Acoustic Startle Responses and Temperament in Individuals Who Stutter

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Fourteen individuals who stutter and 14 individuals who do not stutter were presented with 10 bursts of white noise to assess the magnitude of their eyeblink responses as a measure of temperament. Both the magnitude of the eyeblink response to the initial noise burst and the mean of the 10 responses were significantly greater for the stuttering group. The Taylor–Johnson Temperament Analysis (R. M. Taylor & L. P. Morrison, 1996) did not distinguish between the two groups, but informal follow-up statistics indicated that the Nervous subscale showed a significant group difference. Scores on this subscale were also significantly positively correlated with the magnitude of the startle response. A discriminant analysis demonstrated that although both the startle response and the nervous trait differentiated the two groups, the startle response measures were more powerful in making this differentiation.

KEY WORDS: stuttering, temperament, startle

It is often said that stuttering emerges as a result of an interaction between constitutional and environmental factors (e.g., Bloodstein, 1995; Van Riper, 1982). A number of writers have further refined this argument to suggest that the constitutional factors in persistent stuttering may include an emotionally reactive temperament (sometimes referred to as a "sensitive" temperament; Brutten, 1986; Brutten & Shoemaker, 1967; Conture, 1991; Guitar, 1998, 2000; Peters & Guitar, 1991). These writers have suggested that a reactive temperament might play its part largely by interfering with recovery from early stuttering. As I have argued elsewhere (Guitar, 1998, 2000), some of the research on temperament indicates that individuals with more reactive temperaments are more likely to have right-dominance for emotions, a proclivity associated with avoidance, withdrawal, and arrest of ongoing behavior (Kinsbourne, 1989; Davidson, Jackson, & Kalin, 2000). If some children react emotionally to their early disfluencies, these right-hemisphere traits may make avoidance, escape behaviors, and physical tension more likely. Moreover, right-hemisphere dominant individuals may be more susceptible to emotional conditioning (Guitar, 1998; Ledoux, 1997), making these children particularly vulnerable to strongly conditioned physical tension, escape, and avoidance behaviors associated with disfluency. They may then consequently be more likely to persist in stuttering because the reactions may generalize from few to many speaking situations and may be resistant to extinction.

Convincing evidence that individuals who stutter have a reactive or

"sensitive" temperament will not come from a single source, but will likely be the result of multiple measures, including those that assess physiological responses, behavioral observations, and psychological scales. Researchers might begin by conducting small-scale studies of existing measures, choosing those that seem promising, and developing new ones, and gradually develop a battery of measures that can be used on a large population.

One tool described in the developmental psychology literature to assess a physiological component of temperament is the acoustic startle response, measured in terms of amplitude of the eyeblink response to a brief pulse of white noise. Snidman and Kagan (1994) found that children with a more reactive temperament (categorized as such by behavioral observations of increased motor activity in response to novel stimuli) demonstrated acoustic startle responses of greater magnitude than children with a less reactive temperament.

The startle response is present in all mammals. It is characterized by co-contraction of agonist and antagonist muscle groups throughout the body, serving to brace the body against anticipated danger or to prepare for escape (Yeomans & Frankland, 1996). The neural circuits responsible for the acoustic startle response are entirely in the brainstem but are interconnected with higher brain structures, such as the amygdala, thus making the startle response modifiable by cognitive and emotional variables (Davis, 1998; Eaton, 1984). These qualities make the acoustic startle response a particularly interesting tool for investigating stuttering because the stuttering block itself is similarly responsive to cognitive and emotional variables and may also be characterized by co-contraction of agonist–antagonist muscle groups (Freeman & Ushijima, 1978; Guitar, Guitar, Neilson, O'Dwyer, & Andrews, 1988).

The acoustic startle response paradigm has been widely used in psychophysiology research since the 1960s (e.g., Hoffman & Searle, 1965) as a "broadly useful tool for studying emotion, its development and modification" (Vrana, Spence, & Lang, 1988, p. 487). Initial studies were conducted with animals, but human participants in both clinical and nonclinical populations have been extensively tested with this paradigm (Dawson, Schell, & Bohmelt, 1999). Studies in both adults and children have demonstrated that increased magnitude of the startle response is often present in individuals with increased emotional vulnerability, such as those with posttraumatic stress syndrome or family history of anxiety disorders (e.g., Grillon, Dierker, & Merikangas, 1997; Morgan, Grillon, Lubin, & Southwick, 1997). The startle paradigm has been used with a variety of contextual stimuli (such as pictures of angry faces or a darkened room) to enhance the response, but it has also been used without added contextual stimuli to demonstrate increased magnitude startle responses in individuals who have been classified as behaviorally inhibited or emotionally reactive (Snidman & Kagan, 1994).

The present study was undertaken to examine the acoustic startle response as one assessment of temperament in adults who stutter compared to those who do not. Adults were chosen because if persistent stuttering is associated with a sensitive temperament, then those individuals whose stuttering has persisted into adulthood would be most likely to manifest such a temperament. It was hypothesized that the stuttering group would demonstrate startle responses of significantly greater magnitude than the nonstuttering group. A self-administered scale (Taylor–Johnson Temperament Analysis; T-JTA, Taylor & Morrison, 1996) was used to make an additional assessment of temperament so that it could be viewed from a psychological perspective and compared with the psychophysiological responses.

Method

Participants

Fourteen adults who stutter and 14 adults who do not stutter participated in the study. There were 12 males and 2 females in each group. The individuals in the stuttering group had all undergone at least 1 year of treatment and were identified as stuttering by the author, a speech-language pathologist with specialty certification in stuttering. All individuals in the stuttering group were self-classified as persons who stutter and all were observed to have core as well as secondary behaviors (Guitar, 1998). The Stuttering Severity Instrument–3 (SSI-3; Riley, 1994) was used to assess the severity of stuttering by participants in the stuttering group. The SSI-3 classified 10 of the participants as mild, 1 as moderate, and 3 as severe in their stuttering. The mean age of the stuttering group was 45.9 years (range = 17–58); the mean age of the group who do not stutter was 47.2 (range = 18–62). The participants in the stuttering group were recruited from those who took part in a previous study (Barasch, Guitar, McCauley, & Absher, 2000) as well as from a support group for adults who stutter. The participants in the nonstuttering group were recruited from those who took part in the study mentioned above, as well as from acquaintances of the experimenter. Before the experiment began, participants in both groups indicated, in response to questioning by the experimenter, that they had no neurological problems. They also indicated that they had no speech or language problems (other than stuttering, for the stuttering participants). In response to a follow-up letter, all participants who could be reached (14 of 14 participants in the stuttering group and 12 of 14 participants in the

nonstuttering group) indicated that they had not taken any drugs or medications (except for aspirin and for 1 participant who took heart medication that was judged not to have influenced the startle responses) before being in the experiment and that they had no significant psychological problems.

Startle Apparatus and Stimuli

The presentation of stimuli and collection of responses were accomplished using hardware and software developed by MED Associates (Georgia, VT). The acoustic stimulus was a 50-ms burst of 95-dB white noise with 10-ms rise and fall times, presented binaurally through Beyerdynamic BT 770 headphones. Startle responses were detected electromyographically via two miniature silver-silver chloride electrodes placed on the periorbital area on the skin below the right eye in accordance with the placement for Orbicularis oculi given by Fridlund and Cacioppo (1986). Care was taken to place the electrodes exactly 2 cm apart. A ground electrode was placed on the participant's forehead. Impedance was checked before beginning the experiment to ensure that it was below 5 kΩ. The electromyographic signal was band-pass filtered between 8 and 1000 Hz, rectified, and integrated with a 5-ms time constant. The response was detected during a 200-ms window that began at the instant of the startle stimulus.

Procedures recommended by researchers in psychophysiology for use of the startle paradigm were followed in this study (Berg & Balaban, 1999). Interelectrode distance was carefully measured for each participant to assure that this factor would not influence startle amplitudes. Our current research on children between the ages of 6 and 12 suggests that body size or muscularity does not influence startle amplitudes because some of the younger children's startle amplitudes are larger than those of the adults in the present study.

Temperament Scales

The Taylor–Johnson Temperament Analysis (Taylor & Morrison, 1996) was used as a second approach to assess reactive temperament. The T-JTA is a self-administered paper-and-pencil test consisting of 180 items. The items are equally divided among nine bipolar traits: nervous versus composed, depressive versus lighthearted, active-social versus quiet, expressive-responsive versus inhibited, sympathetic versus indifferent, subjective versus objective, dominant versus submissive, hostile versus tolerant, and self-disciplined versus impulsive. The T-JTA was selected because of its reliability and validity and its long history of use and development (Sporakowski, 2001; Trotter, 2001).

Procedure

Upon arriving at the laboratory, participants were informed that the experiment involved a hearing test, followed by a task in which they would hear brief bursts of noise that would produce involuntary eye blinks, followed by conversation and reading, which would be videotape recorded. Then participants were asked to read a lay summary and sign a consent form. All testing was performed individually.

Participants' hearing was screened in each ear with pure tones (125, 250, 500, 1000, 2000, 4000, and 8000 Hz) and white noise at 10 dB. All participants passed the white noise hearing screening. During pure tone testing, several participants showed a slight loss at 4000 Hz but had otherwise normal hearing. One participant had a moderately severe loss in her right ear. However, with the same degree of hearing loss she had performed without difficulty on tests of auditory perception in an earlier study (Barasch et al., 2000).

Subsequent to hearing screening, electrodes were affixed and the participants were fitted with headphones for the startle stimulus. They were then told that they would hear a series of 10 bursts of white noise (at this point the sound of white noise was imitated by the experimenter) separated by a randomly chosen interval between 20 and 30 s. They were instructed to do nothing as they listened to the noise bursts other than sit still and look at the wall in front of them. After completing the startle task, participants were videotaped while engaging in conversation about their work and hobbies for 2 min and then reading a 200-syllable passage. Following this, they were given instructions about completing the T-JTA and asked to take it home, complete it on their own, and return it in a self-addressed stamped envelope.

Reliability

Reliability of the measure of stuttering—the SSI-3—was assessed by randomly selecting 3 of the 14 participants who stutter and remeasuring their conversation and reading samples. The initial SSI-3 scores on each component of the instrument, the results of the experimenter's remeasurement (conducted 4 weeks after the initial measurement), and the results of measurements by another observer who had had several years' experience with individuals who stutter are presented in Table 1. Because SSI-3 scores can range from 0 to a high of 46, these remeasurements appear to be relatively close.

Aspects of reliability (stability and consistency) of the T-JTA are discussed extensively in the manual (Taylor & Morrison, 1996). Scoring of the T-JTA was simply

Table 1. Intra- and interobserver reliability for frequency, duration, and physical concomitants subscales and total overall score on the Stuttering Severity Instrument–3.

Participant	Source	Frequency	Duration	Physical concomitants	Overall score
1	Original assessment	5	4	4	13
	Intraobserver	5	4	4	13
	Interobserver	5	2	2	9
2	Original assessment	12	4	6	22
	Intraobserver	11	4	6	21
	Interobserver	13	4	3	20
3	Original assessment	7	6	4	17
	Intraobserver	7	6	4	17
	Interobserver	6	8	3	17

a matter of using a template to record answers to the items. Therefore, it was deemed unnecessary to remeasure participants' answers on the scale.

Test–retest reliability of the acoustic startle paradigm has been demonstrated in the psychophysiology literature (Jennings, Dawson, Schell, Earlywine, & Runyan, 1994; Larson, Ruffalo, Nietert, & Davidson, 2000).

Results

Group Differences in Startle Magnitudes

Table 2 summarizes the means and standard deviations of the stuttering and nonstuttering groups. Data are presented in terms of peak magnitude of the eyeblink response. As is frequently the case in the startle literature (e.g., Blumenthal, 1997), magnitudes are given in arbitrary analog-to-digital units. These units were derived by multiplying the electromyographic voltage by 20,480.

Table 2. Means and standard deviations for magnitude of startle responses for 1st trial, average of 10 trials, and difference between 1st and 10th trials for stuttering and nonstuttering participants.

	Source of data					
	1st trial		Average of 10 trials		Difference between 1st and 10th trial	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stuttering	876**	352	552**	224	406	312
Nonstuttering	483	204	372	135	191	204

Note. Magnitude of startle response is given in arbitrary analog-to-digital units derived from the electromyographic signal.

**$p < .01$.

Independent samples t tests were used to examine whether significant differences existed between the startle magnitude means of the two groups. Alpha was set at .05 and a Bonferroni correction was used to decrease the chance of a Type I error. Thus, because three t tests were performed, probabilities had to reach .017 to be considered significant. A one-tailed t test performed on the means of the two groups' first trials showed that the stutterers' startle responses were of significantly greater magnitude, $t(26) = 3.4$, $p = .001$. A second one-tailed t test compared the group means using the average of the 10 trials for each participant. This test also showed that the stutterers' startle responses were of significantly greater magnitude, $t(26) = 2.58$, $p = .008$. A two-tailed t test was used to compare the differences between the first trial and the 10th trial for the two groups to examine the possibility that one group or the other adapted more quickly to the startle stimulus. Results indicated no significant group difference, $t(26) = 2.2$, $p = .04$. The decrease in magnitude in relation to the initial magnitude (mean difference between 1st and 10th trials for the group divided by mean of the 1st trial) is somewhat similar for each group. The stuttering group's percentage decrease was 46 and the nonstuttering group's percentage decrease was 39. Thus, both groups showed about the same amount of adaptation to the stimulus. The standard deviations for the stuttering group appear to be larger, but this is true only in an absolute sense, reflecting the larger means. The standard deviations in relation to the means of the stuttering group (.40 for the 1st trial; .41 for the mean of 10 trials) were similar to those of the nonstuttering group (.42 and .36, respectively).

Table 3. Correlations between the magnitude of the startle response on the first trial and measures of stuttering for each participant in the stuttering group.

Measure of stuttering	Pearson's *r*	*p*
SSI-3 total	.30	.30
Frequency of stuttering	.35	.22
Mean duration of 3 longest stutters	.25	.39
Physical concommitants score	.22	.44

Startle Magnitudes Versus Measures of Stuttering

Pearson product–moment correlations were used to examine the relationship between measures of stuttering severity and the magnitude of the startle response on the first trial. Only data from the first trial were used because this group difference was greater than the mean of the 10 trials. Table 3 contains the correlations between the magnitude of the startle response for each participant and four measures of stuttering. None of the correlations was significant.

Startle Magnitudes and Taylor–Johnson Temperament Assessment

Table 4 shows the means and standard deviations for the nine traits of the T-JTA for the stuttering and nonstuttering groups. A multivariate analysis of variance was used to explore overall group differences on these traits. Results indicated that there was no difference between the groups when the T-JTA scales were considered together, $F(9, 18) = 1.22$, $p = .34$. However, informal inspection of the univariate between-participants' effects indicates that the trait labeled Nervous showed a significant difference between the two groups, $F(1, 26) = 5.95$, $p = .02$, and that no other trait showed a significant difference between the groups. "Nervous" is defined as "tense, high-strung, apprehensive" as well as "excitable" (Taylor & Morrison, 1996, p. 8). Pearson product–moment correlations between the nine T-JTA traits and the magnitude of the first trial of the stuttering groups' startle responses showed that only the Nervous trait was significantly correlated with the startle response ($r = .39$, $p = .04$). A discriminant analysis was conducted to examine the extent to which the two measures of startle response and scores on the nervous temperament trait would discriminate between the stuttering and nonstuttering groups. The two groups were significantly differentiated (Wilks's $\Lambda = .637$, $p = .011$), and the order in which the dependent variables differentiated the groups was as follows: magnitude of 1st trial of startle response ($r = .883$), magnitude of mean of 10 trials of startle response ($r = .669$), and Nervous temperament trait ($r = .633$).

Discussion

Group Differences in Startle Magnitudes

The results support the hypothesis that the stuttering group would demonstrate significantly larger magnitude startle responses than the nonstuttering group. Because the magnitude of startle response has been shown to be significantly greater in individuals with reactive temperaments than in those with less reactive temperaments (Snidman & Kagan, 1994), the present finding also supports the speculation that individuals with persistent stuttering may have more reactive temperaments than nonstutterers. Elsewhere, I have speculated that a reactive temperament may make an important contribution to the persistence of stuttering (Guitar, 1998, 2000). The present findings, in concert with other evidence of reactive temperaments in adults and children who stutter (Anderson, Pellowski, & Conture, 2001; Embrechts & Ebben, 2000; Fowlie & Cooper, 1978; Oyler, 1992; Oyler & Ramig, 1995; Oyler & Rustin, 1998), are indirect support for this possibility.

The present study also found that individuals in the stuttering group showed greater differences from the nonstuttering group in their first trial responses than in the average of their 10 trials. This may reflect an

Table 4. Means and standard deviations for stuttering and nonstuttering groups on nine traits from the Taylor–Johnson Temperament Analysis.

	Trait																	
	Nervous		Depressive		Social		Expressive		Sympathetic		Subjective		Dominant		Hostile		Self-disciplined	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Stuttering	9.9*	4.6	4.8	4.6	16.9	6.2	17.2	7.3	17.4	5.4	6.6	3.6	15.4	3.4	7.5	4.3	14.4	2.9
Nonstuttering	5.8	4.3	4.7	4.7	17.6	6.5	18.8	7.7	18.6	6.5	6.0	4.2	14.9	6.8	5.9	6.2	13.9	7.1

*$p < .05$.

important aspect of reactive temperament, namely, that the greatest reactivity is to a new or unfamiliar stimulus (Kagan, Reznick, & Snidman, 1988). The finding that there was not a significant difference between the stuttering and nonstuttering groups on the magnitude of difference between the 1st and 10th trials suggests that the stuttering group did not show any lesser or greater adaptation to the stimulus. The stuttering group appeared to be most reactive to the initial stimulus, but continued to be more reactive than the nonstuttering group throughout the 10 trials.

Startle Magnitudes Versus Severity

It seems possible that the magnitude of startle responses might be related to an individual's stuttering severity. The lack of significant correlations between the startle magnitudes and the four measures of stuttering used in this study may be the result of several limitations that could be corrected in future studies. First, the restricted range of severity of stuttering in the experimental group (10 of the 14 participants in this group were individuals with mild stuttering) may not have provided an adequate sample to reflect a relationship between the magnitude of the startle response and the frequency, duration, and physical concomitants of stuttering. Second, there may be other aspects of stuttering behavior that would be a more direct consequence of an emotionally reactive temperament. The suggestion was made earlier that physical tension, escape, and avoidance behaviors may be related to this type of temperament and may thus be related to the magnitude of startle response. They should be explored in future studies with the use of questionnaires such as the Perceptions of Stuttering Inventory (Woolf, 1967) and direct observation. It may also be relevant to assess stuttering behaviors in more real-world environments than in the laboratory.

Startle Magnitudes and T-JTA

The fact that the overall T-JTA did not differentiate the two groups may be related to the tendency for individuals to portray themselves in a relatively positive way on self-report measures (e.g., Allport, 1937). In contrast, physiological measures, such as the acoustic startle paradigm, are likely to be less affected by such response biases. The results of this study provide preliminary evidence supporting the startle paradigm as a measure of some aspect of temperament.

Despite the lack of a statistically significant overall group difference on the T-JTA, the data in Table 4 suggest that the Nervous trait was notably different between the groups. The stuttering group's mean was almost twice that of the nonstuttering group's, and the between-participants test showed a significant group difference for that scale. The fact that this trait may differentiate the two groups is not entirely surprising, given that descriptors of the trait are *tense* and *excitable*—not unlike the descriptions of individuals with reactive temperaments given by Kagan and his colleagues in their review of temperament in children (Kagan et al., 1988). This finding gives further confirmation that reactive temperament is a discriminating characteristic of the stuttering group and may be a common trait among individuals with persistent stuttering. The evidence that the nervous temperament trait was significantly correlated with the magnitude of the first trial of the startle response further supports the contention that the startle response measures were assessing a general characteristic of the participants, rather than the transient effect of being in a new situation. The T-JTA was completed by participants at home and mailed to the experimenter several days after the participant had been tested in the laboratory, making it unlikely that increased anxiety from the experimental situation affected the T-JTA responses.

Individual data support the results of the group results. Eleven of the 14 participants in the stuttering group had startle magnitudes above the mean for nonstutterers. Ten of the 14 participants in the stuttering group had Nervous trait scores above the mean for the nonstuttering group. Two of the stuttering group participants demonstrated startle magnitude scores more than 1 *SD* above the mean for their group; both had Nervous trait scores above the mean for the stuttering group.

The discriminant analysis results are strong evidence that the magnitude of the first startle response may be useful in exploring reactivity in stuttering. The discriminant analysis was performed to determine which of the dependent variables would best predict whether an individual was someone who stutters or someone who does not. The magnitude of the first startle trial was the best predictor of group membership, suggesting that the startle response is a potent tool for exploring the nature of stuttering, perhaps more reliable than paper-and-pencil measures and generally more efficient to administer if the appropriate equipment is available.

Conclusions

The present study provided further evidence that individuals who stutter, as a group, may have a more reactive temperament than nonstutterers. Earlier speculation on the relationship between reactive temperament and persistent stuttering (Guitar, 1998; Peters & Guitar, 1991) suggested that the neurophysiological basis for this connection might be the increased

levels of facial and laryngeal tension manifest in individuals with reactive temperaments (Kagan, Reznick, & Snidman, 1987). Increased tension in these areas so highly related to speech, combined with speech disruptions resulting from other factors (see Guitar, 1998), may set the stage for the spiral of increasingly tense and maladaptive patterns of stuttering, perceived negative listener reactions, and emotional conditioning that causes the stuttering to generalize to more and more situations.

Limitations of this study include the small size of the current sample, as well as the age and severity range of participants. It should also be noted that this study has merely scratched the surface in exploring physiological as well as psychological tools to assess the multidimensional concept of temperament.

Considering the preliminary nature of this study, it is somewhat presumptuous to suggest clinical implications of the findings. However, if further studies confirm the evidence that, as a group, individuals who stutter have a more reactive temperament, treatment for those individuals who show high levels of reactivity may be more helpful when coupled with activities that counteract this reactivity. Elsewhere (Guitar, 1998), I have speculated that the most helpful treatment components may be those that emphasize approach and exploration—moving toward the moment of stuttering and feared situations, damping the biological proclivities toward avoidance and withdrawal. This strategy can be empirically tested for highly reactive individuals to assess whether it is more or less effective than other approaches.

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