=.304, 95% CI=.026 to .582, *p*=.032) was significantly positively correlated with mean tonic SCL during narratives, which was consistent with the present writer's prediction. Conversely, the path analysis indicated that Negative Affectivity score was not associated with mean tonic SCL during narratives ($\beta$=.096, 95% CI=-.146 to .339, *p*=.437). Likewise, the path analysis indicated that mean tonic SCL during narratives was not associated with percentage of stuttered disfluencies per 100 words during narratives ($\beta$=-.048, 95% CI=-.239 to .142, *p*=.618).

[34] After log-transformation (i.e., log[stuttered disfluencies percentage+1]), the distribution of percentage of stuttered disfluencies per 100 words during naratives was normalized, skewness=.113, W=.992, df=147, p=.624.

[35] Indirect effect occurs "when a change in one variable causes a change in a second variable, which in turn, causes a change in a third variable" (McCrudden, Schraw, Lehman, & Poliquin, 2007).

*Indirect Effect of Emotional Stress Condition (i.e., Emotional Stress) on Stuttered Disfluencies through Sympathetic Arousal (Hypothesis 5)*

Findings did not support the hypothesis 5, indicating no indirect effect of emotional stress condition on percentage of stuttered disfluencies per 100 words through sympathetic arousal: positive vs. baseline emotional stress condition: $\beta$=-*.014,* p=.619, 95% CI=-.072 to .043, negative vs. baseline emotional stress condition: $\beta$=-*.014,* p=.625, 95% CI=-.073 to .044. Interestingly, however, the path analysis indicated significantly higher mean tonic SCL during narratives following the negative ($\beta$=.195, 95% CI=.120 to .270, $p$<.001) as well as positive ($\beta$=.195, 95% CI=.112 to .278, $p$<.001) emotional stress conditions compared to baseline condition, findings consistent with our prediction.

*Indirect Effect of Interaction between Emotional Reactivity (i.e., Emotional Diathesis) and Emotional Stress Condition (i.e., Emotional Stress) on Stuttered Disfluencies through Sympathetic Arousal (Hypothesis 6)*

Findings did not support the hypothesis 6, indicating no indirect effect of emotional reactivity (i.e., Surgency & Negative Affectivity scores) × emotional stress condition (i.e., positive vs. baseline as well as negative vs. baseline) interaction terms on percentage of stuttered disfluencies per 100 words through sympathetic arousal: Surgency score × positive vs. baseline emotional stress condition ($\beta$=.001, 95% CI=-.005 to .008, $p$=.650), Surgency score × negative vs. baseline emotional stress condition ($\beta$=-.001, 95% CI=-.005 to .004, $p$=.803), Negative Affectivity score × positive vs. baseline emotional stress condition ($\beta$=.002, 95% CI=-.007 to .012, $p$=.629), Negative Affectivity score × negative vs. baseline emotional stress condition ($\beta$=.003, 95% CI=-.009 to .014, $p$=.622).

## Ancillary Consideration

One ancillary analysis was conducted to assess a relevant issue relating to emotional diathesis and childhood stuttering, but not necessarily the six a priori hypotheses.

*Does Positive Emotional Reactivity Have an Indirect Influence on Stuttered Disfluencies through MLU (i.e., High Emotional Reactivity → Longer MLU → More Stuttered Disfluencies)? (Ancillary Analysis 1)*

Similar to the analyses used for hypotheses 4-6, the ancillary analysis – assessment of a possible indirect effect of emotional reactivity on stuttered disfluencies through MLU[36] – involved a path analysis. These analyses employed the statistical software Mplus (Muthén & Muthén , 2012) with adjusted standard error and chi-square (Asparouhov, 2006; Muthén & Muthén , 2012). The independent variable was participants' Surgency score from the CBQ. The mediator (i.e., MLU during narratives) was log-transformed[37] and the dependent variable (i.e., percentage of stuttered disfluencies per 100 words during narratives) was also log-transformed because both variables – MLU and percentage of stuttered disfluencies per 100 words – were not normally distributed. Additionally, CWS's gender[38], EVT raw score, composite language score, dummy-coded emotional stress condition, Negative Affectivity and Effortful Control score from the CBQ were included as covariates in the model.

[36] As would be expected, there was a strong positive correlation between MLU and number of words spoken during the narratives (.375<r<.571, p<.008, see Table 4). This relation has potential for impacting measures of stuttering (i.e., more words, more opportunity to stutter). To address this issue, percentage of stuttered disfluencies per 100 words rather than raw number of stuttering was used as the dependent variable. Further, when assessing relation of MLU to stuttering, a child's language ability may confound analysis of this relation. To minimize such a confounding effect, language ability was statistically controlled for in statistical models assessing MLU.

[37] The distribution of MLU was not normal (skewness=.803, W=.961, df=147, $p<.001$). After log-transformation, MLU distribution during narratives was normalized, skewness=.137, W=.994, df=147, $p=.799$.

[38] To minimize a possible gender impact on MLU, gender was included in the model as a covariate.

Findings indicated that there was no significant indirect effect[39] of positive emotional reactivity on percentage of stuttered disfluencies per 100 words through MLU ($\beta$=.041, 95% CI=-.011 to .093, $p$=.125). However, the path analysis indicated that Surgency was significantly associated with MLU ($\beta$=.218, 95% CI=.005 to .431, $p$=.044) and MLU was significantly associated with percentage of stuttered disfluencies per 100 words ($\beta$=.186, 95% CI=.027 to .346, $p$=.022). In contrast, there was no significant association between MLU and Negative Affectivity score ($\beta$=-.016, 95% CI=-.245 to .212, $p$=.888).

[39] The indirect effect was estimated based on the product of a path a (i.e., a path connecting an independent variable and a mediator) and a path b (i.e., a path connecting a mediator and a dependent variable).

# CHAPTER IV

# DISCUSSION

## Overview of Main and Ancillary Findings

With regard to *a priori* hypotheses, the present study resulted in three main findings. The first main finding indicated that preschool-age CWS's positive emotional reactivity was significantly positively associated with their percentage of stuttered disfluencies per 100 words regardless of emotional stress conditions. The second main finding indicated that preschool-age CWS's negative emotional reactivity was more positively correlated with their percentage of stuttered disfluencies per 100 words during narratives after positive, compared to, baseline emotional stress condition. The third main finding indicated a positive association between positive emotional reactivity and mean tonic SCL during narratives as well as a significantly higher mean tonic SCL during narratives following the negative and positive, compared to baseline, emotional stress conditions for preschool-age CWS.

One relevant ancillary finding indicated that preschool-age CWS's MLU was positively associated with their percentage of stuttered disfluencies per 100 words as well as positive emotional reactivity. The implications of these various findings – both those related to a priori hypotheses, and ancillary assessment - will be discussed below, followed by a brief general discussion, study limitations and conclusions.

## Implications relative to Main Findings

### *Impact of Endogenous Emotional Diathesis on Stuttering*

The first main finding indicated that preschool-age CWS with greater positive emotional reactivity stutter more than preschool-age CWS with lower positive emotional reactivity during narratives after baseline, positive and negative emotional stress conditions. Generally, less empirical attention has been paid to the association between positive emotional reactivity and childhood stuttering than to the association between negative emotional reactivity and childhood stuttering. Some, however, have suggested that positive emotion may contribute to the development of stuttering. For example, Starkweather and Gottwald (1990) suggested that positive emotional arousal, such as excitement, disrupts fluency more than fear or anxiety. Consistent with such a suggestion, Adams (1992) stated that based on parents' reports, children's increased stuttering is often associated with their positive emotional arousal.

Despite considerable anecdotal as well as clinical evidence, only a few, studies have empirically investigated a connection between positive emotion and stuttering. For example, Johnson et al. (2010) reported that preschool-age CWS were more disfluent after receiving a desired gift than after receiving a disappointing gift. Although this finding did not explicitly indicate that preschool-age CWS's positive emotional reactivity increases percentage of stuttered disfluencies per 100 words, this finding suggests that preschool-age CWS's positive emotion is associated with percentage of stuttered disfluencies per 100 words more than negative emotion is. Furthermore, Eggers et al. (2010) reported that based on a Dutch version of the Children's Behavior Questionnaire (CBQ-D; Van den Bergh & Ackx, 2003), preschool- and school-age CWS, compared to their CWNS peers, scored higher on the scale of “Approach” and “Motor activation” (i.e., positive emotional reactivity). Conversely, Anderson et al. (2003) reported, based on the Behavioral Style Questionnaire (BSQ; McDevitt & Carey, 1978) no significant difference between preschool-age CWS and CWNS in activity level, approach or withdrawal. Perhaps CWS’s positive emotional reactivity may interact with their chronological age to affect recovery from or persistence with stuttering, a possibility that must await further empirical study. For the present, however, this study’s first main finding seems consistent with the notion that there is an association between positive emotional reactivity and stuttering for preschool-age CWS.

To better understand the association of positive emotional reactivity and childhood stuttering, it seems helpful to recall that the present study’s measure of positive affect was based on the CBQ’s factor of “Surgency,” the latter including mainly “high-arousal” positive affect (e.g., Activity Level, High-intensity Pleasure, Impulsivity; Rothbart, 2011). In other words, the present study’s measure of positive affect (i.e., Surgency) does not appear to include “low-arousal” positive affect (e.g., agreeableness or affiliation; Putnam, 2012). High-arousal positive affect such as Surgency has been reported to be associated with low emotional regulation (Dennis, Hong, & Solomon, 2010; Mitchell, 2010; Polak-Toste & Gunnar, 2006; Putnam, Rothbart & Gartstein, 2008; Rothbart, Derryberry, & Hershey, 2000; Rydell, Berlin, & Bohlin, 2003). On the other hand, Kochanska, Aksan, Penney, and Doobay, 2007 found that low-arousal positive affect (e.g., agreeableness or affiliation) was associated with enhanced effortful control. Perhaps, relatively high Surgency with relatively low emotion regulation contributes to disruptions in CWS’s speech (dis)fluency, a possibility that must await the findings of further empirical study[40].

[40] Indeed, as shown in Table 4, Surgency and Effortful Control were marginally negatively correlated (Spearman’s *rho*=-.272, *p*=.058).

*Joint Impact of Endogenous Emotional Diathesis and Exogenous Emotional Stress on Stuttering*

The second main finding indicated that for preschool-age CWS, there was a significant interaction between negative emotional reactivity and positive versus baseline emotional stress condition. This finding suggests that CWS's negative emotional reactivity is more likely to be associated with their percentage of stuttered disfluencies per 100 words under positive, compared to baseline, emotional stress. This finding is consistent with Jones et al.'s (2014) finding that CWS's stuttered utterances were significantly more likely to be associated with their negative affect (measured by means of behavioral observation) following a positive rather than angry or neutral condition (e.g., emotional-inducing overheard conversations). Nonetheless, it remains somewhat unclear why there is a significant relationship between negative emotional reactivity and percentage of stuttered disfluencies per 100 words under positive – but not negative – emotional stress, a finding that appears less expected at first glance.

One possible explanation for this less-expected interaction may be that increased stuttering occurred as a result of a conflict between opposing drives to speak and to hold back from speaking, as suggested by Approach-Avoidance Conflict theory (Sheehan, 1953). Such speculation arose from the notion that positive affect tends to increase approach behavior whereas negative affect tends to increase avoidance behavior (Davidson, 1995; Elliot, 1999; Elliot & Covington, 2001). Perhaps, CWS with higher *negative* emotional reactivity who have a tendency to avoid or "shy away from" speaking may experience a conflict between speaking and not speaking under *positive*-emotion inducing condition where the tendency to approach or engage in talking is stronger.  The resulting conflict – between avoidance engendered by inherent negative emotional reactivity tendencies and approach engendered by a positively valenced condition - may contribute to disruption in their speech fluency.

A second, alternative explanation, suggests that preschool-age CWS who tend towards negative emotional reactivity may learn how to down-regulate their negative emotion during conditions of negative emotion stress, but less so during conditions of positive emotion stress. In other words, positive stress may release their negative emotion from inhibition or regulation, which may lead to disruption of their speech fluency (Arnold et al., 2011; Walden et al., 2012). These speculations, however, must await further empirical investigation for support or refutation.

*Relations of Endogenous Emotional Diathesis and Exogenous Emotional Stress to Sympathetic Arousal*

The third main finding indicated a positive association between positive emotional reactivity and mean tonic SCL during narratives as well as a significantly higher mean tonic SCL during narratives following the negative and positive, compared to baseline, emotional stress conditions for preschool-age CWS. Such findings are congruent with Kreibig's (2010) recent review of 134 published studies of autonomic nervous system (ANS) specificity[41] Results of this review suggest that there is an increase in mean tonic SCL in response to high-arousal negative emotions (e.g., Anger, Disgust, & Fear) as well as in response to high-arousal positive emotions (e.g., Amusement & Joy) based on at least three replicated studies.

In contrast, the present finding also suggested that negative emotional reactivity was not associated with change in mean tonic SCL. One possible explanation for the present

[41] Specificity refers to the extent to which ANS responses differ for particular emotions (Levenson, 2014).

finding is that the association of mean tonic SCL and negative emotional reactivity, the latter indexed by Negative Affectivity on the CBQ, may have been weakened because the CBQ Negative Affectivity factor includes both high-arousal (e.g., Fear & Anger) and low-arousal (e.g., Sadness) negative emotions as subscales. Consistent with this line of argument, Kreibig reported that high-arousal negative emotions such as Fear and Anger are associated with an increase in SCL where as low-arousal negative emotion such as Sadness is associated with a decrease in SCL. Perhaps, a decrease in SCL in low-arousal negative emotion (e.g., Sadness) may have "neutralized" or minimized the effect of high-arousal negative emotions (e.g., Fear & Anger) on SCL, a possibility that must await further empirical study.

On the other hand, the present study's finding did not support the a priori hypotheses regarding the indirect effect being examined, that is, the influence of emotional reactivity (i.e., emotional diathesis) or emotional stress condition (i.e., emotional stress) and their interaction on percentage of stuttered disfluencies per 100 words through sympathetic arousal (the latter indexed by mean tonic SCL). Given the significant findings (e.g., increased mean tonic SCL during narratives following positive and negative emotional stress conditions) described in the previous paragraph, this null finding seems to mainly result from the non-significant relation between sympathetic arousal and percentage of stuttered disfluencies per 100 words during narratives. Although it was a priori predicted, greater sympathetic arousal – whether induced by either exogenous emotional stress or endogenous emotional diathesis – did not seem to be associated with the percentage of preschool-age CWS's stuttered disfluencies.

Perhaps, some preschool-age CWS may already be establishing successful avoidance behavior that may weaken the association between sympathetic arousal and percentage of stuttered disfluencies per 100 words, a speculation similar to that provided by Weber and Smith (1990) for their findings based on AWS[42]. An alternative explanation is that there may be other mediators through which emotional diathesis or emotional stress is associated with percentage of stuttered disfluencies per 100 words than sympathetic arousal. For example, MLU may be a possible mediator considering its relation to percentage of stuttered disfluencies per 100 words *and* positive emotional reactivity. Therefore, in this study's ancillary analysis, MLU was investigated as an alternative mediator between positive emotional reactivity and percentage of stuttered disfluencies per 100 words, to be discussed below.

## Implications Relative to Ancillary Finding

*Relations among Positive Emotional Reactivity, MLU and Stuttering*

This study's ancillary finding indicated that for preschool-age CWS, there was no overall indirect effect of positive emotional reactivity on percentage of stuttered disfluencies per 100 words through MLU (i.e., high positive emotional reactivity → longer MLU → increased stuttering). However, the path analysis for each path (*path a*: higher positive emotional reactivity → longer MLU; *path b*: longer MLU → increased stuttering) suggested significant relations among positive emotional reactivity, MLU[43] and percentage of stuttered disfluencies per 100 words. These findings are consistent with previous findings that longer utterances and complex language are associated with increased stuttering (e.g., Richels, Buhr,

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[42] Weber and Smith (1990) reported that for adult who stutter (AWS) in the reading task, disfluent utterances were associated with greater tonic SCL where as for spontaneous speech, such association was not observed. Weber and Smith suggested that these equivocal findings may be due to AWS's avoidance behaviors (e.g., using substitutions, postponements, and circumlocution) during spontaneous speech.

[43] Although MLU is widely/often employed as an index of children's grammatical development (Brown, 1973), Paul & Kellogg (1997) suggested that MLU may be viewed not as a measure of language complexity, but of talkativeness or willingness to elaborate and expand utterance that may be related to children's activity and shyness for older children.

Conture, & Ntourou, 2010; Zackheim & Conture, 2003) and that outgoing children with a temperamental tendency toward social approach produced longer and more complex utterances during their conversational speech (Paul & Kellogg, 1997).

Although caution is needed when interpreting this finding due to the absence of a significant overall indirect effect, this result may be taken to suggest that the mechanism(s) that underlie the relation between (high-arousal) *positive* emotional reactivity and childhood stuttering may differ from those underlying the relation between *negative* emotional reactivity and childhood stuttering. In other words, any endogenous "agent" that encourages and/or requires a preschool-age CWS to plan and produce sentences whose lengths are in the 3$^{rd}$ and 4$^{th}$ quartile *above* the mean length of his or her utterances, may be associated with greater stuttering. In the present study, that "agent" appears to be positive emotional reactivity. Undoubtedly, other "agents" (e.g., a child's more frequent use of longer sentences to maintain the "speaking floor" or listener's attention as well as minimize listener's interruptions) exist, but must await further empirical study to be identified and better understood.

## General Implications

Overall, the present study's findings have at least three implications: (1) an endogenous diathesis (especially positive emotional reactivity), when "activated" by an exogenous stressor (whether neutral, negative or positive in valence), is associated with increased stuttering, (2) the strength of the relation between preschool-age CWS's temperamental characteristics (particularly negative affectivity) and the amount of stuttering appears to vary depending on the nature of concurrent emotional stressors (specifically, positive emotional stress condition), and (3) although there was no significant overall indirect effect of positive emotional reactivity on the amount of stuttering through MLU, there were two significant path relations. Specifically, one path was between positive emotional reactivity and MLU and a second path was between MLU and percentage of stuttered disfluencies per 100 words. These significant path relations seem to suggest a need to further explore a possibility that positive emotional reactivity may impact stuttering "through" MLU.

The first two implications appear to support salient aspects of the DD-S model of childhood stuttering. Whether such reactivity is positive or negative in nature, it seems import to note that a theorized diathesis, when activated by an emotional stressor, was associated with increased stuttering for preschool-age children who stutter. Of course, it is unknown, in this "mixed" sample of preschool-age children (e.g., those who will and will not recover from stuttering), whether those who persist exhibit more negative than positive reactivity (or vice versa) compared to those who recover. Such within-group differences between CWS who persist versus recover, however, would appear to be an intriguing subject for future research. The third implication about the association of positive emotional reactivity, MLU and percentage of stuttered disfluencies per 100 words may suggest a possible interactive process between emotional and speech-language domains of the DD-S model. Perhaps, preschool-age CWS's positive emotional reactivity may induce some of them to more frequently produce utterances above their average length of utterances. These longer utterances, in turn, may serve as a linguistic stressor that activates their speech-language diathesis leading to speech disfluencies. Viewed from the perspective of "directionality of effect," one might diagram these relations as follows: high positive emotional reactivity → longer MLU → greater speech-language stress → activation of speech-language diathesis → increased stuttering. As with the first two implications, however, such speculation regarding confirmation or refutation of the third implication must await empirical study.

## Limitations

Contrary to expectations, the positive and negative video presentations (i.e., exogenous emotional stress) did not produce a clear effect on CWS's overall stuttering. Although the manipulation check as well as psycho-physiological measure (i.e., tonic SCL) verified that most participants are actually experiencing the emotions of interest, it was unclear whether the present study's elicited emotions were strong or relevant enough to meaningfully impact participant's speech disfluencies. Therefore, further empirical study of various life stressors (e.g., daily (e.g., getting to school on time), acute (e.g., a bad cold) vs. chronic (e.g., asthma stress), as Monroe and Simons (1991) suggested, is probably necessary to support or refute the possibility that emotional stress is associated with change in percentage of stuttered disfluencies per 100 words.

A second limitation is that the study assessed only sympathetic activity in relation to stuttering without considering the impact of parasympathetic activity. Jones et al. (in press) reported that preschool-age CWS displayed a significant positive relation between parasympathetic activity indexed by respiratory sinus arrhythmia (RSA) and sympathetic activity indexed by tonic SCL. Jones et al. took these findings to suggest that preschool-age CWS exhibit a less adaptive pattern of physiological responding (e.g., opposing autonomic activity)[44]. Given this finding, it seems reasonable to speculate that both sympathetic and parasympathetic activity concurrently impact instances of stuttering in preschool-age CWS, whereas the present study only measured sympathetic (i.e., SCL) activity. Thus, at least from a theoretical perspective, measuring physiological *reactivity* (e.g., SCL) concomitantly with physiological *regulation* (e.g., RSA) would seem to provide the most comprehensive understanding of physiological associates of emotion. With such understanding we might, in turn, better comprehend how these concurrently activated aspects of the autonomic nervous system (ANS) jointly impact childhood stuttering.

[44] This interpretation is based on Porges' (2007) Polyvagal Theory that well-regulated autonomic systems exhibit reciprocal activity (i.e., higher sympathetic activity and lower parasympathetic activity or lower sympathetic activity and higher parasympathetic activity).

# CHAPTER V

# CONCLUSION

In general, present findings addressed the questions of 'whether', 'when' and 'how' the relationship between emotional processes and stuttering exists. Regarding 'whether' the relation between emotional processes and stuttering exists, the first finding suggests that yes, such an association exists for preschool-age CWS, at least for positive emotional reactivity. Relative to 'when' the relation between emotional processes and stuttering exists, the second finding suggests that preschool-age CWS's negative emotional reactivity is more associated with their percentage of stuttered disfluencies per 100 words under positive emotional stress compared to relatively neutral emotional stress. Concerning 'how' emotional processes may impact childhood stuttering, the third finding, cautiously interpreted, suggests that for preschool-age CWS, positive emotional reactivity may be associated with stuttering through MLU rather than sympathetic arousal.

It is thought that the present as well as similar findings (e.g., Choi et al., 2013; Jones et al., 2014; Walden et al., 2012) should help develop: (1) a more comprehensive understanding of the association of emotional processes and childhood stuttering, (2) better understanding of possible mechanisms that underlie this association and (3) empirical evidence to test the Dual Diathesis-Stress model of childhood stuttering (Conture & Walden, 2012). Based on the present findings, one might plausibly speculate that different (e.g., positive vs. negative) emotions impact childhood stuttering in different ways. For example, regarding the association between positive emotion and stuttering, MLU may be a possible mediator whereas for the relation between negative emotion and stuttering, poorly regulated reactivity or opposing autonomic activity may be a possible mediator. Although such differences may be suggestive of sub-types among children who stutter, it is just as possible that the two "mechanisms" can be observed within one child who stutters.

Such speculation, of course, must await further investigation for support or refutation. Until results of such future research are available, current findings – and a developing line of empirical evidence (e.g., Anderson et al., 2003; Arnold et al., 2011; Choi et al., 2013; Eggers et al, 2010; Johnson et al., 2010; Jones et al., in press; Jones et al., 2014; Ntourou et al., 2013; Walden et al., 2012) – appear to support the notion that emotional processes play a role and warrants inclusion in any truly comprehensive account of childhood stuttering.

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*Figure 1*. Dual Diathesis-Stressor (DD-S) model (after Conture & Walden, 2012), with emotional domain (diathesis + stressor) being circumscribed by a solid red line. This solid red line indicates that the emotional domain of the DD-S model was the focus of the present study.

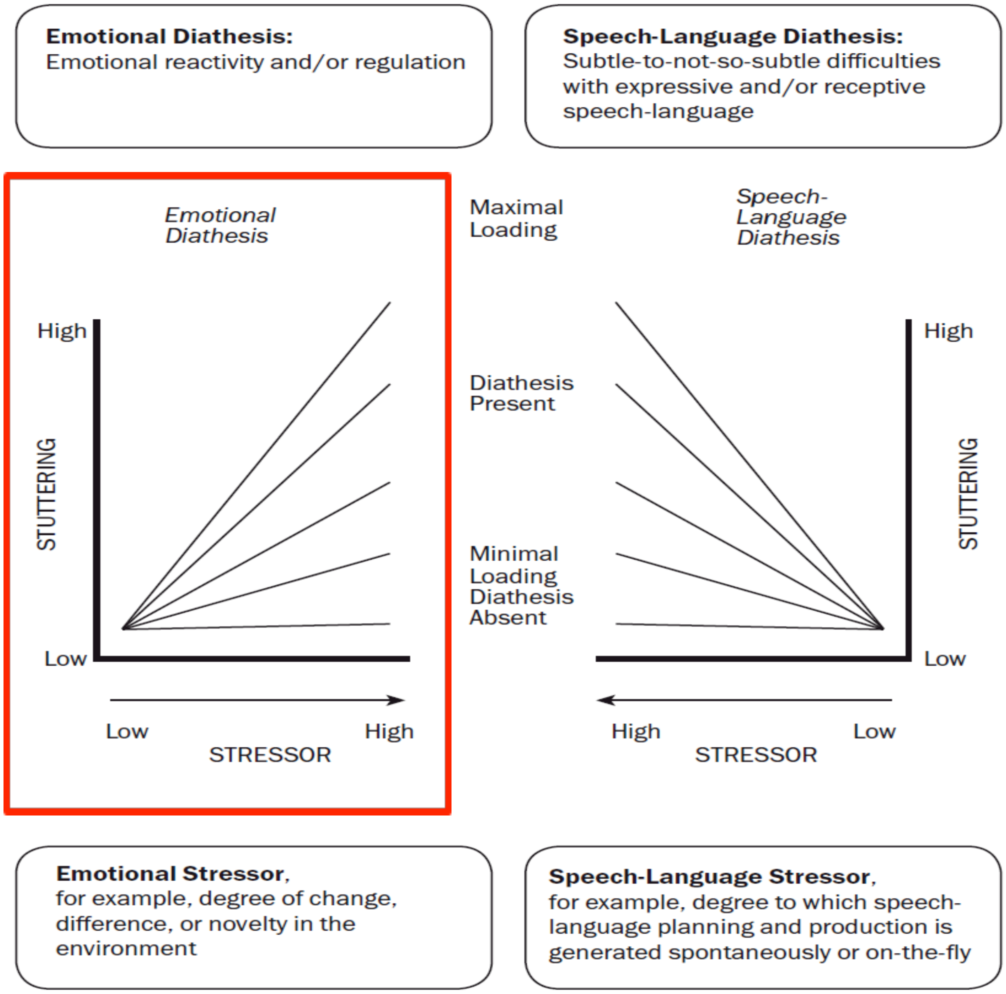


*Figure 2.* A graphic representation of the hypothesized relations between this study's independent, mediator and dependent variables (Adapted from Barron and Kenny [1986, p.1179]'s path diagram). Hypotheses (H) 1-3, solid lines and Hypotheses (H) 4-6, dashed lines (see text).

*Note:* ——▶ = *Total effects;* - - - -▶ = *Indirect effects*

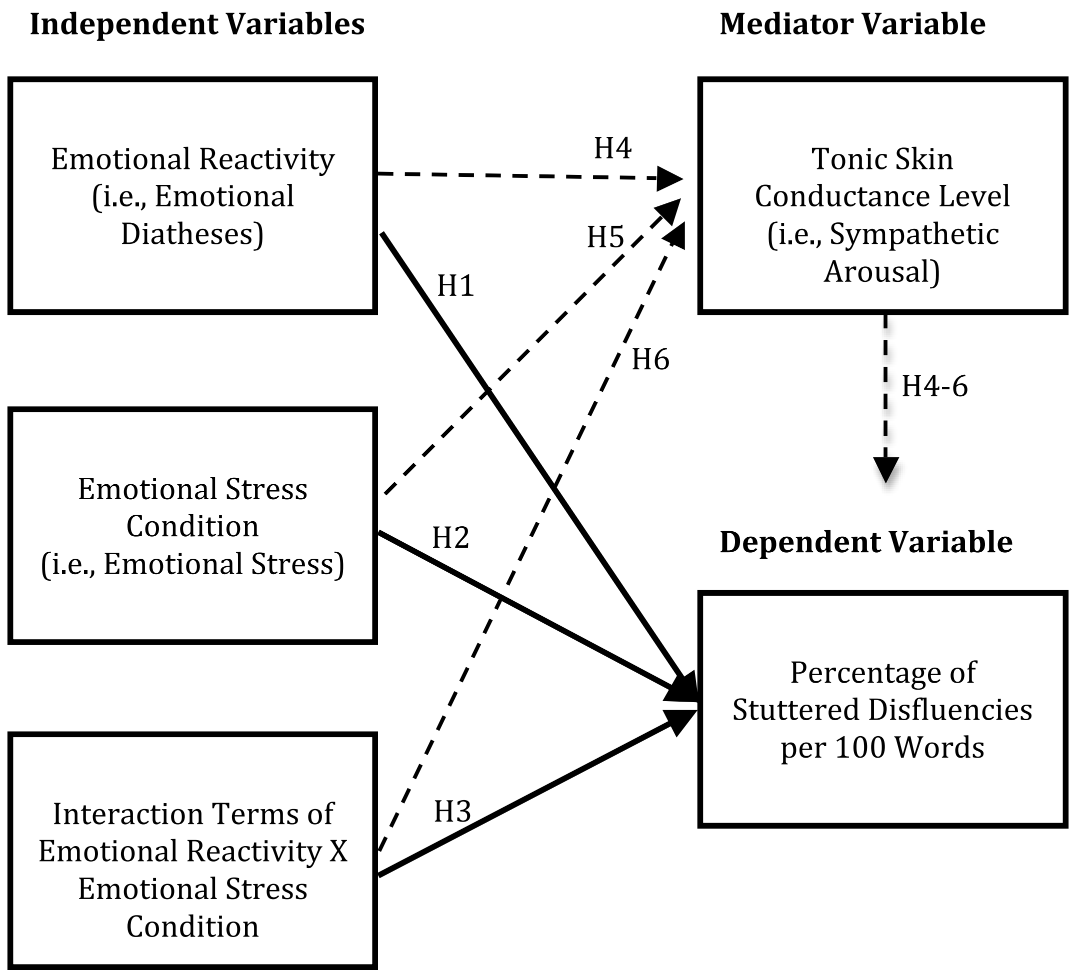
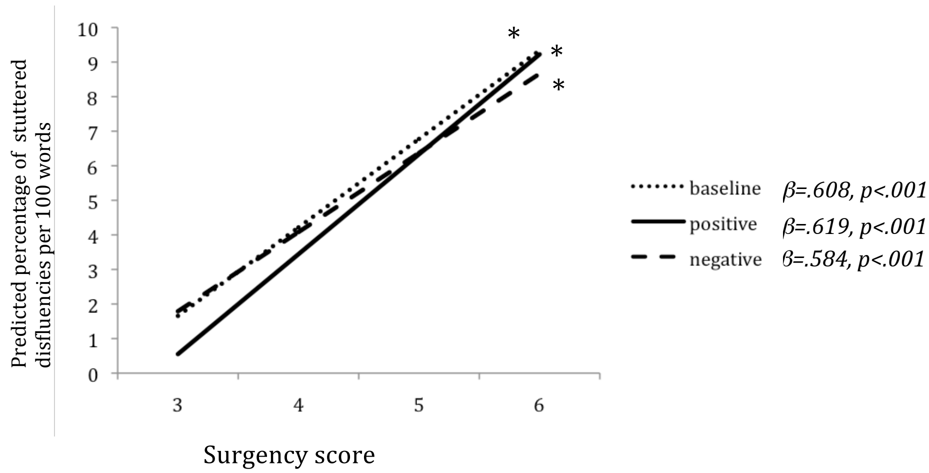


*Figure 3.* Relations between emotional reactivity and the percentage of stuttered disfluencies per 100 words predicted from the GEE model per each emotional stress condition (Legend: baseline=baseline condition, positive = positive emotional stress condition, negative=negative emotional stress condition; * refers to significance at .05 level).

**(3-A)** Relation between Surgency score (i.e., positive emotional reactivity) and predicted percentage of stuttered disfluencies per 100 words per each emotional stress condition




**(3-B)** Relation between Negative Affectivity (i.e., negative emotional reactivity) and predicted percentage of stuttered disfluencies per 100 words per each emotional stress condition

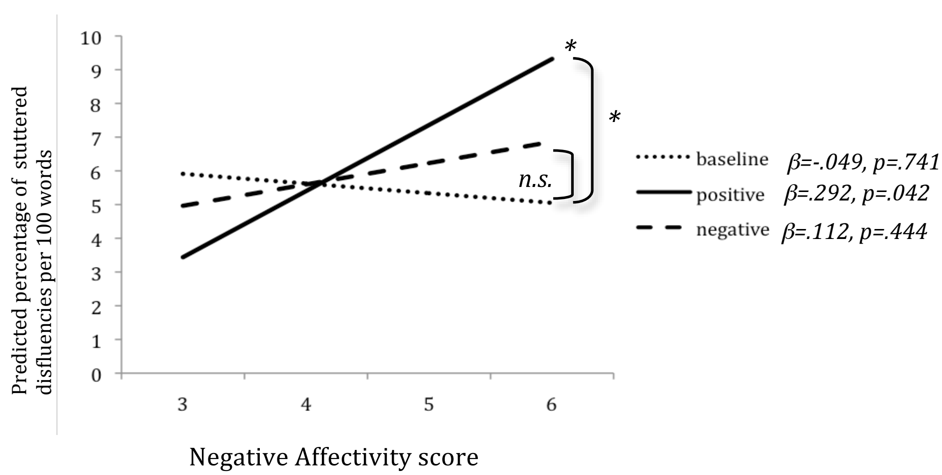


Table 1. *Hypotheses (1-3) as well as related independent and dependent variables regarding Research Issue I.*

| | |
|---|---|
| **Research issue I** | **Investigated whether preschool-age CWS's emotional diathesis, emotional stress, or their interaction affects their percentage of stuttered disfluencies per 100 words** |
| **First research** hypothesis | Preschool-age CWS's emotional reactivity affects their percentage of stuttered disfluencies per 100 words. |
| **Independent variables** | **Emotional reactivity (i.e., Surgency and Negative Affectivity scores from the CBQ)** |
| Dependent variable | Percentage of stuttered disfluencies per 100 words |
| **Second research** hypothesis | Emotional stress condition affects preschool-age CWS's percentage of stuttered disfluencies per 100 words. |
| **Independent variables** | **Emotional Stress condition (Two dummy coded variables that compare positive vs. baseline as well as negative vs. baseline)** |
| Dependent variable | Percentage of stuttered disfluencies per 100 words |
| **Third research** hypothesis | The interaction between preschool-age CWS's emotional reactivity and emotional stress condition affects their percentage of stuttered disfluencies per 100 words. |
| **Independent variables** | Interaction terms of preschool-age CWS's **emotional reactivity and emotional stress conditions** |
| Dependent variable | Percentage of stuttered disfluencies per 100 words |
| Analytical procedure | Generalized Estimating Equations with Poisson distribution |

*Note:* Children who stutter (CWS)

Table 2. *Hypotheses (4-6) as well as related independent, mediator and dependent variables regarding Research Issue II.*

| **Research issue II** | **Explored whether there is a mediation component of the emotional dimension of the DD-S model** |
|---|---|
| **Fourth research** hypothesis | Preschool-age CWS's emotional reactivity affects their percentage of stuttered disfluencies per 100 words through their sympathetic arousal. |
| **Independent variables** | **Emotional reactivity (i.e., Surgency and Negative Affectivity scores from the CBQ)** |
| Dependent variable | Percentage of stuttered disfluencies per 100 words |
| **Mediator** | **Sympathetic arousal (i.e., Tonic SCL)** |
| **Fifth research** hypothesis | Emotional stress condition affects preschool-age CWS's percentage of stuttered disfluencies per 100 words through their sympathetic arousal. |
| **Independent variables** | **Emotional Stress condition (Two dummy coded variables that compare positive vs. baseline as well as negative vs. baseline)** |
| Dependent variable | Percentage of stuttered disfluencies per 100 words |
| **Mediator** | **Sympathetic arousal (i.e., Tonic SCL)** |
| **Sixth research** hypothesis | The interaction between preschool-age CWS's emotional reactivity and emotional stress condition affects their percentage of stuttered disfluencies per 100 words through their sympathetic arousal. |
| **Independent variables** | Interaction terms of preschool-age CWS's **emotional reactivity and emotional stress condition** |
| Dependent variable | Percentage of stuttered disfluencies per 100 words |
| **Mediator** | **Sympathetic arousal (i.e., Tonic SCL)** |
| Analytical procedure | Path analysis using Mplus (Muthén & Muthén , 2012) |

*Note:* Children who stutter (CWS).

Table 3. *Descriptive information regarding participants: Means (M) and standard deviations (SD) for measures of age, socioeconomic status (SES), speech disfluency, speech-language, CBQ factor scores and mean tonic SCL for all, boy and girl children who stutter (CWS).*

| | **All CWS (N=49)** | | **Boy CWS (N=38)** | | **Girl CWS (N=11)** | | **Gender difference** | | ***Effect size*** | ***Confidence Interval*** |
|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *Mann-Whitney U* | *Exact.Sig.* | *r* | *CI for r* |
| **Age/SES** | | | | | | | | | | |
| Age (months) | 51.04 | 10.28 | 50.41 | 10.48 | 53.24 | 9.72 | 174.50 | .417 | .012 | -0.17 to 0.39 |
| SES | 49.83 | 11.17 | 49.24 | 11.65 | 51.86 | 9.51 | 187 | .606 | .008 | -.21 to .35 |
| **Speech disfluency** | | | | | | | | | | |
| Percentage of total disfluencies /100 words | 12.34 | 5.72 | 12.06 | 5.64 | 13.30 | 6.14 | 191.00 | .675 | .06 | -.23 to .34 |
| Percentage of stuttered disfluencies /100 words | 7.45 | 4.76 | 7.25 | 4.82 | 8.12 | 4.67 | 169.50 | .351 | .14 | -.15 to .41 |
| Percentage of non-stuttered disfluencies /100 words | 4.89 | 2.59 | 4.81 | 2.30 | 5.18 | 3.53 | 207.00 | .351 | .01 | -.27 to .29 |
| SSI total | 16.92 | 4.59 | 16.68 | 4.83 | 17.73 | 3.71 | 163.00 | .273 | .16 | -.13 to .42 |
| **Speech language** | | | | | | | | | | |
| PPVT standard score | 115.65 | 11.46 | 117.08 | 11.26 | 110.73 | 11.26 | 145.5 | .131 | .22 | -.07 to .47 |
| EVT standard score | 116.31 | 11.04 | 116.55 | 10.99 | 115.45 | 11.70 | 207.00 | .967 | .01 | -.27 to .29 |
| TELD-R standard score | 118.85 | 14.48 | 117.39 | 15.03 | 124.40 | 11.07 | 134.50 | .162 | .20 | -.09 to .46 |
| TELD-E standard score | 112.27 | 15.54 | 111.32 | 15.82 | 115.90 | 14.63 | 156.50 | .403 | .12 | -.17 to .39 |
| GFTA standard score | 108.41 | 11.72 | 108.16 | 12.49 | 109.27 | 9.01 | 203.00 | .892 | .02 | -.26 to .30 |
| MLU | 5.58 | 1.33 | 5.31 | 1.14 | 6.52 | 1.55 | 119.00 | .030[45] | .31 | .03 to .54 |
| **CBQ scores** | | | | | | | | | | |
| Surgency score | 4.65 | .67 | 4.70 | .58 | 4.49 | .91 | 173.00 | .397 | .12 | -.17 to .39 |
| Negative Affectivity score | 3.96 | .46 | 3.90 | .44 | 4.18 | .50 | 141.50 | .108 | .23 | -.05 to .48 |
| Effortful Control score | 4.75 | .44 | 4.70 | .40 | 4.93 | .54 | 140.00 | .101 | .24 | -.04 to .49 |
| **Mean Tonic SCL (μS)** | | | | | | | | | | |
| Mean tonic SCL during narratives | 17.02 | 7.95 | 17.14 | 8.26 | 16.64 | 6.90 | 1771.00 | .959 | <.001 | -.16 to .16 |

*Note.* SES range: 6-66; SSI range: 0-56; CBQ range: 1-7.

[45] To adjust for possible spurious findings due to multiple testing, Bonferroni correction was conducted by dividing the nominal alpha level (i.e., p=.05) by the number of comparisons (i.e., 5: PPVT, EVT, TELD-R, TELD-E, and MLU). After Bonferroni correction (p=.01), the difference between boys and girls in MLU lost its significance.

Table 4. *Correlations (i.e., Spearman's rho) between variables investigated in the present study per each emotional stress condition for CWS (N=49).*

| | | | | **BASELINE Emotional Stress Condition** | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***During a Narrative*** | | | | | | | |
| 1. Percentage of stuttered disfluencies per 100 words | - | .091 | .164 | .209 | .296* | -.023 | .214 |
| 2. Tonic SCL | | - | .049 | .229 | .280 | .095 | -.047 |
| 3. MLU | | | - | .563** | .097 | -.054 | .177 |
| 4. Number of words | | | | - | .005 | -.188 | .176 |
| ***CBQ Factors*** | | | | | | | |
| 5. Surgency | | | | | - | -.072 | -.272 |
| 6. Negative Affectivity | | | | | | - | -.180 |
| 7. Effortful Control | | | | | | | - |
| | | | | **POSITIVE Emotional Stress Condition** | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***During a Narrative*** | | | | | | | |
| 1. Percentage of stuttered disfluencies per 100 words | - | .087 | .303* | .338* | .375** | .128 | .122 |
| 2. Tonic SCL | | - | .084 | .325* | .219 | .001 | -.117 |
| 3. MLU | | | - | .375** | .163 | .052 | .087 |
| 4. Number of words | | | | - | .217 | -.056 | -.042 |
| ***CBQ Factors*** | | | | | | | |
| 5. Surgency | | | | | - | -.072 | -.272 |
| 6. Negative Affectivity | | | | | | - | -.180 |
| 7. Effortful Control | | | | | | | - |
| | | | | **NEGATIVE Emotional Stress Condition** | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ***During a Narrative*** | | | | | | | |
| 1. Percentage of stuttered disfluencies per 100 words | - | -.020 | .187 | .326* | .336* | .052 | .007 |
| 2. Tonic SCL | | - | .206 | .285 | .313* | -.006 | -.129 |
| 3. MLU | | | - | .571** | .160 | .074 | .010 |
| 4. Number of words | | | | - | .213 | -.069 | -.049 |
| ***CBQ Factors*** | | | | | | | |
| 5. Surgency | | | | | - | -.072 | -.272 |
| 6. Negative Affectivity | | | | | | - | -.180 |
| 7. Effortful Control | | | | | | | - |

*Note.* *=significant at 0.05 level of confidence. **= significant at 0.01 level of confidence. SCL: skin conductance level, MLU: mean length of utterance.

APPENDIX

*Information regarding independent and dependent variables: Means (M) and standard Deviations (SD) for measures of mean tonic skin conductance level (SCL), mean length of utterance (MLU) and percentage of stuttered disfluencies per 100 words for: (i) all CWS, (ii) CWS with high versus (iii) low Surgency, and (iv) CWS with high versus (v) low Negative Affectivity per each emotional stress condition (i.e., baseline, positive and negative).*

| Emotional Stress Conditions | **(i) All CWS** | **(ii) CWS with high Surgency** (Top 25%, N=13) | **(iii) CWS with low Surgency** (Bottom 25%, N=13) | **(iv) CWS with high Neg. Affect.** (Top 25%, N=13) | **(v) CWS with low Neg. Affect.** (Bottom 25%, N=13) |
|---|---|---|---|---|---|
| | *M(SD)* | *M(SD)* | *M(SD)* | *M(SD)* | *M(SD)* |
| | | | ***Tonic SCL*** *during narratives* | | |
| Baseline | 14.83 (7.84) | 17.02 (10.19) | 12.64 (5.82) | 16.47 (5.63) | 14.35 (8.99) |
| Positive | 18.13 (7.95) | 21.23 (10.76) | 16.81 (6.20) | 18.50 (6.58) | 16.84 (8.94) |
| Negative | 18.10 (7.76) | 22.15 (9.07) | 15.68 (5.82) | 18.15 (6.95) | 17.25 (9.89) |

| Emotional Stress Conditions | **All CWS** | **CWS with high Surgency** (Top 25%, N=13) | **CWS with low Surgency** (Bottom 25%, N=13) | **CWS with high Neg. Affect.** (Top 25%, N=13) | **CWS with low Neg. Affect.** (Bottom 25%, N=13) |
|---|---|---|---|---|---|
| | *M(SD)* | *M(SD)* | *M(SD)* | *M(SD)* | *M(SD)* |
| | | | ***MLU*** *during narratives* | | |
| Baseline | 6.50 (1.35) | 6.48 (1.87) | 6.12 (1.11) | 6.34 (1.45) | 6.52 (1.31) |
| Positive | 6.49 (1.50) | 6.46 (1.59) | 6.00 (1.31) | 6.79 (1.75) | 6.41 (1.40) |
| Negative | 6.37 (1.53) | 6.31 (1.68) | 5.88 (1.23) | 6.76 (1.73) | 6.20 (1.22) |

| Emotional Stress Conditions | **All CWS** | **CWS with high Surgency** (Top 25%, N=13) | **CWS with low Surgency** (Bottom 25%, N=13) | **CWS with high Neg. Affect.** (Top 25%, N=13) | **CWS with low Neg. Affect.** (Bottom 25%, N=13) |
|---|---|---|---|---|---|
| | *M(SD)* | *M(SD)* | *M(SD)* | *M(SD)* | *M(SD)* |
| | | | ***Percentage of stuttered disfluencies per 100 words*** *during narratives* | | |
| Baseline | 5.70 (5.23) | 6.81 (5.15) | 3.30 (2.60) | 4.35 (3.00) | 5.94 (5.38) |
| Positive | 5.23 (5.59) | 6.93 (4.77) | 3.13 (2.64) | 5.35 (4.56) | 5.12 (4.58) |
| Negative | 5.56 (5.28) | 6.20 (4.21) | 3.68 (3.67) | 5.04 (3.88) | 5.76 (4.40) |