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Anxiety and speaking in people who stutter: An investigation using the emotional Stroop task.

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Abstract

People with anxiety disorders show an attentional bias towards threat or negative emotion words. This exploratory study examined whether people who stutter (PWS), who can be anxious when speaking, show similar bias and whether reactions to threat words also influence speech motor planning and execution. Comparisons were made between 31 PWS and 31 fluent controls in a modified emotional Stroop task where, depending on a visual cue, participants named the colour of threat and neutral words at either a normal or fast articulation rate. In a manual version of the same task participants pressed the corresponding colour button with either a long or short duration. PWS but not controls were slower to respond to threat words than neutral words, however, this emotionality effect was only evident for verbal responding. Emotionality did not interact with speech rate, but the size of the emotionality effect among PWS did correlate with frequency of stuttering. Results suggest PWS show an attentional bias to threat words similar to that found in people with anxiety disorder. In addition, this bias appears to be contingent on engaging the speech production system as a response modality. No evidence was found to indicate that emotional reactivity during the Stroop task constrains or destabilises, perhaps via arousal mechanisms, speech motor adjustment or execution for PWS.

Keywords: stuttering; anxiety; emotional Stroop; attentional bias; speech motor control

Educational Objectives: The reader will be able to: (1) explain the importance of cognitive aspects of anxiety, such as attentional biases, in the possible cause and/or maintenance of anxiety in people who stutter, (2) explain how the emotional Stroop task can be used as a measure of attentional bias to threat information, and (3) evaluate the findings with respect to the relationship between attentional bias to threat information and speech production in people who stutter.

1. Introduction

There is more to stuttering than disfluencies in speech production. For example, research has shown increased psychosocial burden and negative impact of stuttering on quality of life (e.g., Beilby, Byrnes, Meagher & Yaruss, 2013; Craig, Blumgart & Tran, 2009; Koedoot, Bouwmans, Franken & Stolk, 2011). One area that has received considerable attention over recent years is the relationship between stuttering and anxiety-related problems. Trait anxiety refers to the general disposition in a person to experience feelings of anxiousness, nervousness, or dread. Studies using self-report instruments such as the Spielberger State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983) have shown higher levels of trait anxiety in people who stutter (PWS) compared to fluent speaking control participants (Alm & Risberg, 2007; Blumgart, Tran & Craig, 2010; Ezrati-Vinacour & Levin, 2004; Mulcahy, Hennessey, & Beilby, 2008). State anxiety is the feeling of anxiousness and apprehension arising at a particular point in time or in a specific situation (e.g., being in public, answering the telephone). Research has also shown elevated levels of state anxiety in PWS (Blumgart et al., 2010; Davis, Shisca & Howell, 2007; Ezrati-Vinacour & Levin, 2004; Mulcahy et al., 2008). While some null findings have been reported in the literature questioning whether trait and state anxiety play an important role in stuttering (e.g., Blood, Blood, Bennett, Simpson & Susman, 1994; see review by Menzies, Onslow & Packman, 1999), a review by Iverach, Menzies, O'Brian, Packman and Onslow (2011) incorporating evidence from a number of recent large scale studies argues that evidence for a link is now more compelling.

From the perspective of multidimensional models of anxiety (Balsamo et al., in press; Elwood, Wolitzky-Taylor & Olatunji, 2012; Ezrati-Vinacour & Levin, 2004) some researchers have sought to identify aspects that are relevant to stuttering. Messenger, Onslow, Packman and Menzies (2004) found increased anxiety compared to fluent controls was experienced by PWS in social situations, but not in relation to physical danger and daily routines (see, also, Ezrati-Vinacour & Levin, 2004). The link between chronic stuttering and social anxiety, in particular, may be explained by emotions aroused through expectations of negative evaluation by others and the impact stuttering has on social interactions in general for PWS (Davis et al., 2007; Messenger et al., 2004). Other studies have confirmed increased social anxiety in PWS with a significant percentage of PWS (approximately 40%) meeting criteria for social phobia or social anxiety disorder (e.g., Blumgart et al., 2010; Kraaimaat, Vanryckeghem, & Van Dam-Baggen, 2002; Lowe et al., 2012; Mulcahy et al., 2008).

However, anxiety may be a contributing factor in the onset and/or maintenance of stuttering (Adams, 1969; Karrass et al., 2006; Messenger et al., 2004; Siegel, 1999). Kleinow and Smith (2006, see, also, Karrass et al., 2006; Smith, Goffman, Sasisekaran & Weber-Fox, 2012; Smith, Sadagopan, Walsh & Weber-Fox, 2010) support a multi-dimensional view, which suggests a number of factors, including language skill, emotion and temperament, combine to influence a vulnerable speech motor system that results in overt stuttering. However, studies have reported no significant correlation between measures of anxiety and estimates of stuttering severity or frequency of stuttering (Alm & Risberg, 2007; Blumgart et al., 2010; Craig, Blumgart & Tran, 2011; Mulcahy et al., 2008, although see Koedoot et al., 2011). Studies that have examined physiological correlates of anxiety, such as heart rate, skin conductance and peripheral blood flow, have also failed to show clear differences between PWS and controls when speaking, challenging the contribution of anxiety related processes to stuttering behaviours (Alm, 2004; Caruso, Chodzko-Zajko, Bidinger & Sommers, 1994; Dietrich & Roaman, 2001; Heitmann, Asbjørsen & Helland, 2004; Peters & Hulstijn, 1984; Weber & Smith, 1990, although, cf. Blood et al., 1994). Therefore, while research using self-report measures has highlighted increased levels of anxiety among PWS, especially social anxiety, other studies have so far failed to provide strong support for anxiety having a more direct impact or mediating role in stuttering, although such a role has been proposed.

1.1 Cognitive processing in anxiety

Models of anxiety, including those specific to social anxiety (e.g., Morrison & Heimberg, 2013), emphasise interactions between behavioural, physiological and cognitive components (Balsamo et al., 2013; Elwood et al., 2012). Indeed, cognitive accounts of anxiety and depression related clinical disorders (e.g., social phobia, panic disorder, depression, generalised anxiety disorder, post-traumatic stress disorder) have stressed the important role cognitive processes, especially biases in attention and negative cognitive appraisals, can play in the aetiology and maintenance of those conditions (e.g., Mathews & Mackintosh, 1998; Morrison & Heimberg, 2013; Williams, Mathews & MacLeod, 1996). Although, the focus of attention may vary with the type of emotion disorder, it has been proposed that a "vicious cycle" exists whereby attentional processes are or become hypervigilant with respect to an area of concern (e.g., bodily sensations of fear, or perceived threat of social harm or negative appraisal of others), which in turn causes an emotional response (e.g., heightened anxiety). The increased awareness and sensitivity to those concerns leads the individual to over-estimate the level of danger or degree of threat, further enhancing emotional disturbance.

A large body of research has confirmed that attentional processes in people with emotional disorders are biased towards threat-related information (Asmundson & Stein, 1994; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & van Ijzendoorn, 2007; MacLeod & Mathews, 1988; Mogg, Bradley, Williams, & Mathews, 1993; Rutherford, MacLeod &

Campbell, 2004; Williams et al., 1996; Yiend, 2010). For example, one of the most widely used paradigms to investigate attentional bias is the emotional Stroop task (Williams et al., 1996). This task is a variant of the colour Stroop task (MacLeod, 1991; MacLeod & MacDonald, 2000) where naming the colour of a printed word is slowed when the word is a colour name conflicting with the response (i.e., the word *red* is in green print and the response should be "green"). The emotional Stroop task compares speed of colour naming for words that are threat related (e.g., *stupid*, *foolish*, for people with social phobia, or *spider*, *cobweb*, for people with a spider phobia) with words that are neutral (e.g., *session*). It is generally found that people with higher levels of anxiety and depression show a Stroop type effect where responding is slower to threat words compared to neutral words, even though the meaning of the word is irrelevant to colour naming (e.g., Bar-Haim et al., 2007; Rutherford et al., 2004; Williams et al., 1996). A common interpretation is that the capacity to attend selectively to the print colour is compromised because attentional resources are biased towards the meaning of the threat word (Reinholdt-Dunne, Mogg & Bradley, 2009; Williams et al., 1996; Yiend, 2010). This interference appears to be an automatic process because slowed colour naming for threat words is still observed in studies that use subliminal presentation of those words (e.g., Mogg et al., 1993; Rutherford, et al., 2004).

1.2 Attentional bias and stuttering

There has been limited research examining the cognitive aspects of anxiety such as attentional bias to threat information in relation to stuttering, although, stuttering has been linked to differences in both attention and emotion related cognitive processes (Lowe et al., 2012). For example, less efficient attention regulation and increased emotional reactivity has been reported for children who stutter compared to fluent controls (Eggers, De Nil & Van den

Bergh, 2012; Karrass et al., 2006; Schwenk, Conture & Walden, 2007; although cf. Johnson, Conture & Walden, 2012). Eggers, De Nil and Van den Bergh (2013) provide evidence of weaker or less efficient inhibitory control in children who stutter. Inhibitory control is an aspect of attention processing which is thought to play an important role in emotion regulation. In other research there is evidence that PWS are more susceptible to increased demands on attentional resources such when performing language and speech tasks under dual-task conditions (Bosshardt, 2006; Jones, Fox & Jacewicz, 2012; Heitmann et al., 2004; Smits-Bandstra & De Nil, 2009). These studies, however, did not vary the emotionality of the stimuli. Similarly, Caruso et al. (1994) showed PWS were slower to respond in a Stroop task that involved naming the print colour of incongruent colour names. Subramanian and Yairi (2006) and Heitmann et al. (2004) showed PWS did not differ in a colour naming Stroop task from controls, suggesting no difference in the attentional processes required to manage the Stroop related conflict.

Some early research dating back to the 1960's has shown PWS respond more slowly to emotion-related words (see Adams, 1969, for a review). Compared to fluent controls, PWS were found to be slower in recalling learned associations from memory (Santostefano, 1960) and slower in performing a word association task (Adams & Dietze, 1965) when threat words were used as stimuli. These effects have been interpreted as a consequence of increased emotional arousal to threat-related words (Adams, 1969) but it is argued that they could also be due to attentional bias.

1.3 The present study

The present study examined whether chronic stuttering in adults is associated with the same type of attentional biases to threat related information when using the emotional Stroop task as that found in people with anxiety and other emotional disorders. Performance on the emotional Stroop task by PWS was compared to a sample of age-matched fluent speakers. Level of anxiety was measured using the STAI trait and state sub-scales in view of their prevalent use in the emotional Stroop literature. Furthermore, we hypothesised that if the locus of the attentional bias in PWS is associated with failure to allocate selective attention to the demands of the task, then bias to threat-related information should be observed independent of the particular response modality. Participants in the present study, therefore, performed an emotional Stroop task with verbal responding (i.e., involving colour naming) and manual responding (pressing the corresponding colour button).

Although previous research has predominantly used the colour-naming version of the emotional Stroop task, standard Stroop interference effects have been reported using manual responding (Ilan & Polich, 1999; Redding & Gerjets, 1977; see review by MacLeod, 1991). Vendemia and Rodriguez (2010) used a modified emotional Stroop task whereby participants who differed in trait anxiety pressed one of two buttons depending on the colour (blue or red) and lexicality (word or nonword), but not the meaning of the stimulus. They found that responses were slower to negative words (e.g., *scream*) compared to neutral words (e.g., *chalk*) for all participants with a trend towards a larger effect for high-anxious compared to low-anxious participants. It was predicted, therefore, that if threat words interfere with capacity to attend selectively to the target attributes of the stimulus (i.e., print colour), then the emotionality effect will be observed in both verbal and manual versions of the emotional Stroop task.

However, anxiety related emotional responses to threat words may affect the speech motor system more directly in a way that is distinctive of PWS. Showing such a link would provide some support for a role that emotional processes play in the aetiology and/or maintenance of stuttering (Kleinow & Smith, 2006). Therefore, to investigate whether the emotionality of words affects verbal responding in PWS at a speech motor level, we included a two-alternative forced choice manipulation that involved changing the rate of speaking when naming the colour of each word. Depending on whether the word presented on each trial was underlined or not, participants named the print colour at a normal rate of articulation or at a self-selected fast rate of articulation.

According to psycholinguistic models of speech production, rate of articulation is encoded during a late stage of speech motor planning referred to as muscle command preparation (Levelt, Roelofs & Meyers, 1999; Peters, Hulstijn & van Lieshout, 2000). At this stage, suprasegmental and other paralinguistic requirements are integrated with the segmental requirements of the utterance to determine context appropriate muscle commands for execution (Hennessey & Kirsner, 1999; Levelt et al., 1999; Perkell et al., 1997; Peters et al., 2000). This includes setting of parameters that determine, for example, sound level, articulatory force characteristics and speech rate. Some studies have shown that PWS may be deficient in muscle command preparation and this may affect their reaction time relative to controls (Grosjean, Van Galen, Peters, van Leishout & Hulstijn, 1997; Hennessey, Nang & Beilby, 2008; van Lieshout, Hulstijn & Peters, 1996a, 1996b; see, also, Peters et al., 2000, for a review). Research has also suggested PWS rely to a greater extent on sensory (e.g., oral kinaesthetic) feedback as a control strategy during speech production, and the speech motor abilities of PWS benefit less from practice and may be more vulnerable to disturbances from increased demands or processing load (e.g., Archibald & De Nil, 1999; Kleinow & Smith, 2000; Namasivayam & van Lieshout, 2011; Namasivayam, van Lieshout & De Nil, 2008; Smits-Bandstra, 2010; Smits-Bandstra, De Nil & Rochon, 2006; van Lieshout et al., 1996a, 1996b; van Lieshout, Hulstijn & Peters, 2004).

In view of these findings, the fast rate condition, being a less familiar pattern of articulation, may be more demanding on speech motor planning and execution for PWS under speeded naming conditions (Namasivayam & van Lieshout, 2011). Further, if emotional reactivity to threat words induces changes in arousal or availability of cognitive resources for speech motor control, then this might have a stronger impact on speech motor planning and execution in the more challenging fast rate condition for PWS, relative to the normal rate condition.

Therefore, the aim of this study was to determine (a) whether PWS show an attentional bias to threat-related words, and (b) whether such a bias in attention can more directly affect speech motor control in PWS. We hypothesised that if PWS but not controls are slower when responding to the colour of threat compared to neutral words because of an attentional bias similar to that found in people who are anxious, then the emotionality effect will be seen in both the verbal and manual versions of the emotional Stroop task. However, an emotional Stroop effect on verbal but not manual responding would suggest the emotionality effect is contingent on engaging the speech production system. We further hypothesized that the emotionality effect for PWS will be larger when naming colours at a fast compared to normal speech rate because the speech motor system would be more vulnerable to interference from the increased attentional demands of the threat words. An interaction of this type will provide evidence that the effect of emotionality does penetrate, perhaps through arousal or attentional pathways, through to the level of speech motor control.

2. Method

2.1 Participants

Thirty one adults who stutter (mean age = 44.1 years, 23 male, 8 female) and 31 age and gender-matched fluent speakers (mean age = 41.8 years, 22 male, 9 female) participated in the study (see Table 1 for participant characteristics). Based on self-report, participants had no history of speech or language difficulties, other than stuttering for the PWS. The PWS volunteered to participate after information was provided to the community based self-help group, The Speakeasy Association of Western Australia. Age and gender-matched controls were recruited through advertisement within the Curtin University population. Ethics approval was received through the Curtin University Human Research Ethics Committee and all participants provided informed consent prior to completing the tasks. An independent samples t-test indicated the groups did not differ in age, $t(60) = 0.54$, $p = .59$. Using the State-Trait Anxiety Inventory (STAI, Spielberger et al., 1983), PWS were significantly higher than controls in both trait anxiety, $t(53.439) = 3.01$, $p = .004$, $d = .78$, and state anxiety, $t(59) = 2.26$, $p = .027$, $d = .59$.

Insert Table 1 about here

Frequency of stuttered speech (percentage of syllables stuttered, %SS) and speech rate (syllables per minute, SPM) for PWS were ascertained from a conversational speech sample conducted with the experimenter. The samples analyzed were at least 2000 syllables in length. Speech measures were conducted by a qualified speech-language pathologist with more than

20 years experience in the assessment and treatment of the disorder. Stuttering was defined as a disruption in fluency of speaking such that an individual is prevented from saying what s/he wishes to say because of an involuntary repetition, prolongation or blocking of sound or other part of speech (World Health Organisation, 1993). The mean level of stuttering frequency across PWS was 6.6 %SS with a range from 2 to 19.

2.2 Stimulus materials

Stimuli used in the verbal and manual emotional Stroop tasks were identical.[1] There were 12 threat words (e.g., *failure*, see Appendix) selected from previous emotional Stroop studies with people with social anxiety disorders (Asmundson & Stein, 1994; MacLeod & Mathews, 1988). Twelve neutral words were matched to the threat words in terms of frequency of use and length. Independent samples *t*-tests showed no significant difference between the threat and neutral items in Kucera and Francis (1967) written word frequency

[1] There were two stages to the data collection. The first stage involved testing 13 PWS and 13 controls but where the verbal and manual emotional Stroop tasks were intermixed with other reaction time tasks. To increase statistical power for the emotional Stroop tasks of interest, but reduce testing time overall, a further 18 participants per group were tested just on the verbal and manual emotional Stroop tasks. The second stage of testing was conducted in the same way using the same experimental program except a laptop was used so that participants could be tested in their homes and the number of stimuli was reduced from 36 (18 threat and 18 neutral) to 24 (12 threat and 12 neutral) by randomly excluding 6 items from each condition. In this study analyses based only on data from the 24 items common to all 62 participants, are reported. The results, however, are unchanged if the number of items had not been reduced for the first 26 participants tested.

(threat $M = 18.2$, $SD = 21.8$; neutral $M = 19.2$, $SD = 24.2$), $t(22) = 0.11$, $p = .92$, number of letters (threat $M = 8.0$, $SD = 1.9$; neutral $M = 7.8$, $SD = 1.9$), $t(22) = 0.21$, $p = .83$, and number of phonemes (threat $M = 7.2$, $SD = 1.7$; neutral $M = 6.8$, $SD = 1.9$), $t(22) = 0.44$, $p = .66$. Practice items included neutral words selected from Macleod and Mathew's (1988) protocol unrelated to the test stimuli. On each trial words were presented in 24 point Arial font in one of three colours: green, red or yellow.

2.3 Procedure

Testing was undertaken with each participant individually in a quiet clinic treatment room at Curtin University Stuttering Treatment Clinic or at the home of the participant. The order of the Stroop verbal and manual tasks was counterbalanced across participants within each group. The STAI Form Y questionnaires were administered following the verbal emotional Stroop task with the trait sub-scale administered after the state sub-scale.

Word stimuli were presented using PsyScope 1.2.5 experiment software (Cohen, MacWhinney, Flatt, & Provost, 1993) on either a Power 7500/100 Macintosh computer or a Mac G3 Powerbook laptop. A Sony ECM-909A microphone connected to a PsyScope button box was used to measure verbal reaction time from stimulus onset to onset of the verbal response in millisecond accuracy. Manual task reaction times were recorded by the participant pressing the corresponding colour button on the PsyScope button box. Audio recordings of the participant's speech sample and verbal responses during the verbal Stroop task were obtained using a Sony ECM-44B electret condenser lapel microphone connected to a Sony TC-D5 PRO II audio-cassette recorder.

2.3.1 Verbal emotional Stroop task

The verbal task involved a single block of 144 test trials (note that for 26 participants there were 216 trials in total of which only 144 were test trials, see Footnote 1) preceded by 12 practice trials. All 24 test items were presented twice in each of three colours (green, red and yellow), once for the fast rate of production and once for the normal rate. This involved six cycles of 24 test trials with each item presented once within each cycle. For counterbalancing, items were randomly split into six subsets each comprising 2 threat and 2 neutral words. Item subsets were allocated to a different colour and rate condition in each of the six cycles of 24 test trials. The order of cycles was counterbalanced across participants in each group.

Each trial began with an asterisk pasted centrally in black on an otherwise plain white screen for 300 ms. This was followed by an interstimulus interval of either 500, 700, 900, 1,100, 1,300 or 1,500 ms duration (randomly selected) before the stimulus for that trial was presented also in the middle of the screen. Rate of production was indicated by underlining (fast rate) or no underlining (normal rate). The stimulus word remained on the screen until the participant's response was detected. The next trial began 1,500 ms after detecting the response. Each participant was told that the colour of the word and manner for producing it will vary from trial to trial. The participant was instructed to name the colour of the stimulus word (ignoring the word) at a fast rate of speaking if the word is underlined, and at a normal rate of speaking if it is not underlined, and "to start the response as soon as you can after the word appears." The participant was also told their reaction time was being measured and encouraged to respond as quickly and accurately as possible.

2.3.2 Manual emotional Stroop task

The manual version of the emotional Stroop task was carried out the same way as the verbal task except for the requirement to respond manually. Participants were instructed to press the green, red or yellow button corresponding to the colour of the stimulus word (ignoring the word) as quickly and accurately as possible. If the stimulus word was underlined they were to “hold the button down like a ‘dah’ in Morse code.” If the stimulus was not underlined, participants were told not to hold the button down, but to “press and lift off immediately, like a ‘dit’ in Morse code.” The duration of the button press was not recorded. The coloured buttons on the PsyScope button box are ordered, left to right, red, yellow and green. The participant was instructed to use the index finger of their preferred hand and to keep their finger poised above the middle (i.e., yellow) button at the start of each trial.

3. Results

3.1 Verbal emotional Stroop task

Participant mean reaction times were calculated for each condition after excluding errors (7.3% of trials) and reaction time outliers (4.3% of trials). Errors included voice key errors, incorrect responses and audible disfluencies. Reaction times less than 250 ms and more than 2 *SD* from the mean of each condition for each participant were classed as outliers. Participant means were analysed using a four way mixed-design analysis of variance with group (PWS vs. controls) as a between groups independent variable, and emotionality (threat vs. neutral words), speaking rate (fast vs. normal), and colour (green, red, yellow) as repeated measures independent variables. Planned comparisons and simple effect contrasts for significant interactions were undertaken using least significant difference tests with unique variances (Kepple, 1991). An alpha level of .05 was used throughout with partial eta squared (partial η^2) the reported effect size (note, the conventions of .01, .06 and .14 are used for small, medium and large eta squared effect sizes, respectively).

Colour was included as a factor in order to increase statistical power by removing systematic variance explained by colour from the error terms (Kepple, 1991). Yellow has 2 syllables and green has a more complex syllable onset (consonant cluster). Phonological encoding and/or speech motor planning may be expected to take more time for verbal responses with more phonemes, more syllables or onsets with greater complexity. However, with just three colour names produced, it is difficult to interpret any differences in reaction time as due to length differences, for example, as distinct from other known or unknown intrinsic properties (e.g., the unique articulation requirements of the onset phonemes). The results did show a main effect of colour on colour naming reaction time, $F(2, 120) = 12.99$, $p < .001$, partial $\eta^2 = .18$, with red (M 739 ± 18 ms) named significantly faster than both green (M 778 ± 21 ms), $p < .001$, and yellow (M 780 ± 18 ms), $p < .001$. However, colour did not interact with any other factor, and no higher order interactions involving colour were significant. The results for colour are not further reported, but are available from the first author upon request.

The analysis of variance showed no significant main effect of group although the mean reaction time for PWS was numerically higher (M 796 ± 26 ms) than for controls (M 735 ± 26 ms), $F(1, 60) = 2.79$, $p = .10$, partial $\eta^2 = .044$ (see Table 2). While there was a main effect of emotionality, with the colour of threat words named more slowly than neutral words, $F(1, 60) = 10.44$, $p = .002$, partial $\eta^2 = .15$, this is qualified by a significant emotionality-by-group interaction, $F(1, 60) = 4.81$, $p = .032$, partial $\eta^2 = .074$. Threat words were 21 ms slower on average than neutral words for PWS (807 ± 32 ms vs. 786 ± 29 ms, respectively),

$F(1, 30) = 12.13$, $p = .002$, partial $\eta^2 = .29$. There was little difference found for controls (736 ± 22 ms vs. 732 ± 21 ms, respectively), $F < 1$.

Insert Table 2 about here

The main effect of rate was significant, $F(1, 60) = 4.89$, $p = .031$, partial $\eta^2 = .075$. Reaction times were quicker overall in the fast (*M* 755 ± 18 ms) compared to the normal (*M* 775 ± 20 ms) articulation rate condition. The difference between fast and normal was slightly larger for PWS (23 ms) than fluent controls (16 ms), however, rate did not interact with group, $F < 1$, partial $\eta^2 = .003$. The effect size for rate was numerically smaller for PWS (partial $\eta^2 = .071$, $p = .14$) compared to controls (partial $\eta^2 = .096$, $p = .085$), suggesting a non-significant trend for the fast and normal condition reaction time distributions to overlap to a greater extent for PWS. In addition, there was no two-way interaction between rate and emotionality, $F < 1$, and no three-way interaction between emotionality, group, and rate, $F < 1$. A focused analysis of just PWS showed emotionality did not interact with rate, $F < 1$, with a similar mean difference between threat and neutral words in the fast (24 ms) and normal (22 ms) rate conditions.

The mean percentage of errors for each condition for PWS and controls are also reported in Table 2. An analysis of variance conducted on arcsine transformed proportions correct showed only a main effect of emotionality, $F(1, 60) = 5.05$, $p = .028$, partial $\eta^2 = .078$, and of group, $F(1, 60) = 9.32$, $p = .003$, partial $\eta^2 = .13$. Across both groups, more errors occurred for responses made to threat compared to neutral items, and PWS produced more errors overall compared to controls.

A post hoc analysis of production durations from a sub-set of participants (n = 17) from each group (34 participants in total) was also undertaken (see Table 2). The mean duration of all correctly produced responses, measured from speech onset to offset using Praat acoustic analysis software, was significantly shorter for fast (M 289 ± 19 ms) compared to normal (M 377 ± 18 ms) responses, $F(1, 32) = 20.45$, $p < .001$, partial $\eta^2 = .39$. There was no interaction between group and rate, $F < 1$, with similar differences in duration between fast and normal articulation rates for PWS (90 ms) and controls (86 ms). Production durations were longer for PWS (M 371 ± 17 ms) compared to controls (M 296 ± 17 ms), $F(1, 32) = 9.92$, $p = .004$, partial $\eta^2 = .237$. Emotionality had no overall impact (M 333 ± 12 ms for both neutral and threat words), and emotionality did not interact with group, $F(1, 32) = 1.66$, $p = .21$, partial $\eta^2 = .049$, or rate, $F(1, 32) = 2.85$, $p = .10$, partial $\eta^2 = .082$. The three-way interaction between emotionality, group and rate was not statistically significant, $F(1, 32) = 2.114$, $p = .156$, partial $\eta^2 = .062$.

3.2 Manual emotional Stroop task

Mean reaction time for each condition for each participant in the manual version of the emotional Stroop task was calculated after excluding errors (0.8% of trials) and reaction time outliers (4.0% of trials). As with the verbal task, a four-way mixed design analysis of variance was used to examine the effects of group, emotionality, length of button press, and colour. Colour was included primarily to increase power by removing variance associated with button position. Some interactions with colour did emerge, however, and these are reported below (see Table 3).

The main effect of group was not significant, $F(1, 60) = 1.96$, $p = .17$, partial $\eta^2 = .032$, although the mean was numerically higher for PWS than controls (858 ± 28 ms vs. 799

± 28 ms). There was no effect of emotionality, $F < 1$, partial $\eta^2 = .02$, and group did not interact with emotionality, $F < 1$, partial $\eta^2 = .015$. Both PWS and controls showed a small difference in reaction time between the mean of the threat and neutral words (860 vs. 856, respectively, for PWS; 798 vs. 800, respectively, for fluent controls). The main effect of length was significant, $F(1, 60) = 22.31$, $p < .001$, partial $\eta^2 = .27$, with mean reaction time for short button presses (816 ± 20 ms) faster than long button presses (841 ± 22 ms). There was no interaction between group and length, $F(1, 60) = 1.87$, $p = .18$, partial $\eta^2 = .030$, and emotionality and length, $F(1, 60) = 1.18$, $p = .28$, partial $\eta^2 = .019$. The three-way interaction between emotionality, group and length was also non-significant, $F < 1$, partial $\eta^2 < .01$.

Insert Table 3 about here

Colour did produce a significant main effect, $F(2, 120) = 21.03$, $p < .001$, partial $\eta^2 = .26$, with responses to yellow words (795 ms ± 23 ms) faster than both green (848 ms ± 22 ms) and red (843 ± 20 ms). This was most likely due to the advantage of having the response finger positioned directly above the yellow button. However, there was a colour-by-length interaction, $F(2, 120) = 7.19$, $p = .001$, partial $\eta^2 = .107$. Long button presses (which are slower in reaction time overall, see below) showed smaller differences between the coloured buttons, compared to the short button presses (see Table 3). There was a significant interaction between group and colour, $F(2, 120) = 3.43$, $p = .036$, partial $\eta^2 = .054$. The group difference in reaction time was not significant when pressing the yellow button (812 vs. 778 ms for PWS and controls, respectively), $F < 1$, or green button (880 vs. 816 ms for PWS and controls), $F(1, 60) = 2.11$, $p = .15$, partial $\eta^2 = .034$, however, the group difference was significant when pressing the red button (883 vs. 803 ms for PWS and controls), $F(1, 60) =$

4.03, $p = .049$, partial $\eta^2 = .063$. This suggests a trend for PWS to respond more slowly than controls for off-centre buttons, especially when moving left of centre.

Colour did not interact with emotionality $F < 1$, partial $\eta^2 < .01$, and there were non-significant higher-order interactions between colour, emotionality and group, $F < 1$, partial $\eta^2 = .01$, colour, length and group, $F(2, 120) = 2.98$, $p = .054$, partial $\eta^2 = .047$, and colour, emotionality and length, $F(2, 120) = 2.98$, $p = .055$, partial $\eta^2 = .047$. There was, however, a significant four-way interaction between colour, emotionality, group and length, $F(2, 120) = 3.70$, $p = .028$, partial $\eta^2 = .058$. This effect may be understood in terms of a three-way interaction between colour, emotionality and length that is present for PWS, $p = .001$, but not controls, $p = .56$. The three-way interaction for PWS can be further broken down into a significant two-way interaction between emotionality and length for green button presses, $p = .002$, partial $\eta^2 = .27$, but not for red, $p = .22$, partial $\eta^2 = .05$, or yellow, $p = .07$, partial $\eta^2 = .107$, button presses. Simple effect analyses of the two-way interaction showed threat words were responded to significantly slower than neutral words for green button presses in the long button press condition (893 vs. 865 ms, respectively), $F(1, 30) = 8.67$, $p = .006$, partial $\eta^2 = .22$. The difference was reversed, although non-significant, in the short button press condition (874 vs. 887 ms, for threat and neutral words, respectively), $F(1, 30) = 1.18$, $p = .29$, partial $\eta^2 = .038$.

A post hoc analysis was undertaken to compare the emotionality effects across the two tasks (verbal and manual responding) for the PWS. In a four-way repeated measures analysis of variance with colour (green, red, yellow), emotionality (threat vs. neutral), rate (fast/short vs. normal/long) and task (manual vs. verbal) as independent variables, the interaction between emotionality and task was significant, $F(1, 30) = 4.73$, $p = .038$, partial $\eta^2 = .136$.

There was also a task main effect with manual reaction times (858 ± 30 ms) significantly slower than verbal (796 ± 30 ms), $F(1, 30) = 5.64$, $p = .024$, partial $\eta^2 = .158$.

The error rates for the manual version of the emotional Stroop task were low averaging 1 error per person for both groups (range = 0 to 9). Seventeen participants in each group produced no errors. Error data were not subject to further statistical analysis.

3.3 Correlations with emotionality effect

Table 4 gives the Pearson correlations for each group between the emotionality effect on verbal reaction time (calculated as a difference score, i.e., overall mean reaction time for threat words minus overall mean reaction time for neutral words), speech measures (%SS & SPM for PWS only), and state and trait anxiety scores. For PWS, the emotionality effect did not correlate significantly with either state or trait anxiety, although the positive correlation with state anxiety was close to significant, $p = .053$. Emotionality did correlate positively with %SS and negatively with SPM. Trait anxiety correlated positively with %SS and state anxiety was close to significant, $p = .057$. The partial correlation between the emotionality effect and %SS, while controlling for trait and state anxiety scores, was significant suggesting the association was not mediated by level of anxiety ($pr = .44$, $df = 27$, $p = .016$). There were no significant correlations for the fluent controls.

Insert Table 4 about here

4. Discussion

Two main findings emerged from the present study. First, PWS did show an emotionality effect but only in the verbal not manual emotional Stroop task. Second, there was no evidence that this effect on colour naming interacted with processes that control speech rate.

4.1 Emotionality effect in the verbal emotional Stroop task

PWS showed significantly higher levels of STAI trait and state anxiety compared to the age and gender-matched fluent controls, which replicates findings reported in previous studies (Ezrati-Vinacour & Levin, 2004; Iverach et al., 2011; Menzies et al., 1999). Furthermore, results confirmed a robust emotionality effect for PWS in the verbal emotional Stroop task, with no such emotionality effect for controls. PWS were slower to name the colour of threat words that relate to concerns of people with social phobia (e.g., *failure*, *pathetic*) than length and word-frequency matched neutral words (e.g., *session*). The findings are consistent with a large body of research using the emotional Stroop task which shows people with anxiety related disorders, or people from non-clinical populations with high-level anxiety, are slower to respond when naming the colour of emotional compared to neutral words (e.g., Reinholdt-Dunne et al., 2009; Rutherford et al., 2004; for reviews see Bar-Haim et al., 2007; Williams et al., 1996).

The emotional Stroop effect has been explained in terms of attentional bias to threat words. In the Mathews and Mackintosh (1998) parallel distributed processing network model of the emotional Stroop task, input features during perceptual processing are monitored by a threat evaluation system that encodes learned signs of threat to the individual and passes activation to perceptual and semantic representations corresponding to the detected threat. If sufficiently activated (e.g., where the threat is significant) those representations can capture attention for evaluation and possible action. The emotional Stroop effect, therefore, is explained in terms of interference to processing resources required to activate the target representations required by the demands of the task (i.e., the colour name) by task irrelevant processing of the meaning of the word. Although other models of attentional bias have been proposed (see, Yiend, 2010), these models share the notion that high-anxious people have an over-active evaluation mechanism that detects and directs attentional resources towards possible threats to the individual (Morrison & Heimberg, 2013; Reinholdt-Dunne et al., 2009; Williams et al., 1996; Yiend, 2010).

The results support previous research showing differences between PWS and controls in attentional processes (e.g., Bosshardt, 2006; Eggers, De Nil & Van den Bergh, 2010, 2012, 2013; Heitmann et al., 2004; Karrass et al., 2006; Smits-Bandstra & De Nil, 2009) and in responses to emotion words (e.g., Adams & Dietze, 1965). This present study, however, is one of the first to provide evidence that hypervigilance towards threat-related information is a characteristic trait of people PWS. These findings are significant because hypervigilance or selective attention towards a threat or negative information may play a role in causing and/or maintaining anxiety (Morrison & Heimberg, 2013; Williams et al., 1996). In the case of people with social anxiety, for example, biased attention toward threats of social harm and anticipation of negative evaluation by other people, key areas of concern for PWS (Craig & Tran, 2006; Messenger et al., 2004), can produce emotional responses (e.g., heightened anxiety and arousal) and behavioural adaptations and strategies (e.g., avoidance-type safety behaviours) that undermine effective social interaction. Some of these avoidance strategies have been reported in PWS including avoiding of eye contact with faces of audiences during speaking (Lowe et al., 2006). Over-estimating the level of threat through attentional biases may, therefore, contribute to the anxiety-related problems experienced by PWS, and if confirmed in future research, would support a focus on cognitive biases and psychosocial management approaches in interventions for PWS (Craig, 2003; Craig & Tran, 2006; Menzies et al., 2008; Menzies, Onslow, Packman & O'Brian, 2009).

4.2 Emotionality effect in the manual emotional Stroop task

In the manual emotional Stroop task, the participants pressed the corresponding colour button as quickly as possible. Unlike the verbal task, there was no significant difference in overall mean reaction time, collapsing across colour and length of button press, for threat and neutral words for either PWS or controls. When the manual and verbal reaction time data were combined into one analysis for PWS, there was a significant task-by-emotionality interaction. This is confirmation that responding to threat and neutral words differed between the verbal and manual versions of the emotional Stroop task for PWS, with an emotionality effect on colour naming reaction time, but not manual reaction time.

It is unlikely that the manual task was relatively easy to perform in comparison to the verbal task, and was therefore restricted in capacity to show an emotionality effect. For PWS, the reaction times in the manual task were significantly longer than the verbal task suggesting processing was not easier. Response choice in the manual task was challenged in a similar way to the verbal task by the additional requirement to respond with either a short or long button press. Furthermore, the manual task did reveal some processing differences between PWS and controls. Although PWS were not slower overall there was an interaction between colour and group: PWS were slower than controls in responding to the colour red, an off-centre button, but not to yellow or green. A number of studies report PWS can perform worse than fluent controls in non-verbal motor tasks, including finger tapping, suggesting an underlying deficit in movement control or timing (Max, Caruso & Gracco, 2003; Olander, Smith & Zelaznik, 2010; Smits-Bandstra et al., 2006). Broader limitations in motor skills, therefore, might explain slower responding for PWS in this manual task.

Of particular interest is the fact that the group difference in responding using the red button did not interact with emotionality. There was a higher-order four-way interaction between emotionality, colour, group and length. When unpacked, the interaction may be explained by one difference, that is, reaction times were slower for threat compared to neutral words just for PWS and just when responding to colour green in the long button press condition. This difference is difficult to interpret because the effect was not consistent across other conditions. Responses to the green button were slow when compared to the central yellow button, therefore, participants may have had more time to pay attention to the meaning of the word as a result. It is unclear, however, as to why this effect was restricted to the green button when the red button was similarly off-centre and was associated with significantly longer reaction times for PWS (although possible hemispheric differences may be involved, Heitmann et al., 2004). The contrast is one of 12 possible comparisons between threat and neutral words (3 colour by 2 length conditions for 2 groups) and could be a Type 1 error.

4.3 The potential destabilising effect on speech production of emotional reactivity to threat words

The emotionality effect appears not to be solely dependent on a failure to attend selectively to the threat word's colour. Otherwise, the emotionality effect should be observed in the manual task as well. Some authors have proposed that state changes linked to emotional responses when speaking, such as increased state anxiety and autonomic arousal, can disrupt the vulnerable speech motor system of PWS (Adams, 1969; Kleinow & Smith, 2000; Smith et al., 2010). Emotional reactions such as increased arousal caused by the threat evaluation system when processing threat words, assuming these reactions can fluctuate on an item by item basis, may have a destabilising effect on the physiological sub-systems of speech and could lead to less efficient and slower speech motor planing and execution, and therefore slower reaction times (although, cf. Heitmann et al., 2004; Peters & Hulstijn, 1984; Weber & Smith, 1990, who found levels of autonomic arousal did not differ between PWS and fluent speaking controls). There may be other channels of influence on speech motor control, however, linked to cognitive processes (Kleinow & Smith, 2006). For example, attentional bias to threat information may result in greater demand on attentional resources and cognitive effort to manage the interference. In doing so, attentional resources required for speech motor control may become depleted thereby affecting the efficiency and accuracy of speech motor planning and execution.

Some findings in the present study are consistent with the possibility that interactions with the speech production system are involved in the emotional Stroop effect for PWS. Not only was the effect limited to the verbal task, but state anxiety was higher for the PWS than controls and was positively correlated with the magnitude of the emotionality effect for PWS (this correlation was close to significant). Further, the emotionality effect correlated significantly with frequency of stuttering (%SS) and speech rate (with the latter two variables strongly and negatively correlated themselves). These correlations suggest that those PWS who showed larger slowing of colour naming of threat words tend to have less capacity to maintain fluency when speaking. Therefore, the emotionality effect appears to be related to a key characteristic of the speech motor system of PWS.

However, other findings failed to support the prediction that the emotional Stroop effect in PWS will interact with speech processes. The results showed that reaction times were faster in the fast articulation rate condition compared to normal rate condition across both groups. The reaction time interval includes initiation time after muscle command preparation in order to begin overt responding (Sternberg, Monsell, Knoll & Wright, 1978). These results suggest initiation times were faster when producing utterances at a fast rate of articulation. From the perspective that stuttering is caused by a deficit in speech motor skills (e.g., Kleinow & Smith, 2000; 2006; Namasivayam & van Lieshout, 2011; van Lieshout et al., 2004) it was predicted that PWS would have more difficulty in speech motor adjustments required to respond in the more challenging and less familiar fast speaking rate condition. Although there was a trend for PWS to be slower overall in verbal reaction time, there was no interaction between rate and group with the difference in reaction time between the fast and normal rate conditions similar for both groups.

Production durations were also shorter in the fast rate compared to the normal rate condition. This confirms participants were making appropriate changes to their articulation in accordance with instructions. However, there was no statistical interaction between group and rate on duration, although PWS were overall slower in production duration compared to the controls. Slower production durations and articulatory movement in fluent speech are commonly reported for PWS (e.g., Caruso et al., 1994; Namasivayam et al., 2008; see Peters et al., 2000, for a review). Namasivayam et al. (2008) show PWS differ from fluent speakers in their control strategy by increasing movement amplitude when speaking at a fast rate. It was suggested that greater movement amplitude serves to generate more sensory (e.g., kinaesthetic) information in order to maintain stability and fluency when speaking. It is possible that the longer durations for PWS reflect a control strategy to maintain stability in speech production when responding at both the fast and normal articulation rates. In the present study, the reaction time and production duration data together suggest that PWS were equally adept at speech rate adjustments (see, also, Namasivayam et al., 2008; Namasivayam, van Lieshout, McIlroy & De Nil, 2009). The rate manipulation, therefore, was not successful in targeting differences in speech motor abilities between PWS and fluent speakers.

In addition, there was no evidence to support our hypothesis that increased disturbance from processing threat words compared to neutral in the fast speech rate condition would lead to slower responding for PWS. Rather, the findings showed the effect of changing speech rate on reaction time was unrelated to the emotionality effect for PWS. According to additive factors logic, therefore, the additive effects of rate and emotionality suggest they impact on separate stages of processing (Sternberg, 2011). It is also of interest that there was an effect of colour on naming reaction time for both groups. The difference in reaction time when producing different colour names may be explained by differences in phonological and phonetic encoding. For example, the longer words *yellow* and *green* had slower reaction times to *red* suggesting more planning time was required (van Lieshout et al., 1996a). Importantly, there was no interaction between colour and emotionality in the verbal emotional Stroop task for PWS, either. These results suggest that the effect of emotionality on reaction time for PWS may be located at an earlier stage of processing than phonological and phonetic encoding and speech motor planning. The findings contrast with research showing linguistic complexity at syntactic and phonological levels can de-stabilise speech motor control in PWS (Kleinow & Smith, 2000; Smith et al., 2010), implicating independent cognitive modules to be involved in emotional versus linguistic effects on speech (Kleinow & Smith, 2006; Sternberg, 2011).

4.4 Levels of state anxiety during verbal tasks

Another possible explanation for why the emotionality effect in PWS is found in the verbal but not the manual task is that PWS experienced elevated state anxiety in the verbal task but not the manual task. It has been claimed that increased state anxiety is a requirement for slower colour naming to threat compared to neutral words during the emotional Stroop task (e.g., Rutherford et al., 2004). However, there appears to be more to the relationship between stuttering and the emotional Stroop effect than can be explained by level of state anxiety. The size of the emotionality effect correlated significantly with frequency of stuttering and speech rate after controlling for level of both state and trait anxiety.

4.5 Factors linking attentional bias and stuttering

Cognitive theories of attention postulate different types of attentional resources (Posner & Rothbart, 2007; Sanders, 1983; Sergeant, 2005). Reinholdt-Dunne et al. (2009) examined the role of selective attention and attentional control in the emotional Stroop task. Selective attention is involved in perceptual identification and orientation to particular input according to task demands, and is influenced by emotional reactivity. Attentional control is responsible for inhibiting task-irrelevant or competing representations. Reinholdt-Dunne et al. have shown that the level of attentional control moderates the emotional Stroop effect (see, also, Williams et al., 1996) such that slowed colour naming of negative emotion stimuli was only evident in participants who were anxious and had poor attentional control.

The demands on attentional control in the manual task under emotional Stroop conditions may be seen as less than the verbal task, and this might explain the reduced emotionality effect in PWS when manually responding. For example, the word itself, although not a colour word, could be a competing (verbal) response in the colour naming emotional Stroop task. But because there is no intrinsic relationship between the word and button pressing, the word cannot be a competing response for the manual task (except to the extent the word might encourage verbal rather than manual responding). There is also some evidence that a deficit in attentional control may be a causal factor in stuttering, although studies investigating this have focused mostly on children (e.g., Karrass et al., 2006; Eggers et al., 2012; 2013) rather than adults (cf. Heitmann et al., 2004). This type of deficit, if characteristic of people with chronic stuttering, might not only explain why emotionality was restricted to the verbal task, but might also explain the positive correlation between the emotionality effect in the verbal task and frequency of stuttering.

4.6 Summary and conclusions

PWS were slower to name the colour of threat words compared to neutral words in an emotional Stroop task. This reflects a similar form of attentional bias to negative information observed in people with anxiety-related emotional disorders. However, the difference in responding to threat words appears not to be solely linked to stimulus driven emotional reactivity and the demands that places on selective attention resources. The emotional Stroop effect for PWS was contingent on engaging the speech production system, not manual responding system, and the magnitude of the effect correlated with speech measures of stuttering (e.g., %SS). We found no evidence to support the possibility that emotional reactivity in the context of the emotional Stroop task can disrupt speech motor control in

PWS, because the emotionality effect did not vary according to whether responding was at a fast or normal articulation rate. The findings suggest the underling processes that cause slower naming of threat words in PWS precede linguistic/motor encoding and speech motor execution. The possibility of a deficit in other components of attention, in particular inhibitory control, was discussed.

These results should be viewed as preliminary in nature. It would be of value to replicate the finding using other paradigms showing attentional bias to threat information. Some tasks involving visual search or visual detection with manual responding, such as the dot-probe task (MacLeod & Mathews, 1988; Yiend, 2010), could be useful to tease out whether the emotionality effect is contingent on speech production for PWS. Studies that compare PWS and controls specifically on attentional control, and relate that to performance on the emotional Stroop task (cf. Reinholdt-Dunne et al., 2009), could also help clarify the nature of the emotionality effect. Other measures of speech motor control where deficits have been observed, such as kinematic measures of inter and intra-articulator coordination (Kleinow & Smith, 2000; van Lieshout et al., 2004), may show effects of emotionality and further confirm that emotional reactivity from threat words does impact the speech motor control system. We only examined responses to negative or threat-related words, and so it is unknown whether attentional bias is also found for positive-valence emotional stimuli in PWS (Rutherford et al., 2004). Finally, it is not possible to draw firm clinical implications from the findings at this stage. Further clarity into the nature of the processes contributing to the emotional Stroop effect in PWS is required. However, given the growing recognition of the importance of providing effective treatments for anxiety-related problems for PWS (Craig, 2003; Craig & Tran, 2006; Menzies et al., 2008; Menzies et al., 2009), further research into the role of cognitive biases in causing or maintaining those problems is warranted.

CONTINUING EDUCATION

QUESTIONS

1. A link between stuttering and anxiety has been well established in the research literature primarily using what type of assessments?

   a) Self report instruments

   b) Cognitive

   c) Measures of skin conductance

   d) Measures of blood flow

   e) Measures of heart rate

2. The emotional Stroop effect, where responding slows down to threat or negative emotion words compared to neutral words, is thought to be a measure of:

   a) Anxiety

   b) Arousal

   c) Attentional bias

   d) Stress

   e) Automatic cognitive processing

3. When the emotional Stroop effect in people who stutter was investigated the main finding was:

   a) There was a Stroop effect in the manual but not verbal version of the emotional Stroop task.

   b) There was a Stroop effect in both the manual and verbal version of the emotional Stroop task.

c) People who stutter did not show an emotional Stroop effect.

d) There was a Stroop effect in the verbal but not manual version of the emotional Stroop task.

e) The emotional Stroop effect did not differ between people who stutter and controls.

4. Which finding suggests the emotional Stroop effect in people who stutter does not directly influence speech motor control during colour naming?

   a) The emotional Stroop effect was dependent on rate of articulation.

   b) The emotional Stroop effect was unrelated to changes in rate of articulation.

   c) The emotional Stroop effect was positively correlated with frequency of stuttering.

   d) The emotional Stroop effect was positively correlated with state anxiety.

   e) The emotional Stroop effect was not found in the manual version of the task.

5. What is the significance of finding that people who stutter but not fluent speaking controls show an emotional Stroop effect?

   a) It would suggest that emotional factors cause stuttering.

   b) It would suggest that emotional factors contribute to the maintenance of stuttering.

   c) It would suggest that anxiety among people who stutter is caused by stuttering.

   d) It would suggest that attentional bias is a probable cause of stuttering

   e) It would suggest that attentional bias is a characteristic of at least some people who stutter that is similar to people who have anxiety problems, and this is significant because attentional bias could be a factor in causing and/or maintaining anxiety.

Answers: 1. a), 2. c), 3. d), 4. b), 5. e)

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Table 1

Participant Characteristics of People Who Stutter and Fluent Controls

	PWS (n = 31)			Controls (n = 31)		
	M	*SD*	Range	*M*	*SD*	Range
Age (Years)	44.1	17.7	22-87	41.8	15.6	21-74
%SS	6.6	4.6	2-19			
SPM	211	20.3	173-257			
State Anxiety	33.7	8.4	20-52	28.9[#]	8.0	20-45
Trait Anxiety	40.6	10.4	23-63	33.6[#]	7.2	20-52

Note. %SS = percentage of syllables stuttered. SPM = Syllables Per Minute. State and Trait Anxiety scores from the State-Trait Anxiety Inventory (Spielberger et al., 1983).

[#] Sample size is 30 due to an incomplete record form.

Table 2

Mean Reaction Time (ms), % Errors and Production Duration for Fast and Normal Emotional Stroop Verbal Responses for People Who Stutter and Fluent Controls

	Fast		Normal	
	Threat	Neutral	Threat	Neutral
PWS (*n* = 31)				
M	796	774	818	797
SE	32	28	33	32
% Errors	10.0	9.5	10.3	7.8
Duration*	324	327	418	412
Fluent Controls (*n* = 31)				
M	728	726	746	739
SE	20	21	24	22
% Errors	4.8	4.2	6.0	5.5
Duration*	252	253	338	339

* *n* = 17 (durations were analysed on a sub-set of participants from each group)

Table 3

Mean Reaction Time (with Standard Errors) in the Manual Version of the Emotional Stroop Task for People Who Stutter and Fluent Controls

	Short		Long	
	Threat	Neutral	Threat	Neutral
PWS (*n* = 31)				
Green	874 (34)	887 (32)	893 (33)	865 (30)
Red	871 (27)	864 (28)	891 (26)	904 (32)
Yellow	810 (35)	789 (33)	821 (37)	827 (36)
Total *M*	852 (30)	847 (29)	868 (31)	865 (31)
Fluent Controls (*n* = 31)				
Green	811 (33)	803 (28)	823 (33)	827 (31)
Red	798 (26)	786 (29)	810 (30)	818 (35)
Yellow	745 (27)	755 (32)	802 (37)	811 (33)
Total *M*	785 (28)	781 (28)	812 (32)	819 (32)

Note. In the short condition participants press the response button for a short duration. In the long condition participants hold the button down for a long duration. Total means collapse across levels of colour.

Table 4

Pearson Correlations Between Variables for PWS (Below Diagonal) and Fluent Controls (Above Diagonal)

	1	2	3	4	5
1. Emotionality effect				-.04	-.32
2. %SS	.47**				
3. SPM	-.50**	-.73**			
4. State Anxiety	.35	.34	-.11		.35
5. Trait Anxiety	.14	.36*	-.01	.78**	

Note. *n* is 31 for PWS and 30 for controls. Emotionality effect = mean verbal reaction time for threat words minus mean verbal reaction time for neutral words. %SS = percentage of syllables stuttered. SPM = syllables per minute. State and Trait Anxiety from the State-Trait Anxiety Inventory (Spielberger et al., 1983).

* $p < .05$ (two-tailed)

** $p < .01$ (two-tailed)

Appendix A

Table A1

Threat and Neutral Items Used for the Verbal and Manual Versions of the Emotional Stroop Task

Threat	
	inferior, inept, foolish, ashamed, lonely, failure, embarrassed, inadequate, pathetic, rejected, stupid, incompetent
Neutral	
	arterial, lumpy, reversed, possess, paraded, session, counterpart, phenomenon, adhesive, appendix, vacuum, equidistant