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Research Article

Emotional Diathesis, Emotional Stress, and Childhood Stuttering

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Purpose: The purpose of this study was to determine (a) whether emotional reactivity and emotional stress of children who stutter (CWS) are associated with their stuttering frequency, (b) when the relationship between emotional reactivity and stuttering frequency is more likely to exist, and (c) how these associations are mediated by a 3rd variable (e.g., sympathetic arousal).

Method: Participants were 47 young CWS (*M* age = 50.69 months, *SD* = 10.34). Measurement of participants' emotional reactivity was based on parental report, and emotional stress was engendered by viewing baseline, positive, and negative emotion-inducing video clips, with stuttered disfluencies and sympathetic arousal (indexed by tonic skin conductance level) measured during a narrative after viewing each of the various video clips.

Results: CWS's positive emotional reactivity was positively associated with percentage of their stuttered disfluencies regardless of emotional stress condition. CWS's negative emotional reactivity was more positively correlated with percentage of stuttered disfluencies during a narrative after a positive, compared with baseline, emotional stress condition. CWS's sympathetic arousal did not appear to mediate the effect of emotional reactivity, emotional stress condition, and their interaction on percentage of stuttered disfluencies, at least during this experimental narrative task following emotion-inducing video clips.

Conclusions: Results were taken to suggest an association between young CWS's positive emotional reactivity and stuttering, with negative reactivity seemingly more associated with these children's stuttering during positive emotional stress (a stress condition possibly associated with lesser degrees of emotion regulation). Such findings seem to support the notion that emotional processes warrant inclusion in any truly comprehensive account of childhood stuttering.

There has been considerable empirical study of, as well as speculation regarding, the possible relation between emotion and childhood stuttering (e.g., Adams, 1992; Bloodstein, 1949; Choi, Conture, Walden, Lambert, & Tumanova, 2013; Conture, Kelly & Walden, 2013; Guitar, 2014; W. Johnson et al., 1959; Jones, Choi, Conture, & Walden, 2014; Yairi, 1997). Although not all of these researchers appear to assume that emotion contributes to childhood stuttering, some of them do seem to assume that if emotion is associated with stuttering, exogenous emotional stress is relevant to this association. For example, when exogenous emotional stress was examined in a nonexperimental research design on the basis of parental report, Yairi and Ambrose (1992) reported that 43% of young children who stutter (CWS) experienced exogenous emotional stress (e.g., divorce of parents, moving to another house, excessive sibling rivalry, or difficult day care arrangements) prior to stuttering onset. It is of interest that emotional stress found to be associated with change in stuttering was not always negative in valence. For example, results of one recent empirical study (Johnson, Walden, Conture, & Karrass, 2010) indicated that when exogenous emotional stimuli were experimentally manipulated, CWS were more disfluent after receiving a desired gift than after receiving a disappointing gift. This finding was taken to suggest that positive emotional stimuli may be associated with increases in children's speech disfluencies (cf. Arnold, Conture, Key, & Walden, 2011; Ntourou, Conture, & Walden, 2013; Walden et al., 2012).

Although exogenous factors are certainly of import to an understanding of the association of emotion and childhood stuttering, some researchers have begun to consider whether CWS's different endogenous emotional

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diathesis[1] causes them to react differently to the similar levels of exogenous emotional stress and whether such individual differences in emotional diathesis may be associated with stuttering (Conture et al., 2013; Conture & Walden, 2012; Karrass et al., 2006; Kefalianos, Onslow, Block, Menzies, & Reilly, 2012; Seery, Watkins, Mangelsdorf, & Shigeto, 2007). For example, several empirical studies, using caregiver reports or behavioral observations, have reported significant differences in emotional diathesis between CWS and children who do not stutter (CWNS; e.g., Anderson, Pellowski, Conture, & Kelly, 2003; Eggers, De Nil, & Van den Bergh, 2010; Embrechts, Ebben, Franke, & Van de Poel, 2000; Karrass et al., 2006; Schwenk, Conture, & Walden, 2007; Wakaba, 1997). On the basis of a review of these empirical studies' findings, Kefalianos et al. (2012) cautiously concluded that preschool-age CWS, when compared with preschool-age CWNS, appear to exhibit (a) lower adaptability, (b) lower attention span/persistency, (c) more negative quality of mood, and (d) greater activity.

More recently, behavioral observations have been used in several empirical studies of the association of young CWS's stuttering and their possible emotional diatheses. For example, Choi et al. (2013) reported that CWS with high behavioral inhibition stuttered more than CWS with low behavioral inhibition. Jones, Conture, and Walden (2014) similarly reported that CWS's negative emotional behaviors (e.g., frowning, crying, etc.) were more associated with their stuttered than fluent utterances. Likewise, Arnold et al. (2011) reported that decreased frequency and duration of regulatory strategies (i.e., distraction or self-stimulation, cognitive restructuring behaviors, and instrumental coping) were associated with more stuttering in CWS. Consistent with these findings, Ntourou et al. (2013) reported that decreases in young CWS's distraction behaviors, an index of emotion regulation, during a frustrating task were associated with increases in the percentage of stuttered disfluencies. Likewise, Ambrose, Yairi, Loucks, Seery, and Throneburg (2015) recently reported that among other differences (e.g., lower performance on standardized tests of language), children with persistent stuttering, when compared with children who recovered from stuttering and normally fluent controls, were also judged by their parents to be more negative in temperament.

In contrast, not all researchers have suggested that there is an association between emotional diathesis and stuttering, at least for a diathesis that is negative in valence. For example, Alm's (2014) review of studies of the emotional characteristics of persons who stutter led him to suggest that persons who stutter are "not characterized by constitutional traits of anxiety or similar constructs" (p. 5), but that a subgroup of persons who stutter are characterized by "traits associated with inattention and hyperactivity/impulsivity" (p. 5).

[1]A *diathesis* (sometimes referred to as a disposition, proclivity, or vulnerability) is a relatively stable predisposing factor open to environmental influences, endogenous to individuals, and usually latent in nature (Ingram & Luxton, 2005).

When is the Relation Between Emotional Diathesis and Stuttering More Likely to Exist?

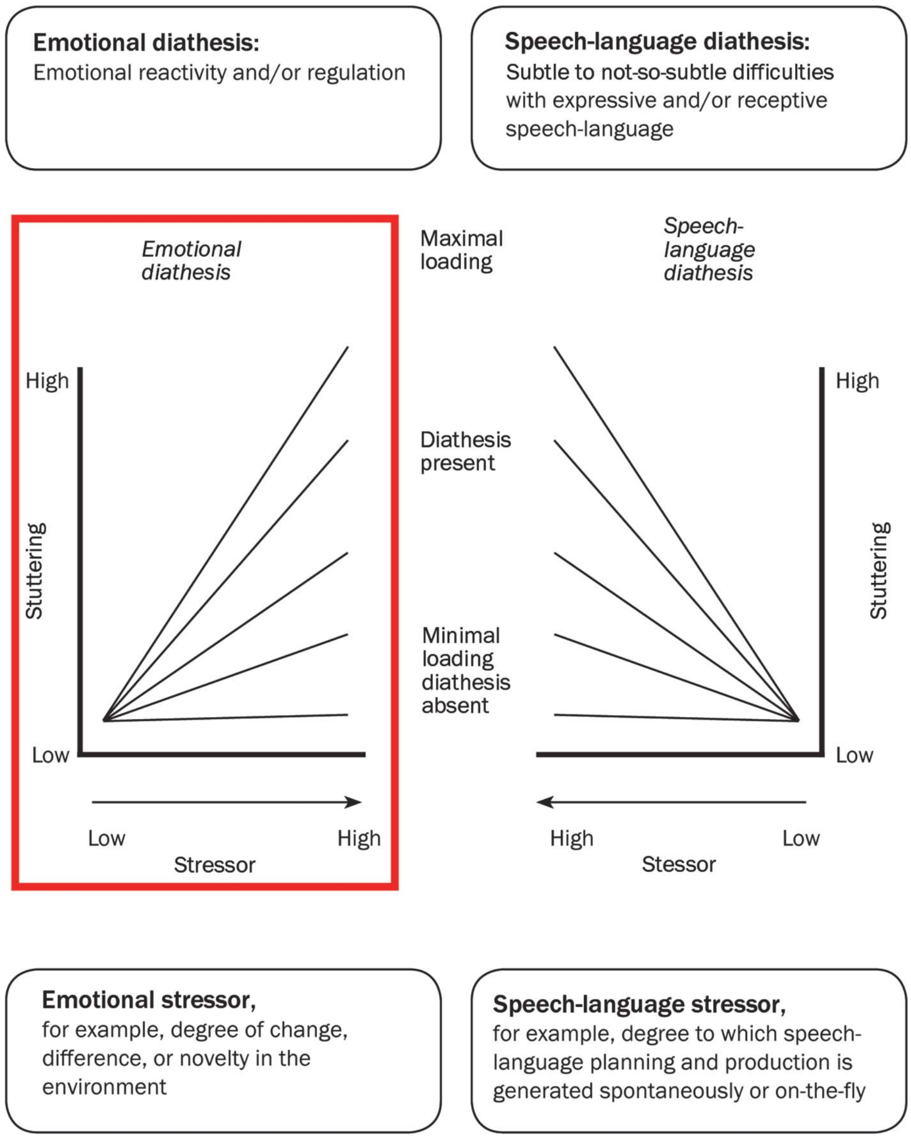
As reviewed above, most studies have investigated whether emotional stress or emotional diathesis independently is associated with childhood stuttering. Thus, there has been little apparent empirical assessment of whether emotional stress and emotional diathesis interact with one another to affect CWS's stuttering. Supporting the empirical study of such interactions, Ingram and Luxton (2005) suggested that considering emotional diathesis and emotional stress separately may restrict researchers' ability to thoroughly describe potentially key associates of behavior or disorders of interest—in this case, childhood stuttering. In theory, Conture and Walden's (2012) Dual Diathesis-Stressor (DD-S) model of childhood stuttering attempts to explain whether emotional diathesis interacts with emotional stress to affect childhood stuttering (Conture & Walden, 2012; see Figure 1). In brief, this model suggests that variable (typically exogenous) emotional stressors (i.e., challenges) may activate CWS's relatively stable (endogenous) emotional diathesis (e.g., high emotional reactivity and/or low emotion regulation). The model further suggests that activation of such a diathesis is associated with disruptions in fluent speech and language planning and/or production.

This theoretical account appears to go beyond the idea that childhood stuttering simply results from exogenous emotional stress to the notion that children are "active agents in their own development" (Rothbart, 2011, pp. 33–34). In other words, the latter notion implies that children's emotional diathesis may actively filter any exogenous emotional stress they might experience. Given considerable empirical support for the idea that children are active agents in their own development (for review, see Rothbart, 2011), it seems appropriate to suggest that the contribution of emotional diathesis and emotional stress interactions to childhood stuttering warrants further empirical study. One recent empirical study (Jones, Conture, & Walden, 2014) investigated this interaction and reported a significant interaction between negative emotional reactivity and emotional (stress) condition. Although Jones, Conture, and Walden's findings are suggestive of an important interaction between emotional diathesis and emotional stress, replication appears necessary to test one of the more salient predictions of the DD-S model. To be specific, the DD-S model predicts that the positive relation between children's emotional diathesis and percentage of stuttering would be stronger when they are under greater rather than lesser emotional stress.

How Might Emotion and Stuttering Be Related?

Furthermore, there is presently not a great deal known about how emotional stress and children's emotional diathesis affect stuttering. As mentioned by Walden et al. (2012), 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

Figure 1. DD-S model of developmental (childhood) stuttering (after Conture & Walden, 2012). The emotional domain (diathesis + stressor) is circumscribed by a solid red line to indicate that this domain of the DD-S model was the focus of the present study. Individual differences in diathetic loadings are represented by a family of lines, with the first line, parallel to the horizontal axis, representing the absence of a diathesis and the next four lines representing low to high diathetic loadings. Figure from Conture & Walden (2012). © National Book Centre. Reprinted with permission.



a latent emotional diathesis is activated by emotional stress, behavioral and/or physiological changes may occur. We speculate that such changes may be one possible mediator between emotional diathesis or emotional stress and stuttering. Given that sympathetic arousal has been reported to be associated with emotional diathesis (Fowles, Kochanska, & Murray, 2000; Jones, Buhr, et al., 2014) as well as emotional stress (Kreibig, 2010) and that sympathetic arousal has been studied in relation to stuttering (e.g., Adams & Moore, 1972; Ickes & Pierce, 1973; Jones, Buhr, et al., 2014; Weber & Smith, 1990), such speculation seems reasonable, and sympathetic arousal may one good candidate for a mediator. Such mediation possibly accounts for, at least in part, how emotional diathesis and/or emotional stress may be associated with stuttering.

Consistent with the use of mediational analytical procedures in the present study, Jones, Conture, and Walden (2014) speculated that heightened sympathetic arousal may divert attentional resources away from speech-language processes. Such an inverse relation between attention and arousal has been also suggested by others (e.g., Das, Naglieri, & Kirby, 1994). For example, Easterbrook (1959) suggested that attentional performance drops dramatically when a state of high arousal is reached. Likewise, Portas et al. (1998) reported that the highest level of attention-related thalamic activity is seen under conditions of low arousal compared with high arousal. Jones, Conture, and Walden further suggested that such diversion of attentional resources may disrupt initiation, ongoing planning, and production of speech and language, resulting in speech disfluencies. Weber and Smith (1990) similarly suggested that respiratory function or reflex pathways involved in speech production may be disrupted by alterations in sympathetic arousal and may contribute to speech disfluency. Prior to empirically testing such speculations, however, further empirical assessment of the association between emotional stress, emotional diathesis, sympathetic arousal, and childhood stuttering appears to be needed.

Purpose

Therefore, it was the purpose of the present study to test two issues pertaining to the emotional diathesis–stressor aspect of the DD-S account of childhood stuttering. To empirically assess these issues, the first author developed six a priori hypotheses.

The first issue (relating to Hypotheses 1–3) addressed whether young CWS's emotional reactivity, emotional stress condition, and their interaction affect stuttering. Hypothesis 1 predicted that young CWS's emotional reactivity would affect their percentage of stuttered disfluencies. Hypothesis 2 also predicted that emotional stress condition would affect CWS's percentage of stuttered disfluencies. Likewise, Hypothesis 3 predicted that the interaction between young CWS's emotional reactivity and emotional stress condition would affect their percentage of stuttered disfluencies. To be specific, it was hypothesized that CWS's emotional reactivity would be more likely to be associated with their percentage of stuttered disfluencies when there is greater, compared to lesser, emotional stress.

The second issue (relating to Hypotheses 4–6) addressed whether those associations predicted in Hypotheses 1–3 would be mediated by sympathetic arousal. Hypothesis 4 predicted that young CWS's emotional reactivity would affect their percentage of stuttered disfluencies through sympathetic arousal. Hypothesis 5 similarly predicted that emotional stress condition would affect young CWS's percentage of stuttered disfluencies through sympathetic arousal. Hypothesis 6 predicted that the interaction between CWS's emotional reactivity and emotional stress condition would affect their percentage of stuttered disfluencies through sympathetic arousal.

Method

Participants

Participants were 47 young CWS (*M* age = 50.69 months, *SD* = 10.34), consisting of 36 boys and 11 girls (a gender ratio typical of young CWS, with gender used as a covariate in all analytical models). All participants were between the ages of 36–71 months, as well as monolingual, native speakers of Standard American English. No participant had received any known or reported formal treatment for stuttering or other communication disorders prior to participation. Also, participants had no known or reported hearing, neurological, developmental, academic, intellectual, or emotional problems.

Participants were paid volunteers referred to the Vanderbilt Developmental Stuttering Laboratory (Nashville, TN, USA) by their parents or speech-language pathologists. Caregivers were informed of the study via (a) a free, widely read, regionally distributed parent-oriented magazine, (b) local health care provider, or (c) self- or professional referral to the Vanderbilt Developmental Stuttering Laboratory. Participants were part of an ongoing series of empirical investigations of linguistic and emotional contributors to developmental stuttering (e.g., Arnold et al., 2011; Clark, Conture, Frankel, & Walden, 2012; Clark, Conture, Walden, & Lambert, 2013, 2015; K. Johnson et al., 2010; Jones, Buhr, et al., 2014; Jones, Conture, & Walden, 2014; Ntourou et al., 2013; Tumanova, Conture, Lambert, & Walden, 2014; Zengin-Bolatkale, Conture, & Walden, 2015) conducted by the Vanderbilt University Developmental Stuttering Project. The study's protocol was approved by the Institutional Review Board of Vanderbilt University. Parents signed informed consent, and children gave assent for participation.

Classification and Inclusion Criteria

CWS

A participant was considered a CWS if he or she (a) exhibited three or more stuttered disfluencies of conversational speech on the basis of a 300-word sample (Curlee, 2007) and (b) received a total overall stuttering severity 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 16th percentile (i.e., −1.0 *SD*) or higher on the (a) Peabody Picture Vocabulary Test–Fourth Edition (A or B; Dunn & Dunn, 2007; standard score *M* = 116.30, *SD* = 11.25), (b) Expressive Vocabulary Test–Second Edition (Williams, 2007; *M* = 116.83, *SD* = 10.97), (c) Test of Early Language Development–Third Edition (Hresko, Reid, & Hamill, 1999; receptive subscale *M* = 118.50, *SD* = 14.62, expressive subscale *M* = 112.74, *SD* = 15.56), and (d) Sounds in Words subtest of the Goldman-Fristoe Test of Articulation 2 (Goldman & Fristoe, 2000; *M* = 110.09, *SD* = 8.11). Furthermore, each child passed a bilateral pure tone hearing screening, with all such speech, language, and hearing tests being administered to each child during his or her visit to the Vanderbilt Developmental Stuttering Laboratory.

Excluded Participants

From an initial group of 68 young CWS who met the above criteria, 21 CWS were excluded for the following reasons: incomplete narrative data due to either noncompliance during the experimental procedure (*n* = 13) or incomplete Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001) data (n = 8). Exclusion of these 21 potential participants resulted in 47 CWS for the final data analyses.

Race

Race was obtained via parental interview. Participants included 81% (n = 38) White, 9% (n = 4) African American, and 10% (n = 5) multiracial children.

Socioeconomic Status

Each participant's socioeconomic status was determined using the Four-Factor Index of Social Status (Hollingshead, 2011). This index takes into account both parents' educational levels and occupations on the basis of self-report. Computed total scores ranged from 28 to 66 (M = 50.12, SD = 11.12), with a higher score indicating a higher socioeconomic status (see Richels, Johnson, Walden, & Conture, 2013, for empirical findings regarding associations between socioeconomic status, parental education, and childhood stuttering).

Procedures

Participants and their parents visited the Vanderbilt Developmental Stuttering Laboratory twice: The second visit occurred approximately 1–2 weeks after the first. The first visit included testing of speech, language ability, and temperament as well as hearing screening. During the second visit, each participant was seated in a car safety seat mounted directly in front of a computer monitor. For collection of tonic skin conductance level (SCL)—the present 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 or her mouth. Each participant was exposed to one emotionally neutral (i.e., baseline emotional stress condition) and two emotionally arousing video clips (i.e., positive and negative emotional stress conditions). For all participants, baseline was the first condition to minimize the possible continuing or lingering impact of emotionally valenced stimuli on participants' baseline or resting SCL (a practice consistent with that used in empirical psychophysiological studies; i.e., Gomez, Zimmermann, Guttormsen-Schär, & Danuser, 2005). However, in attempts to minimize order effect, the order of the presentation for positive and negative stimuli was counterbalanced.

After each of the three conditions—baseline, positive, and negative emotional stress—the participant performed a speaking task, in which he or she was asked to produce a narrative while viewing pictures from one of six storybooks about a boy, a dog, and a frog by the author Mercer Mayer (1967/2003a, 1969/2003e, 1971/2003b, 1973/2003d, 1974/2003c, 1975/2003f). These speaking tasks technically are best described as "picture-assisted narrative storytelling." However, for the sake of brevity, these tasks are described as a "narrative" throughout the present text. During these three narrative epochs, each participant's speech disfluencies and SCL were collected.

Psychophysiological Data Acquisition

Tonic SCL was acquired with the Biopac MP150 system (Biopac Systems, Goleta, CA). Data were recorded using Acknowledge software (Ver. 4.1 for Macintosh, Biopac). Tonic SCL was recorded with a pair of Ag-AgCl electrodermal electrodes (Model TSD203; Exosomatic measurement). These electrodes were 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 participant's right hand, with the electrodes connected to a Biopac GSR100C skin conductance amplifier. The resulting tonic SCL data were sampled at 1250 Hz, with the gain set at 10 µS/V and a low-pass filter at 1 Hz.

Following data acquisition, the Connect Endpoints math function of the Biopac Acknowledge 4.1 software was used to correct data artifacts that occurred due to the behavior of individuals and/or the environmental conditions during data collection (e.g., mechanical pressures on the electrodes, loose electrodes, wire drag, gross body movements, and/or ambient noise; Boucsein et al., 2012). No more than 10% of the total data for any narrative epoch were corrected. Data presented in the Results section are expressed in microsiemens (µS).

Description of Independent, Dependent, and Mediator Variables

As described in further detail immediately below, the independent variables for the present study were (a) emotional reactivity, (b) emotional stress condition, and (c) the interaction terms between (a) and (b). The dependent variable was percentage of stuttered disfluencies. Last, the mediator variable was sympathetic arousal as measured by tonic SCL.

Independent Variables

Emotional reactivity. Emotional reactivity was chosen as this study's emotional diathesis on the basis of the DD-S model of stuttering (Conture & Walden, 2012). *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). Rothbart et al. (2001) suggested that emotional reactivity includes emotional reactions related to both negative and positive events. Conture and Walden (2012) also 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 present study, both positive and negative emotional reactivity were measured using the standard (195-item) version of the CBQ (Rothbart et al., 2001).

The CBQ is a well-established measure of temperament in children from 3 to 7 years of age. The questionnaire is based on parental report and has been used in previous studies of temperament of young CWS (e.g., Eggers, De Nil, & Van den Bergh, 2009, 2010; Walden et al., 2012). The standard CBQ consists of 195 items reflecting 15 scales: (a) Activity Level, (b) Anger/Frustration, (c) Approach/Positive Anticipation, (d) Attentional Focusing, (e) Discomfort, (f) Falling Reactivity/Soothability, (g) Fear, (h) High-intensity Pleasure, (i) Impulsivity, (j) Inhibitory Control, (k) Low-intensity Pleasure, (l) Perceptual Sensitivity, (m) Sadness, (n) Shyness, and (o) Smiling and Laughter.

Scale-level factor analyses of the 15 CBQ scales for children between the ages of 3 and 7 years have indicated that scores from some of the 15 scales can be combined into three higher level factors: (a) Surgency, (b) Negative Affectivity, and (c) Effortful Control (Rothbart et al., 2001). *Surgency* was calculated by averaging scores for Activity Level, High-intensity Pleasure, Impulsivity, and Shyness (with Shyness making a negative contribution). *Negative Affectivity* was calculated by averaging scores for Anger/Frustration, Discomfort, Fear, Sadness, and Soothability (with Soothability making a negative contribution). *Effortful Control* consisted of an average of scores for Low-intensity Pleasure, Inhibitory Control, Perceptual Sensitivity, and Attentional Control.

For the purposes of the present study, Surgency was used as an index of positive emotional reactivity, and Negative Affectivity was used as an index of negative emotional reactivity. These two indices—Surgency and Negative Affectivity—served as independent variables in the present study, with Effortful Control (an index of emotion regulation) serving as a covariate.

Emotional stress condition. Emotional stress conditions included baseline, positive, and negative emotional stress conditions. For the baseline emotional stress condition, the participant viewed an animated screensaver of a three-dimensional fish tank for 4 min. This screensaver contained minimal action and was assumed to be suitable for establishing participants' baseline level of emotional arousal. After the baseline condition, the participant was presented (in a counterbalanced order across participants) 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 4 min. in duration, were intended to elicit negative or positive affective states.

Because there were three emotional stress conditions (i.e., baseline, positive, and negative emotional stress conditions), two dummy-coded variables[2] were created. These two dummy-coded variables—(a) positive versus baseline emotional stress condition and (b) negative versus baseline emotional stress condition—served as independent variables for the present study.

Emotional Reactivity × Emotional Stress Condition interaction terms. To examine interaction effects as well as indirect effects of the interaction terms between emotional reactivity and emotional stress conditions, four interaction terms were created: (a) Surgency Score × Positive Versus Baseline Emotional Stress Condition, (b) Surgency Score × Negative Versus Baseline Emotional Stress Condition, (c) Negative Affectivity Score × Positive Versus Baseline Emotional Stress Condition, and (d) Negative Affectivity Score × Negative Versus Baseline Emotional Stress Condition. In order to avoid multicollinearity issue, variables used in the analyses were centered around the mean prior to forming product terms (Howell, 2002).

The DD-S model does not specify whether the valence of emotional diathesis and emotional stress must be congruent for emotional diathesis by emotional stress interaction to be associated with an increase in stuttering. Thus, the interaction analyses for this study included congruent (e.g., positive vs. baseline emotional stress by positive emotional diathesis interaction) as well as incongruent (e.g., positive vs. baseline emotional stress and negative emotional diathesis interaction) permutations of diathesis and stress.

Dependent Variable: Percentage of Stuttered Disfluencies

The present authors and three independently trained speech-language pathologists measured percentage of stuttered disfluencies (i.e., sound/syllable repetitions, monosyllabic whole-word repetitions,[3] and prolongations) during a narrative following each baseline, positive, and negative video clip via online or real-time analysis of fluency based on 300 words (Conture, 2001).

Mediator Variable: Sympathetic Arousal

As a measure of sympathetic activity, mean tonic SCL was used for the study. Mean tonic SCL was defined as an average level of skin conductance in a given epoch exclusive of phasic (i.e., moment-by-moment, wavelike changes in SCL) responses (skin conductance responses; Lykken & Venables, 1971). Mean tonic SCL was chosen because (a) tonic SCL is considered to vary depending on psychological state (Rani, Sarkar, & Liu, 2005), (b) "unlike most autonomic nervous system responses, tonic SCL provides a relatively direct and undiluted representation of sympathetic activity" (Dawson, Schell, & Filion, 2007, p. 167), and (c) tonic 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 a period of time (Dawson et al., 2007). The use of mean tonic SCL is consistent with the focus of the present study to assess the association of overall percentage of stuttered disfluencies (rather than specific instances

[2]*Dummy coding* refers to a process of coding a categorical variable into a dichotomous or a set of dichotomous variables. It is considered a way of including categorical variables in a regression model.

[3]For the present study, on the basis of 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. On the other hand, perceptually effortless, nontense 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 (Clark et al., 2013).

of stuttered disfluency) and overall sympathetic arousal during a narrative after each emotional stress condition.

Data Analyses

Prior to conducting this study's main data analyses, the Shapiro-Wilk W test (Razali & Yap, 2011) was used to assess the normality of distribution of the investigated dependent variable (i.e., percent stuttered disfluencies). Consistent with the findings of Tumanova et al. (2014), the Shapiro-Wilk W test indicated that percentage of stuttered disfluencies was not normally distributed, displaying a high level of positive skew (skewness = 2.470, W = .767, df = 141, p < .001). Therefore, the present authors used two statistical procedures that take nonnormality of the dependent variable's distribution into account: (a) for Hypotheses 1–3, generalized estimating equations (GEE) with the Poisson distribution and log-link function, and (b) for Hypotheses 4–6, M*plus* (Muthén & Muthén, 2012)[4] mediational analyses using the MODEL INDIRECT command with log-transformed dependent variable (i.e., percentage of stuttered disfluencies). Throughout the Results section, and subsequent to the reporting of individual inferential analyses, the standardized regression coefficient, beta (i.e., β), is provided as an estimate of strength of the relation between the independent and the dependent variables.

In the GEE models for Hypotheses 1–3, independent variables included Surgency and Negative Affectivity scores from the CBQ, dummy-coded emotional stress conditions, and their interaction terms. For these analyses, the dependent variable was percentage of stuttered disfluencies. In addition, gender, language composite score[5] mean length of utterance and Effortful Control score from the CBQ were included as covariates due to their potential influence on children's frequency of stuttering (see Eggers et al., 2010, for findings pertaining to the relation between Effortful Control and childhood stuttering).

Also, in the mediational analyses for the Hypotheses 4–6, independent variables were participants' Surgency and Negative Affectivity scores on the CBQ, dummy-coded emotional stress conditions, and their interactions. The mediator was mean tonic SCL measured during narratives and the dependent variable was log-transformed percentage of stuttered disfluencies. In addition, gender, language composite score, mean length of utterance, and Effortful Control score from the CBQ were included as covariates in the mediation models.

Although Baron and Kenny (1986) suggested that the overall association between independent and dependent variables (i.e., total effect) should be established to conduct a mediation analysis, more recently others have stated that such a criterion is no longer required when the total effect is likely to be affected by competing causes or a random effect or suppression is possible (Collins, Graham, & Flaherty, 1998; MacKinnon, Krull, & Lockwood, 2000; Shrout & Bolger, 2002). For example, one possible factor that could suppress the influence of sympathetic arousal on stuttering would be parasympathetic activity (i.e., physiological correlate of emotion regulation) that may occur concurrently with sympathetic arousal (Alm, 2004; Berntson, Cacioppo, & Quigley, 1991; Jones, Buhr, et al., 2014). For the present study, therefore, the mediational analysis was performed on the basis of this more recent reasoning.

Inter- and Intrajudge Measurement Reliability

Speech Disfluencies

Intraclass correlation coefficients (ICCs; McGraw & Wong, 1996; Shrout & Fleiss, 1979) using the absolute agreement criterion were computed to assess inter- and intrajudgment reliability for the measurement of stuttered disfluencies, nonstuttered disfluencies, and total disfluencies.

Interjudge agreement for stuttered, nonstuttered, and total disfluencies were accomplished by the first author and three trained coders independently judging stuttered disfluencies for 33 participants from video-recorded speech samples. The 95% confidence interval (CI) ranged from 0.981 to −0.994, with average measures of ICC of .989, p < .001, for identification of stuttered disfluencies; with a CI [0.921, −0.977], with average of .955, p < .001, for identification of nonstuttered disfluencies; and a CI [0.975, −0.993], with average of .987, p < .001, for identification of total disfluencies. Assessment of intrajudge 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 nonstuttered disfluencies, and from .952 to .985 (M = .974) for identification of total disfluencies. These inter- and intrajudge ICC reliability values exceeded the popular criterion of .7 (Yoder & Symons, 2010).

Tonic SCL

ICC using the absolute agreement criterion was computed to assess inter- and intrajudgment reliability for the measurement of mean tonic SCL during narratives. Interjudge 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 0.999 to 1.00, with average

[4]Standard errors and a chi-square test of model fit were adjusted to take into account nonindependence of observations in M*plus* (Asparouhov, 2006; Muthén & Muthén, 2012).

[5]A language composite score was calculated by averaging three different language scores (i.e., Peabody Picture Vocabulary Test–Fourth Edition, Expressive Vocabulary Test–Second Edition, Test of Early Language Development–Third Edition standard scores). The language composite score served as a covariate due to its potential influence on children's stuttering.

measures of ICC of 1.000, $p < .001$, for identification of mean tonic SCL during narratives. Assessment of intrajudge 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 intrajudge 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 elicited positive, negative, or neutral emotion as intended. On the basis of 16 children's randomly selected video clips, results indicated that overall or mean percentage of correct identification of video clips was 78.9% (with percentage of correct identification = number of video clips correctly identified by the coders divided by the total number of video clips). "Correct identification" in the context of this study, refers to accurately identifying the emotional valence that the video clip was intended to elicit (e.g., negative, positive, or baseline). To be specific, percentage of correct identification of the video clips was 68.8% for a positive emotional stress condition, 65.6% for a negative emotional stress condition, and 90.64% for a baseline condition.

Statistical Power

A power analysis for an interaction model, similar to that described by Diggle, Heagerty, Liang, and Zeger (2002, p. 165), was used to estimate how much regression coefficient (i.e., beta) of a slope changes, assuming a correlation of individuals' repeated measurements is $r = .5$. 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, $d = 0.45$ assuming $p < .05$, power = .80.

On the basis of 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 ($N = 47$). However, small effects may not be detected due to low power.

Results

Descriptive Information

Participants' Stuttered, Nonstuttered, Total Disfluencies, and Stuttering Severity

Participants had a mean of 7.44% stuttered disfluencies ($SD = 4.79$), 4.81% ($SD = 2.61$) nonstuttered disfluencies, and 12.25% total disfluencies ($SD = 5.75$). Participants' mean stuttering severity (i.e., SSI-3 total score) was 17 ($SD =$ 4.55).

Participants' Correlations Between Variables per Each of the Three Emotional Stress Conditions

Additionally, correlations between main variables investigated in the present study per each of the three emotional stress conditions were presented in Table 1.

Findings Related to A Priori Hypotheses

Relation of Emotional Reactivity to Stuttering Percentage (Hypothesis 1)

Consistent with Hypothesis 1, the GEE analysis indicated that CWS's Surgency score was significantly positively associated with percentage of stuttered disfluencies, Wald $\chi^2 = 21.120$, $df = 1$, $p < .001$, $\beta = 0.576$. (See Table 1 for the correlations between Surgency score and percentage of stuttered disfluencies during each of the three emotional stress conditions.) On the other hand, CWS's Negative Affectivity score was not significantly associated with the percentage of stuttered disfluencies, Wald $\chi^2 = 1.634$, $df = 1$, $p = .201$, $\beta = 0.180$.

Relation of Emotional Stress Condition to Stuttering Percentage (Hypothesis 2)

Findings on the basis of the GEE analysis did not support Hypothesis 2 (i.e., emotional stress condition would affect CWS's percentage of stuttered disfluencies). To be specific, participants' percentage of stuttered disfluencies during the narrative following the positive emotional stress condition was not significantly different from that following baseline (Wald $\chi^2 = .608$, $df = 1$, $p = .436$, $\beta = -0.036$). Participants' percentage of stuttered disfluencies during a narrative following the negative emotional stress condition was also not significantly different from that following baseline condition (Wald $\chi^2 = .213$, $df = 1$, $p = .644$, $\beta = 0.024$).

Interaction Between Emotional Reactivity and Emotional Stress Condition on Stuttering Percentage (Hypothesis 3)

Findings of the GEE analysis indicated that there was a significant interaction between Negative Affectivity score and positive versus baseline emotional stress condition, Wald $\chi^2 = 5.207$, $df = 1$, $p = .022$, $\beta = 0.370$. Follow-up regression analysis using the mean predicted value for the dependent variable suggests that CWS's Negative Affectivity score is more associated with percentage of stuttered disfluencies during a narrative after a positive ($B = 2.208$, $\beta = 0.344$, $p = .018$), compared with baseline ($B = .087$, $\beta = 0.016$, $p = .917$), emotional stress condition (see Figure 2).

Inconsistent with Hypothesis 3, there was no interaction between (a) Negative Affectivity score and negative versus baseline emotional stress condition (Wald $\chi^2 = .001$, $df = 1$, $p = .970$, $\beta = 0.005$), (b) Surgency score and positive versus baseline emotional stress condition (Wald $\chi^2 = 1.476$, $df = 1$, $p = .224$, $\beta = 0.153$), or (c) Surgency score and negative versus baseline emotional stress condition (Wald $\chi^2 = .350$, $df = 1$, $p = .554$, $\beta = -0.066$).

Table 1. Correlations (i.e., Spearman's rho) between variables investigated in the present study (N = 47) per each of the three emotional stress conditions for CWS (i.e., baseline, positive and negative).

Parameter	Emotional stress condition						
Baseline	1	2	3	4	5	6	7
During a narrative							
1. Percentage of stuttered disfluencies	—	.074	.198	.176	.291*	.004	.125
2. Tonic SCL		—	.059	.203	.271	.146	−.090
3. MLU			—	.615**	.059	−.102	.209
4. Number of words				—	−.004	−.180	.162
CBQ Factors							
5. Surgency					—	−.170	−.269
6. Negative Affectivity						—	−.196
7. Effortful Control							—
Positive							
During a narrative							
1. Percentage of stuttered disfluencies	—	.061	.322*	.329*	.352*	.143	.096
2. Tonic SCL		—	.096	.272	.234	.027	−.180
3. MLU			—	.393**	.125	.048	.125
4. Number of words				—	.101	−.089	−.006
CBQ Factors							
5. Surgency					—	−.170	−.269
6. Negative Affectivity						—	−.196
7. Effortful Control							—
Negative							
During a Narrative							
1. Percentage of stuttered disfluencies	—	−.052	.169	.302*	.338*	.068	−.020
2. Tonic SCL		—	.205	.252	.327*	.022	−.186
3. MLU			—	.506**	.133	.054	.033
4. Number of words				—	.256	−.007	−.034
CBQ Factors							
5. Surgency					—	−.170	−.269
6. Negative Affectivity						—	−.196
7. Effortful Control							—

Note. SCL = skin conductance level; MLU = mean length of utterance, CBQ = Children's Behavior Questionnaire. Dashes indicate data not observed/obtained/recorded.

*= significant at .05 level of confidence. **= significant at .01 level of confidence.

Indirect Effect of Emotional Reactivity on Stuttering Percentage Through Sympathetic Arousal (Hypothesis 4)

Mediational analyses did not support Hypothesis 4 (i.e., high emotional reactivity → high sympathetic arousal → high stuttering percentage), as there was no indirect effect of emotional reactivity on the percentage of stuttered disfluencies through sympathetic arousal measured by tonic SCL: Surgency score: $\beta = -0.021$, $p = .494$, Negative Affectivity score: $\beta = -0.010$, $p = .524$.

It is of interest and consistent with our prediction that the path analysis for each constituent's path (i.e., the *a* path: independent variable → mediator and the *b* path: mediator → dependent variable) indicated that Surgency score ($\beta = 0.297$, $p = .046$) was significantly positively correlated with tonic SCL during narratives. Inconsistent with our prediction, however, the path analysis indicated that Negative Affectivity score was not associated with tonic SCL during narratives ($\beta = 0.140$, $p = .286$). Likewise, the path analysis indicated that tonic SCL during narratives was not associated with the percentage of stuttered disfluencies during narratives ($\beta = -0.071$, $p = .459$).

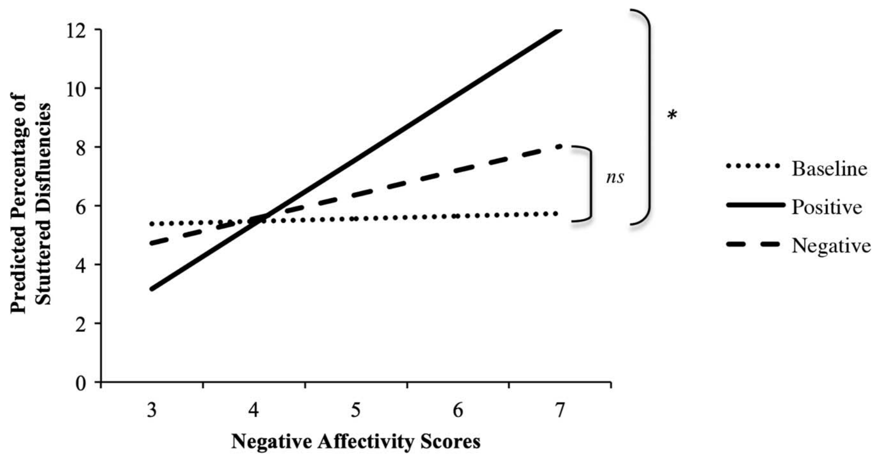
Indirect Effect of Emotional Stress Condition on Stuttering Percentage Through Sympathetic Arousal (Hypothesis 5)

Mediational analysis did not support Hypothesis 5 (i.e., high emotional stress → high sympathetic arousal → high stuttering percentage) in that there was no indirect effect of emotional stress condition on the percentage of stuttered disfluencies through sympathetic arousal indexed by tonic SCL: positive versus baseline emotional stress condition: $\beta = -0.014$, $p = .463$, and negative versus baseline emotional stress condition: $\beta = -0.014$, $p = .472$. Consistent with our prediction, however, the path analysis for each constituent's path indicated significantly higher tonic SCL during narratives following the negative ($\beta = 0.196$, $p < .001$) and the positive ($\beta = 0.197$, $p < .001$), compared with baseline, emotional stress condition.

Indirect Effect of Interaction Between Emotional Reactivity and Emotional Stress Condition on Stuttering Percentage Through Sympathetic Arousal (Hypothesis 6)

Mediational analysis did not support Hypothesis 6 (i.e., High Emotional Reactivity × Emotional Stress interaction

Figure 2. Association between negative emotional reactivity indexed by Negative Affectivity score and predicted percentage of stuttered disfluencies for each emotional stress condition (baseline, negative, or positive). *Note*. On horizontal axis, 3 = *low* and 7 = *high* for Negative Affectivity; baseline = baseline condition; positive = positive emotional stress condition; negative = negative emotional stress condition; * = an interaction effect that is significantly greater than chance (i.e., $p < .05$); *ns* = nonsignificant.



→ high sympathetic arousal → high stuttering percentage) as there was no indirect effect of the interaction between emotional reactivity and emotional stress condition on the percentage of stuttered disfluencies through sympathetic arousal measured by tonic SCL: Surgency Score × Positive Versus Baseline ($\beta = 0.002$, $p = .558$), Surgency Score × Negative Versus Baseline ($\beta = -0.001$, $p = .748$), Negative Affectivity Score × Positive Versus Baseline ($\beta = 0.004$, $p = .504$), and Negative Affectivity Score × Negative Versus Baseline ($\beta = 0.005$, $p = .478$) emotional stress conditions.

Discussion

Overview of Main Findings

With regard to a priori hypotheses, the present study resulted in three main findings. The first main finding indicated that CWS's positive emotional reactivity was significantly positively associated with the percentage of stuttered disfluencies during narratives regardless of emotional stress condition. The second main finding indicated that CWS's negative emotional reactivity was more positively correlated with the percentage of stuttered disfluencies during the positive, compared with baseline, emotional stress condition. The third main finding indicated no indirect effect of emotional reactivity, emotional stress condition, or their interaction terms on percentage of stuttered disfluencies through sympathetic arousal, at least during this experimental narrative task following emotion-inducing video clips. The implications of these findings are discussed below.

Implications of Main Findings

Impact of Endogenous Emotional Diathesis on Stuttering

The first main finding (associated with Hypothesis 1) indicated that CWS with greater positive emotional reactivity stutter more than those with lower positive emotional reactivity during narratives after the baseline, positive, and negative emotional stress conditions. The aspect of the DD-S model supported by the first main finding involves the contribution of positive emotional diathesis to young CWS's stuttering frequency.

To date, 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 stuttering. However, some 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. Likewise, Adams (1992) stated that parental report indicates that children's stuttering is often associated with positive emotional arousal.

Despite considerable anecdotal as well as clinical evidence, only a few empirical studies have investigated a connection between positive emotion and stuttering. For example, on the basis of behavioral observation, K. Johnson et al. (2010) reported that preschool-age CWS were more disfluent after receiving a desirable gift than after receiving a disappointing gift. Although this finding does not conclusively prove that young CWS's positive emotional reactivity causes increases in their speech disfluencies, it does suggest that young CWS's positive emotion is associated with increases in speech disfluencies. Furthermore, Eggers et al. (2010) reported that on the basis of a Dutch version of the CBQ (Van den Bergh & Ackx, 2003), that when compared with their CWNS peers, preschool- and school-age CWS scored higher on Approach and Motor Activation (with both scales relating to positive emotional reactivity). On the other hand, Anderson et al. (2003) using a different parent questionnaire, the Behavioral Style Questionnaire (McDevitt & Carey, 1978), reported no significant difference between young CWS and CWNS in activity level, approach or withdrawal. Given our present finding and previous findings described above, the association between CWS's positive emotion and speech disfluencies appears to be supported, although empirical support for differences in positive emotional reactivity between CWS and CWNS remains somewhat equivocal.

In attempts to explain why CWS's positive emotional reactivity was associated with their percentage of stuttered disfluencies, it maybe helpful to recall that the present study's measure of positive emotional reactivity was based on the CBQ's factor of Surgency, a factor that mainly includes "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 include "low-arousal" positive affect (e.g., agreeableness or affiliation; Putnam, 2012). This is relevant to interpretation of our first main finding because high-arousal positive affect such as Surgency has been reported to be associated with low emotion regulation (Dennis, Hong, & Solomon, 2010; Mitchell, 2010; Polak-Toste & Gunnar, 2006; Putnam, Rothbart, & Gartstein, 2008; Rothbart, Derryberry, & Hershey, 2000; Rydell, Berlin, & Bohlin, 2003; cf. Kochanska, Aksan, Penney, & Doobay, 2007, who reported that low-arousal positive affect [e.g., agreeableness or affiliation] was associated with enhanced effortful control[6]).

It might be speculated that young CWS's relatively high Surgency with relatively low emotion regulation is related to disruptions in their speech fluency, the latter speculation consistent with the findings reported by Arnold et al. (2011). It is of interest that Kagan (2012) suggested that children who are high positive (i.e., more surgent) as infants " retained their profile of high sociability and low timidity through school entrance because these child behaviors are not subject to disapproval by adults and peers" (p. 73). Therefore, one might speculate that surgent CWS, particularly those with lower levels of emotion regulation, who lack environmental disincentives to change such surgent tendencies, may continue to exhibit stuttering in the context of high, positive emotional arousal—for example, receiving and opening birthday presents. Whatever the case, the exact relation, if any, between high-arousal positive emotion, decreased emotion regulation, and increased stuttering in children, must await further empirical study[7].

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

The second main finding (associated with Hypothesis 3) indicated that for CWS, negative emotional reactivity was more likely to be associated with percentage of stuttered disfluencies during the positive, when compared to baseline, emotional stress condition. This finding seems to support some aspects of the DD-S model that relate to the interaction between an emotional diathesis and an emotional stressor. This finding is consistent with Jones, Conture, and Walden's (2014) finding (on the basis of coded behavioral observations) that CWS's stuttered utterances were significantly more likely to be associated with negative affect following a positive rather than neutral condition (i.e., emotional overheard conversations). Nonetheless, it remains somewhat unclear why there is a significant relation between negative emotional reactivity and percentage of stuttered disfluencies during the positive—but not negative—emotional stress condition. One possible explanation for this finding is briefly discussed below.

Perhaps the apparently incongruent pattern of interaction (i.e., Negative Emotional Reactivity × Positive Emotional Stress) may indicate that young CWS who tend towards negative emotional reactivity have learned how to down-regulate negative emotion during negative emotional stress conditions; however, they may not have readily learned to do so during positive emotional stress conditions. In other words, a positive emotional stress condition may disinhibit their tendency to regulate negative emotion, leading to disruptions of speech fluency (Arnold et al., 2011; Walden et al., 2012). At present, empirical support or refutation for this account must await future research.

Indirect Effect of Emotional Diathesis and Emotional Stress on Stuttering Through Sympathetic Arousal

The third main finding (associated with Hypotheses 4–6) did not support the a priori hypotheses that emotional reactivity, emotional stress, or their interaction influence stuttered disfluencies through sympathetic arousal measured by tonic SCL during a narrative task following listening to and watching an emotion-inducing film clip. This null finding seems to mainly result from the nonsignificant relation between participants' tonic SCL and percentage of stuttered disfluencies during narratives. Inconsistent with our prediction, greater tonic SCL—whether induced by either exogenous emotional stress or endogenous emotional diathesis—did not appear associated with the percentage of stuttered disfluencies for young CWS (see Figure 3).

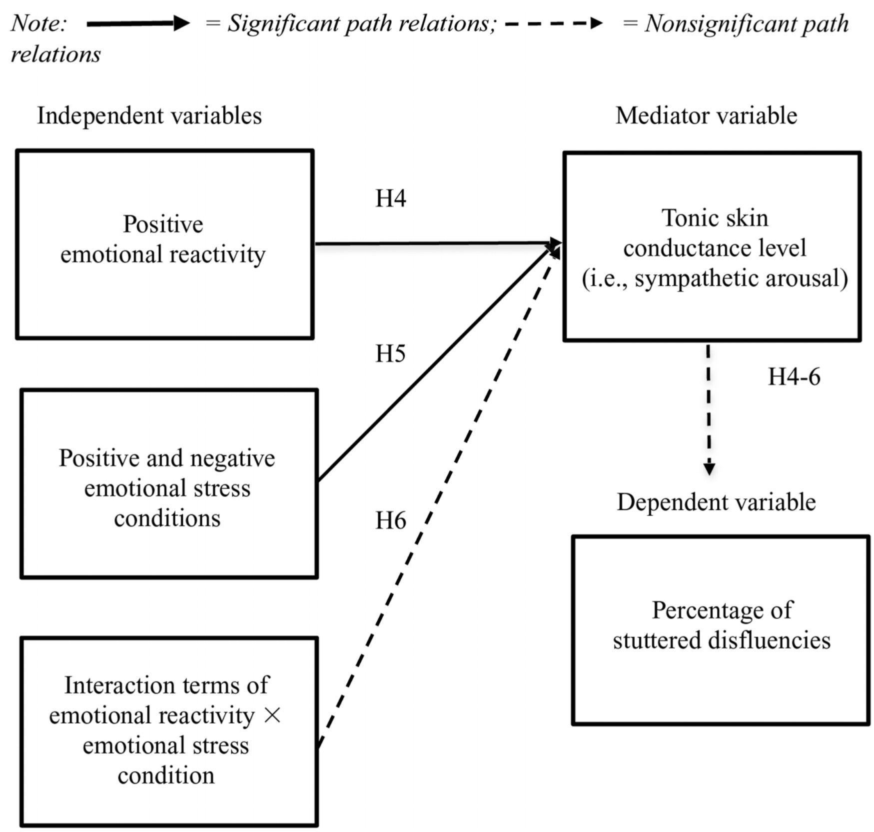
Perhaps some young CWS may already be establishing relatively successful avoidance behavior, behavior that may weaken the association between participants' tonic SCL and percentage of stuttered disfluencies during a narrative. This speculation is similar to that provided by Weber and Smith (1990) for their findings that for adults who stutter, greater SCL was associated with disfluent utterances in reading but not during spontaneous speech. To be specific, they suggested that participants' spontaneous speech may have allowed them to avoid stuttering by using substitutions, postponements, or circumlocutions.

It is of interest that present analyses indicated (a) a positive association between positive emotional reactivity and tonic SCL during narratives, and (b) a significantly higher tonic SCL during narratives following both negative and positive, compared with baseline, emotional stress

[6]Studies on the physiological response of low-arousal positive emotion indicate decreased SCL (Kreibig, 2010).

[7]Indeed, as shown in Table 1, Surgency and Effortful Control (the latter related to emotion regulation) were marginally negatively correlated (Spearman's rho = −.272, p = .058).

Figure 3. For findings pertinent to Hypotheses 4–6, this graphic representation indicates the indirect effect of emotional diathesis, emotional stress, and their interaction on the percentage of stuttered disfluencies through sympathetic arousal. Significant path relations are expressed in solid lines and nonsignificant path relations are expressed in dashed lines. H = Hypothesis; solid arrow = significant path relations; dotted arrow = nonsignificant path relations.



conditions. Such findings are congruent with Kreibig's (2010) recent review of 134 published studies of autonomic nervous system specificity (i.e., the extent to which autonomic nervous system responses differ for particular emotions, Levenson, 2014). This review suggested that there is an increase in SCL in response to high-arousal negative (e.g., anger, disgust, and fear) as well as positive emotion (e.g., amusement and joy) on the basis of at least three replicated studies.

In contrast, the present finding also suggested that negative emotional reactivity was not associated with change in tonic SCL. Perhaps, the association between SCL and negative emotional reactivity may have been weakened due to the fact the CBQ Negative Affectivity factor includes both high-arousal (e.g., fear and anger) and low-arousal (e.g., sadness) negative emotions. In support of this argument, Kreibig (2010) reported that high-arousal negative emotions such as fear and anger are associated with an increase in SCL, whereas low-arousal negative emotions such as sadness is associated with a decrease in SCL. Taken together—high- and low-arousal emotion scales—a decrease in SCL in low-arousal negative emotion (e.g., sadness) may have minimized the effect of high-arousal negative emotions (e.g., fear and anger) on young children's SCL, a possibility that awaits further empirical study.

Limitations

Contrary to expectations, the positive and negative video presentations—our experimental attempt to manipulate positive and negative emotional stress—did not produce a clear effect on CWS's overall stuttering. Although the manipulation check as well as psychophysiological measure (i.e., tonic SCL) indicated that most participants seemed to experience the emotions of interest, it was unclear whether the present study's elicited emotions were of sufficient duration, strength, or relevance to meaningfully affect young children'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], and 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 increases or decreases in young CWS's stuttering frequency.

A second limitation is that the study assessed only sympathetic activity in relation to stuttering without considering the impact of parasympathetic activity. Jones, Buhr, et al. (2014) reported that preschool-age CWS displayed a significant positive relation between parasympathetic activity indexed by respiratory sinus arrhythmia and sympathetic activity indexed by SCL. In other words, for young CWS, both parasympathetic and sympathetic activities were coactivated (i.e., higher sympathetic activity and higher parasympathetic), which is not typically expected. Instead, the expected relation is usually more reciprocal or oppositional in nature. For example, increases in parasympathetic system would be typically thought to be associated with decreases in sympathetic system activity. Jones, Buhr, et al. took their findings to suggest that young CWS exhibit a less adaptive pattern of physiological responding.[8]

Given this physiological finding, it seems reasonable to speculate that both sympathetic and parasympathetic activity concurrently affect instances of stuttering in some young CWS. Thus, at least from a theoretical perspective, measuring physiological reactivity (e.g., tonic SCL) concurrently with physiological regulation (e.g., respiratory sinus arrhythmia) would appear to provide the most comprehensive understanding of physiological associates of emotion. As we gain such understanding, we may eventually develop a more comprehensive appreciation of how these concurrently activated aspects of the autonomic nervous system jointly, if they do, affect childhood stuttering.

Conclusion

In general, the present findings addressed the questions of whether, when, and how the relation between emotional processes and stuttering exists. Regarding whether the relation between emotional processes and stuttering exists, the first main finding suggests that such an association does exist for young CWS, at least for positive emotional reactivity. Relative to when the relation between emotional processes and stuttering exists, the second main finding suggests that CWS's negative emotional reactivity is more associated with more stuttered disfluencies during the positive (when compared with baseline) emotional stress condition. Concerning how emotional processes may affect childhood stuttering, the third main finding leads the present authors to cautiously suggest that emotional reactivity and emotional stress condition may not be associated with young CWS's stuttering, at least in association with the level and nature of sympathetic arousal used in the current study.

Despite the insights into the relation between emotion and childhood stuttering discussed above, there remain several unknowns that must await further empirical study. For example, as Conture et al. (2013) suggested, the "directionality of effect" regarding emotion and stuttering (e.g., emotion → stuttering vs. emotion ← stuttering) continues to remain unclear. It is also unknown, in this mixed sample of young children (i.e., some participants will and some will not recover from stuttering), whether those who persist exhibit more positive than negative emotional reactivity (or vice versa) compared with those who recover. Such within-group differences between CWS who persist versus recover, however, would appear to be an intriguing topic for future research (see Ambrose et al., 2015, for empirical findings relative to this topic).

What is presently known, however, is that current findings—and those of a developing line of similar empirical evidence (e.g., Anderson et al., 2003; Arnold et al., 2011; Choi et al., 2013; Eggers et al., 2009, 2010; K. Johnson et al., 2010; Jones, Buhr, et al., 2014; Jones, Conture, & Walden, 2014; Ntourou et al., 2013; Walden et al., 2012)—appear to support the notion that emotional processes play a role and warrant inclusion in any truly comprehensive account of childhood stuttering.

[8]This interpretation is consistent with Porges' (2007) polyvagal theory that posits that well-regulated autonomic systems exhibit oppositional or reciprocal activity (i.e., higher sympathetic activity and lower parasympathetic activity or lower sympathetic activity and higher parasympathetic activity). Such oppositional activity is in contrast to coactivation (i.e., higher sympathetic activity and higher parasympathetic) or co-inhibition (i.e., lower sympathetic activity and lower parasympathetic), patterns thought to represent less adaptive physiological responding.

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