The neural correlates of blushing: Piloting an elicitation protocol

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ABSTRACT

Blushing is a physiological response to emotional stimuli, caused by the vasodilation of cutaneous blood vessels. This response is typically associated with the social, self-conscious emotion of embarrassment and is often a primary complaint of patients diagnosed with social anxiety disorder. Although previous studies have investigated blushing in relation to social anxiety, no study has yet explored the neural correlates of blushing. This research was a pilot study aimed at developing an elicitation protocol for blushing that is both reliable and transferable to an MRI scanner environment. Participants were 25 females between the ages of ages of 18 and 25 years. They were assessed using the MINI neuropsychiatric interview, Modigliani's Embarrassability Scale, the Liebowitz Social Anxiety Scale, Blushing Propensity Scale (BPS), and the Blushing, Trembling, and Sweating Questionnaire (BTS-Q). Blushing was elicited by video recording the participants singing and then playing their performance back to them. The protocol followed an AB block design, using the performance of a professional singer as a baseline. Blushing elicitation was confirmed with 2 physiological measures: heart rate (HR) and galvanic skin response (GSR), both measured by an ambulatory psychophysiological monitoring system. Visual analogue scales (VAS) were used to obtain subjective measures on participants' rating of embarrassment and perception of their blush response, and the researcher's visual confirmation of the blush response. The protocol successfully elicited blushing, as measured by HR and GSR and the self-report and researcher VAS. Based on correlations with the physiological and subjective confirmations of blushing, the BPS and BTS-Q were identified as pre-screening measures to eliminate individuals that may not blush readily. This successful protocol can be transferred to a scanner environment for a pioneering fMRI study to determine the neural correlates of blushing.

Key words: neural correlates; blushing; embarrassment; fMRI; affective neuroscience; emotion elicitation; social anxiety.

Until recently, many neuroscientists assumed that, because neurons process stimuli in similar ways despite their function, affective brain processes were simply variants of cognitive processes (Panksepp, 2003). Recent work, however, indicates that emotions are distinct processes in terms of their neurochemical, anatomical and functional criteria. It is now believed that emotions allow us to make cognitive decisions, and are an important evolutionary development. Human emotional experience is believed to be emergent from "ancient neurosymbolic systems of the mammalian brain that unconditionally promote survival" (Panksepp, 1992, p. 559). Emotional processes include motor-expressive, sensory-perceptual, autonomic-hormonal, cognitive-attentional, and affective-feeling aspects (Panksepp, 2003). In order to study them, emotional processes need to be dissected into elementary operations, such as the perception of stimuli, expressive behaviour production and activity of the autonomic nervous system (Davidson & Sutton, 2005).

Specialised strategies are required to understand the unique neural basis of emotions, and thus a new sub-field of neuroscience has emerged. This sub-field, Affective Neuroscience, can lead research on cortical and subcortical interactions in emotional regulation, and how emotional processing differs across individuals. The field has the potential to inform both pharmacological and psychological therapeutics in the development of treatments.

Basic and Social Emotions

Controversy in the field of affective psychology has largely focused on the debate around the existence of basic emotions that are universal across culture. Ekman (1992) and Izard (1992) argue the case for the existence of basic emotions. These are considered to be the product of evolutionary adaptation, and evidence for their existence comes from research demonstrating universal facial expressions, distinct physiological patterns of the autonomic nervous system, phylogenetic comparisons and discovery of common antecedent events. Happiness, sadness, anger, fear, surprise and disgust (combined with contempt) are regarded by contemporary theorists, including Izard and Ekman, as the six basic emotions (Keltner & Buswell, 1997).

Basic emotions can no longer be discussed without consulting neurobehavioural data. Animal work and neuroimaging data have revealed that affective-emotional processes are mediated by distinct brain systems. There is strong evidence for at least four executive systems of basic emotions, coined "fear," "rage," "expectancy" and "panic" systems, that are responsible for the instigation and mediation of affective experiences (Panksepp, 2003, p. 554).

Compared to basic emotions, social emotions emerge later in development, involve complex cognitive processes and have social rather than biological goals (Lewis, 1993). Embarrassment, guilt, shame and pride are classified in the same family of "self-conscious" emotions, a subset of social emotions. Pride is positively-valenced, whereas embarrassment, guilt and shame are negatively-valenced (Eisenberg, 2000). Fundamental to self-conscious emotions is the individual's ability to understand and evaluate the self. In order to experience these affective states an individual has to understand social norms and what constitutes the violation of them, as well as possess the ability to understand how others may perceive the situation.

This self-evaluation during social norm violation can be clearly seen in the experience of embarrassment – an emotion dependent on the presence of others, real or imagined (Eisenberg, 2000). Thus, embarrassment is a public emotion that usually occurs during personal interactions. Previously considered a variant of shame, it is now distinguished as a separate emotion (Keltner & Buswell, 1997). This distinction can be made on the basis of separate triggers: when comparing embarrassment to shame and guilt, the former is more closely related to a violation of social conventions and an increase in social exposure, whereas the latter two are associated with violations of moral norms. Furthermore, observers are able to accurately distinguish it from emotions most likely to be confused with it, such as shame, amusement, enjoyment, anger, and disgust, because embarrassment is characterized by a distinct facial display consisting of gaze aversion, smiling and often blushing (Keltner, 1995).

Blushing as a Functional Adaptation

Blushing is a universal emotional response (Leary, Britt, Cutlip, & Templeton, 1992). Darwin (1892/1904, p. 327) regarded it as the "most peculiar and most human of all expressions". Facial blushing, caused by cutaneous blood vessel dilatation, is both a salient and rapidly developing response elicited by emotional stimuli (Drott, Claes, & Rex, 2002). This response is mediated by the sympathetic nervous system: the blush region is supplied with beta-adrenoreceptors, resulting in a dilator effect on the basal tone of the vasculature (Drummond, 1997; Mellander, Andersson, Afzelius, & Hellstrand, 1982). The blush region includes the face, forehead, neck, ears and sometimes the upper chest (Gerlach, Wilhelm, Gruber, & Roth, 2001). Blushing is socially produced, and is not to be confused with non-social reddening (flushing), caused by temperature changes, physical exertion or consumption of alcohol (Leary et al., 1992). Blushing may differ between individuals in frequency and intensity

(across cultures and ages), and perceptibility (depending on skin darkness; Darwin 1982/1904). Despite this variation, it remains a universal human phenomenon.

Face-to-face contact involving self-conscious emotions of embarrassment or shame is the predominant cause of blushing (Shields, Mallory, & Simon, 1990). Social situations that elicit blushing include threats to an individual's public identity (through the violation of social norms), or undesired social attention from others (through scrutiny or positive attention and praise). The intensity of the blush depends on the amount of stress experienced in such social situations (Mulkens, de Jong, Dobbelaar, & Bögels, 1999).

Displaying embarrassment or shame may have instrumental value in social interactions, because it indicates that the individual recognises the social transgression that he or she has made and regrets having done so (Keltner & Buswell, 1997). This signal of admittance may effectively diffuse a threatening situation by appeasing the recipient or observer of the social transgression. Such displays in both human and non-human animals involve gaze aversion, smiling, displaying the neck and reducing physical size. This phylogenetic similarity indicates an evolutionary basis for human variants of appeasement. In humans, blushing is a salient signal, making it a likely indicator of shame and embarrassment that can appease the other individuals in a situation (Leary et al., 1992; Keltner, 1995).

Blushing and Social Anxiety

Despite its potential adaptive function, blushing is often regarded as undesirable response that individuals seek to conceal (de Jong & Peters, 2005; Shields et al., 1990). This undesirability has made it is a cardinal symptom of social anxiety disorder, and a sub-type of this disorder exists where erythophobia (fear of blushing) is the primary complaint (Drott, 2004). This sub-type is characterized by frequent episodes of severe blushing that are easily and instantly elicited, and are often associated with embarrassment and social incapacitation (Drott et al., 2002).

Treatment options available to patients with a fear of blushing include behaviour modification, medication, or surgery. It is recommended that individuals who suffer from social anxiety should first attempt to treat the underlying cause of blushing, using evidence-based therapy, before considering the drastic option of surgery (Bracha & Lenze, 2006). One such method, cognitive-behaviour therapy, involves decreasing a patient's anxiety surrounding the blush response (Mulkens, Bögels, de Jong, & Louwers, 2001).

There are several medications available for the treatment of erythophobia. Given the proposed sympathetic mediation of the blush response, beta blockers, that target symptoms

related to the sympathetic nervous system, have been proposed (Drott et al., 2002). Yet, these have proved ineffective for many people. There is some evidence of efficacy for Selective Serotonin Reuptake Inhibitors (SSRI), suggesting the involvement of seratonergic systems in the blush response. Sertraline, one such SSRI, has been found to reduce fear, avoidance and the physiological symptoms of blushing and palpitations (but not trembling and sweating) in patients with social anxiety disorder (Connor, Davidson, Chung, Yang, & Clary, 2006). This reduction, however, may be as a side-effect of the anxiety reducing effects of SSRIs, as it is not a treatment aimed specifically at blushing.

In severe cases, patients obtain no relief from either psychotherapy or medication. A more drastic treatment is an endoscopic thoracic sympathecotomy, a surgery that interrupts the facial sympathetic innervation of the upper thoracic chain (Drott et al., 2002). This surgery has been found to effect a 94% reduction in facial blushing among patients. For some patients, surgery may be worse than the experience of blushing, because severe side effects, such as compensatory sweating, have been reported in a high proportion of patients (Bracha & Lenze, 2006). Despite the options currently available, there is no ideal treatment for blushing in blushing-fearful individuals, and more efficient pharmacotherapies and psychotherapies should be investigated. Such improvement in treatment relies, at least in part, on an improved understanding of the physiological and neurological bases of self-conscious emotions and blushing.

Neuroimaging Studies of Self-Conscious Emotions

Various neuroimaging studies on social, self-conscious and moral emotions have revealed certain brain areas correlated with their expression. The amygdala, a brain region heavily implicated in the conditioning and expression of basic emotions, has been implicated in affective response to one's own moral transgressions (Berthoz, Grèzes, Armony, Passingham, & Dolan, 2006). Using films and still images to elicit discrete emotions, Britton et al. (2006) found that social emotions activate the amygdala, as well as the superior temporal gyrus, hippocampus and posterior cingulate. Moll, de Oliveira-Souza, Eslinger et al. (2002) aimed to directly elicit basic and moral emotions through presenting emotionally charged pictures with or without moral content. They found that stimuli eliciting both basic and moral emotions recruited the amygdala, upper midbrain and thalamus, but that moral emotions additionally recruited the orbital and medial prefrontal cortex and superior temporal sulcus. This finding suggests that these additional substrates form part of a cortical-limbic network, termed the 'moral sensitivity network' by these authors, that is involved in critical moral appraisal.

A similar study, requiring participants to judge short statements (neutral, moral or non-moral) as right or wrong, confirmed the recruitment of this proposed network in moral judgements (Moll, de Oliveira-Souza, Bramati, & Grafman, 2002).

This research using scenarios involving both moral and emotional content suggests that the proposed network integrates moral judgment with emotion. Thus, emotions may reinforce moral actions. As an emotion responsive to social transgressions, embarrassment has been tentatively classified as a prosocial emotion within the family of moral emotions (Moll et al., 2007). In a study where participants imagined how they would feel in a variety of action scenarios, different categories of moral emotions were found to have distinct neural activation patterns: prosocial emotions (embarrassment, guilt and compassion) activated the prefrontal cortex and superior temporal sulcus, empathetic emotions (guilt and compassion) additionally activated the mesolimbic pathway, and other critical emotions (disgust and indignation) activated the amygdala (Moll et al., 2007). Thus, different categories of emotions activate specific components of the proposed moral sensitivity network.

Activation patterns of evaluation of guilt and embarrassment both include the ventrolateral and dorsomedial prefrontal cortex, although embarrassment produces greater activation in the bilateral hippocampus, right anterior temporal cortex, and visual cortex (Takahashi et al., 2004). This increased activation suggests that the processing of embarrassment may require more complex processing of social information. In addition to showing activation when processing embarrassment or guilt, it should be noted that the ventrolateral and dorsomedial prefrontal cortex is increasingly active for social transgressions in the presence of an audience, and for all moral transgressions (with or without audience). It has been suggested that these regions process aversive social stimuli in order to facilitate a change in behaviour from the one prompting the aversive reaction to a more beneficial one (Finger, Marsh, Kamel, Mitchell, & Blair, 2006).

Methodological critiques of these studies. The studies reviewed above have allowed great insight into the neural correlates of self-conscious emotions, but a major criticism of their approach (and thus of our ability to draw firm conclusions from them) is that they have investigated the *evaluative process* of these emotions, and not *direct elicitation*. The crux of the matter is that it is debatable whether indirect and evaluative elicitation studies provide meaningful indications of the neural correlates of the actual emotion under investigation.

The ultimate achievement in affective fMRI studies is imaging the actual experience of an emotion (S. Malcolm-Smith, personal communication, April 5, 2008). This, however, is difficult to achieve in an fMRI scanner, because it requires the elicitation of emotions that often involve complex antecedents and processes. As a result, neuroimaging studies commonly use protocols that measure participants' evaluative experience of emotionally valenced statements (e.g., Moll, de Oliveira-Souza, Bramati et al., 2002; Moll et al., 2007; Takahashi et al., 2004) or rely on participants' response to hypothetical situations (e.g., Berthoz et al., 2006; Finger et al., 2006). The resulting neural correlates are not necessarily involved in the actual emotions, but are related to the evaluation or contemplation of them. Moll, de Oliveira-Souza, Bramati, et al. (2002) note that indirect elicitation lacks agency, since emotional judgement does not require reference to participants' own behaviour. In direct elicitation studies, researchers have to be certain that they are truly eliciting the emotion of interest. Such elicitation often evolves complex social tasks (e.g., Drummond et al., 2007; Gerlach et al., 2001; Mulkens et al., 1999). In the case of social-conscious emotions, a social interaction is required, and creative ways of achieving this while an individual is restricted in an fMRI scanner need to be developed.

In addition to the difficulty of designing a protocol for use in the scanner environment, neuroimaging research is particularly expensive, given the capital outlay and procedural expenses. Large-scale studies are time-consuming and costly, and funding bodies require evidence of feasibility before allocating funding to such endeavours (Lancaster, Dodd, & Williamson, 2004). This feasibility can be ascertained by conducting a pilot study, a small-scale version of a complete study, involving the pre-testing of a research tool or method (van Teijlingen & Hudley, 2001). Such studies are essential for methodological adjustment and formation of an effective study design, and increase the likelihood of success in the main study. Pilot studies that are effectively designed and conducted can yield valuable information about the most appropriate research protocol and sometimes about likely results. They are essential for neuroimaging studies, given the expense of such studies.

In order to ensure an effective emotion elicitation neuroimaging study, it is imperative to use an elicitation protocol that has produced the best results in behavioural studies. Superior blushing experiments should use tasks that approximate real-world situations as closely as possible to elicit blushing (Drummond et al., 2007). Whereas some blushing studies rely on imagined situations and self-report data (e.g., Bögels & Lamers, 2002; de Jong & Peters, 2005), other studies have elicited blushing directly using audio and video recordings. Shearn, Bergman, Hill, Abel and Hinds (1990) and Mulkens et al. (1999) elicited

blushing by getting female participants to watch a pre-recorded video of themselves singing in the presence of confederates. Similarly, Gerlach et al. (2001) gave participants the words to a children's song and instructed them to sing it repeatedly for 3 minutes while being videotaped. The videotape was then watched by participants in the presence of two other people, with footage of an empty chair viewed as a control. Drummond et al. (2007) asked participants to prepare an impromptu speech that was audio recorded and played back while the experimenter watched their faces. Methods of this nature proved strong enough to produce some facial colouration in all participants.

To objectively confirm the effectiveness of blushing elicitation methods, the blush response needs to be quantified and confirmed using physiological measures that correlate with the response. It is advisable to substantiate data by using more than one physiological measure of blush response (Drummond et al., 2007). Because blushing is characterised by vasodilation of cutaneous blood vessels (Drott et al., 2002), it is essential to measure changes in facial blood flow or cheek coloration using either a photoplethysmograph (Gerlach et al., 2001; Mulkens et al., 1999; Shearn et al., 1990) or a photoelectric pulse transducer (Drummond et al., 2007). In addition, physiological arousal should be measured, because blushing is a salient indicator of physiological stress caused by embarrassing or shameful social situations. Galvanic skin response (Mulkens et al., 1999) and heart rate (Gerlach et al., 2001) can be used as correlates of this arousal. Cheek temperature changes can be measured, as these are interoceptive cues to an individual that blushing has occurred, but this is more relevant to studies concerned with blushing-fearful individuals (Mulkens et al., 1999). It is important that the ambient temperature and heat sources in the experimental setting are carefully controlled to prevent external temperature from interfering with blush expression (Drummond et al., 2007).

While fMRI studies have investigated the neural correlates of self-conscious emotions, and blushing has been researched in terms of cognitive and affective factors responsible for blushing and blushing phobia using physiological measures for objectivity, no study has yet looked specifically at the neural correlates of blushing. Ekman (2003, p. 266) explained, in a New York Academy of Sciences panel discussion on emotion, that he had been involved in one study, about 20 years ago, that simultaneously measured facial temperature changes, facial muscular activity and brain activity, but that the results "never saw the light of day".

SPECIFIC AIMS

Imaging studies investigating social emotions like embarrassment have, to date, relied on participants imagining a particular scenario and imagining how they or the people in that situation would feel (e.g., Takahashi et al., 2004). Thinking about how oneself or another individual would feel in a given situation, is not the same as actually experiencing the situation. It is generally recognized that the only way to clearly identify the neural correlates of any emotion is to elicit that emotion, and to image the neural activity that occurs during the experience. However, developing reliable elicitation protocols that will work in a scanner environment has proved to be a difficult task.

The aim of this study was to pilot a protocol of blushing elicitation that can be transferred to a scanner environment where the neural correlates of blushing will be determined. It was hypothesised that by following a protocol loosely based on the method of Mulkens et al. (1999), blushing would be reliably elicited. The research aimed to objectively confirm blushing using three physiological measures, while using self-report questionnaires to obtain a subjective perspective. The focus was specifically blushing, rather than general embarrassment, given its clinical relevance in populations suffering from social anxiety disorder. Not only will results from such a study enhance the knowledge base of affective neuroscience, but they may be informative in developing alternative treatments for fear of blushing in patients with social anxiety disorder.

METHOD

Design

This study was an ABABABABAB quasi-experiment, alternating the A (participants view professionals singing) and B (participants viewing themselves singing) conditions, each of which was 40 seconds in length. Between each condition, there was a 2-minute rest period in which a distractor task was employed.

Participants

Twenty-six female participants between 18 and 25 years ($M = 20.88 \pm 1.66$) were recruited from the University of Cape Town. This age group was chosen because it is believed that social anxiety is highest during adolescence and early adulthood (Drott et al., 2002), and that the onset of social anxiety is most likely to occur during this time (Kleinknecht, Kleinknecht, Hiruma, & Harada, 1997). Thus, participants of this age will most likely blush easily.

Previous research has reliably elicited blushing in females (e.g., Mulkens et al., 1999; Shearn et al., 1990), so the sample was restricted to females. Exclusion criteria included the presence of current psychopathology, particularly depression; the use of psychoactive medication; any serious medical or neurological condition; and any cardiovascular condition or medication that impacts on the cardiovascular system.

All experimental procedures received approval from the Research Ethics Committee of University of Cape Town's Faculty of Health Sciences.

Materials

Physiological measures. An ambulatory monitoring system (VU-AMS, version 5fs; Amsterdam, The Netherlands) was be used to measure heart rate (ECG signal), cardiac impedance (ICG signal), and galvanic skin response (GSR). This system was attached to participants via electrodes: three ECG electrodes attached to the chest, four ICG electrodes attached the chest and back, and one GSR electrode attached to the index and middle finger of the non-dominant hand, according to system specifications.

A plethysmograph attachment (MLT1020PPG IR Velcro model, AD Instruments, New Zealand) for the ActiveTwo Biosemi EEG machine, was secured to the forehead by a headband, and used to measure change in facial blood flow. Photoplethysmography has been used in previous blushing studies (Gerlach et al., 2001; Mulkens et al., 1999; Shearn et al., 1990), and is considered to be the best method for measuring rapid changes in facial blood volume associated with the blush response.

Digital recording and task equipment. A digital recorder, recording directly onto a computer, was used to videotape the singing performance of participants. Karaoke videos containing instrumentals and lyric text but no vocals were used for the recording. The songs sung by the participants were chosen because their lyrics were particularly embarrassing to perform. The video clips of the two professional singers were chosen for their limited choreography, mainly consisted of the singer standing in front of the camera singing. This simple content would be comparable to the participants' performance.

Each AB block featured a control and an elicitation condition. The control condition featured a professional singing a song, and the elicitation condition featured the participant singing a song by the same artist. The songs used in the control condition were "The voice within" by Christina Aguilera and "Unfaithful" by Rhianna. The songs used in the elicitation condition were "Beautiful" by Christina Aguilera and "Umbrella" by Rhianna. The songs in

the control and elicitation conditions were not the same in order to prevent comparative evaluation between the two conditions. The two songs in each block were, however, comparable in terms of form and content.

The AB design was programmed into an E-Prime (Schneider, Eschmann, & Zuccolotto, 2002) computer task. Each A and B condition was followed by completion of subjective ratings and performing the adult "Reading the Mind in the Eyes" test as a distractor task (Baron-Cohen & Wheelwright, 2001). The two conditions were repeated to create the total of 5 blocks; Blocks 1, 3, and 5 featured songs by Christina Aguilera, and blocks 2 and 4 featured songs by Rhianna. Each participant completed the same protocol.

Questionnaires. The Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996) was used to screen for clinical depression, with the intention of excluding participants who presented with clinically significant scores (more than 20). This is a well-established measure that uses a self-report format to determine the current level of depression over 21 items. The BDI-II is highly reliable and widely used (Lezak, Howieson, & Loring, 2004).

The Social Phobia module of the MINI Neuropsychiatric interview (Lecrubier & Sheehan, 1997) was used to screen for the presence of social anxiety disorder. The intention here was not to exclude participants who presented with this disorder, but rather to use information about their diagnostic status to inform data interpretation. The interview was conducted by a suitably trained researcher who has clinical experience and the agency to make referrals.

Modigliani's (1968) Embarrassability Scale (ES; Appendix A) was used to determine the amount of embarrassment usually experienced in social situations. The ES consists of 26 items, each describing a situation that is potentially embarrassing. Participants rate how embarrassed they would feel on a 9-point scale ranging from "acutely embarrassed" to "not the least embarrassed". This scale has been used in previous blushing research (Gerlach et al., 2001), and has demonstrated good internal consistency (Cronbach's $\alpha = 0.88$; Withers & Vernon, 2006) and strong reliability and validity (Leary, 1990).

The Liebowitz Social Anxiety Scale (LSAS; Appendix B) assessed the degree of social anxiety present in participants. The LSAS consists of 24 questions, each describing a situation that is potentially anxiety inducing. Participants rate how fearful or anxious the situation would make them feel on a 4 point scale from "none" to "severe," and how often they would avoid the situation on a 4 point scale from "never" to "usually". A score less than 50 indicates a clinically insignificant level of social anxiety, between 55-65 indicates a

moderate level, between 65-80 indicates a marked level, between 80-95 indicates a severe level, and above 95 indicates a very severe level. This measure has been found to have good internal consistency (Cronbach's $\alpha = 0.95$) and test-retest reliability ($r = 0.83$; Baker, Heinrichs, Kim & Hoffman, 2002). The LSAS was used in conjunction with the ES to obtain a parallel assessment of anxiety and embarrassment across social situations.

The "fear of blushing" subscale from the Blushing, Trembling and Sweating Questionnaire (BTS-Q; Bögels & Reith, 1999; Appendix C) was used to determine anxiety about blushing. This subscale consists of 7 items, each related to blushing in social situations. Participants respond on a visual analogue scale from "not at all" to "very much". The BTS-Q has been found to possess high internal consistency (Cronbach's $\alpha = 0.95$) and a high intercorrelation with the Dutch Social Phobia and Anxiety Inventory ($r = 0.71$; Mulkens et al., 1999). It demonstrates good discriminant validity through the discrimination of socially anxious individuals with fears of somatic symptoms, such as blushing, from socially anxious individuals devoid of these fears.

The Blushing Propensity Scale (BPS; Leary & Meadows, 1991; Appendix D) was used to determine the degree to which participants blush in everyday social situations. The BPS consists of 14 items, each describing a social situation. Participants indicate how often they would feel themselves blush in each situation on a 5-point scale from 'never' to 'always'. This scale has high internal consistency (Cronbach's $\alpha = 0.92$) and a high test-retest reliability ($r = 0.93$; Mulkens et al., 1999). Both the BTS-Q and BPS have been used in previous blushing studies (de Jong & Peters, 2005; Drummond et al., 2007; Mulkens et al., 1999).

Visual analogue scales (VAS) were administered to participants within the computer elicitation task to determine their level of embarrassment, and how intensely they felt they blushed (Appendix E). Participants moved a bar up or down on the scale to select the level of embarrassment and blushing they experienced. VAS were also used by the researcher for each A or B clip to determine whether participants were visibly blushing (Appendix F).

Procedure

The presence of an audience is critical to the experience of self-conscious emotions: Social transgressions are usually only embarrassing if witnessed by others (Eisenberg, 2000). Taking this into consideration, two young male confederates served as an audience during the elicitation protocol. The blushing elicitation session was conducted individually for each participant. Upon arrival, the participant was introduced to the two confederates, who were

seated in the reception room working on their computers. The participant was then ushered into an adjacent room, where a consent form was signed.

Multiple studies have confirmed that having participants sing a song and watch video playback of their performance reliably induces blushing, and the advantage of playback is that no other task demands will confound physiological measures (e.g., Gerlach et al., 2001; Mulkens et al., 1999; Shearn et al., 1990). Watching playback of one's own singing has been termed an "intense social stressor" (Mulkens et al., 1999, p. 1122). Given this previous research, the participant was asked to sing 2 well-known songs, Beautiful (by Christina Aguilera) and Umbrella (by Rhianna). These performances were digitally recorded. The original version of each song was played prior to the participant singing it, in order to ensure that they were familiar with it. A karaoke video, providing instrumentals and written lyrics, of each song was projected onto a white wall using a data projector. Participants were instructed to look directly at the camera as often as possible, and to give a serious performance without any acting or dancing (theatrics can be used to make a performance humorous, thereby potentially reducing its embarrassing effects).

There was a 20-minute break following recording, which allowed the participant to relax and return to baseline functioning, and gave the researcher time to edit the recordings and organize them into a format for presentation. During this break, the participant was assessed with the Social Phobia module of the MINI, and completed the BDI, LSAS, BTS-Q and BPS.

The researcher then explained the physiological measures to the participants, and set up the equipment that measured and recorded ECG, ICG, GSR and facial blood flow. Prior to task commencement, the confederates were re-introduced: participants were told that the confederates would also be watching the playback in the adjacent room, and would be rating their performance. While Mulkens et al. (1999) positioned confederates in the same room as the participant during playback, this will not be possible when the protocol is transferred to the scanner. Thus, deception was used to induce the social situation required for embarrassment. In order to maintain an authentic deception, the confederates were given a compact disc, containing the participant's performance, in front of the participant. They also conducted a sound and video check on their computers in preparation for the viewing, and informed the experimenter when all settings were functioning correctly.

Participants were then asked to begin the E-Prime computer task. Playback alternated between the performance of a professional singer (condition A), and that of the participant's recorded performance (condition B) in the order of ABABABABAB. Each condition was 40

seconds in length. There was a 2-minute rest period between each condition, where participants engaged with the distractor task. Physiological data (ECG, ICG, GSR and facial blood flow) was collected for the duration of the task, and events were marked for each block. After each condition, prior to the 2-minute rest period, participants were asked to complete VAS self-report questionnaires (inserted into the task) of how embarrassed they felt, and how intensely they thought they blushed during the video playback. The researcher also marked the visible blush response of the participant for each condition on a VAS. This block design ensured that physiological and self-report data for both neutral and embarrassing events were captured, allowing for comparison. This design was used because it is an effective fMRI design, and will ensure that the elicitation protocol can be directly transferred to the neuroimaging study.

The participant was not immediately debriefed at the end of the session, in order to prevent the possibility of other participants finding out about the deception prior to their session. They were, however, told that the singing recordings would not be distributed to or viewed by anyone else and were encouraged to ask any questions or raise any concerns that they had about their experience. After all data had been collected, all participants were sent an explanatory letter via electronic-mail which outlined the aims of the study, and explained the purpose of the different aspects of the protocol in relation to these aims. It was revealed that the confederates were, in fact, not watching their performance. Participants were encouraged to contact the researcher if they had any further questions or comments, or if the information contained in the letter concerned them in any way. No participants felt the need to do so.

Data analysis

Pre-processing. The ECG and GSR data were analysed using the AMS5sf package (Amsterdam, The Netherlands), and was converted into a format appropriate for statistical analysis. Sixty-second epochs were used when marking events for analysis, beginning from the onset of each A or B condition, and continuing for 10-seconds past the event. The plethysmograph and ICG data were not analyzed, because the complexity of analysis was beyond the scope of this project. They do, however, provide valuable data and will be used in the future to inform the fMRI study.

The participants' scores for each of the ES, LSAS, BPS (tallying scores for each question) and BTS-Q (the average mark placement across the VAS scales) were calculated. Any participants that scored above 20 points on the BDI or who presented with social anxiety

disorder as diagnosed by the MINI would have been excluded or their diagnosis used to inform interpretation of their data respectively, but no such cases occurred. The VAS scales completed by each participant and the researcher for each control and elicitation condition were averaged across the 5-blocks.

Statistical Analysis. Statistica version 8 software package (StatSoft Inc., 2007) and Microsoft Office Excel (Microsoft Corporation, 2003) were used for all statistical analyses. The physiological and VAS data were tested for normality using the Shapiro-Wilks test.

The physiological data did not violate the assumption of normality. Repeated measures *t*-tests were performed on the EGC and GSR data to determine whether there was a difference between the physiological data for the control and elicitation conditions. Two analyses, one using an average over all 5 blocks (*5-block design*) and the other using an average over only 3 blocks *(3-block design)*, were conducted. Two analyses were necessary, because while 5-blocks are optimal in order to achieve sufficient power in fMRI research, there was concern that the blush response would weaken after several repeated blocks as the participants became habituated to watching their performance. The 5-block design was, however, used for all further analysis and comparisons with other data.

Administered scales (BDI, ES, LSAS, BPS and BTS-Q) were tested for inter-correlation using Pearson's Product Moment correlation. Similarly, the two VAS administered within the E-Prime task and the VAS completed by the researcher were correlated with each other to confirm their reliability.

Distributions of the three VAS scores deviated from normality, and thus non-parametric Wilcoxon matched-pairs tests were performed to determine whether there was a significant difference between the control and elicitation conditions for these measures.

Pearson's Product-Moment correlations were also performed between the VAS and physiological data. Because they were administered post-elicitation, these correlations served to determine whether the objective and subjective measures of blushing confirmed the same outcome. Because the ES, LSAS, BPS and BTS-Q were administered pre-elicitation, they were correlated with the physiological data and VAS scores in order to determine potential pre-screening measures to eliminate potential participants who do not blush readily.

Effect sizes and proportion of explained variance for the tests of significance were calculated using r and r^2 (the coefficient of determination) respectively. These effect size estimates were chosen over other possibilities because they are restricted to a particular range of values, and can be used for a wide range of different tests, thus making them easy to interpret (Rosenthal & Rosnow, 2008).

RESULTS

Administered Scale Scores

Table 1 shows the means and standard deviations of the scores participants obtained on the various administered scales. No participants presented with Social Phobia, as assessed by the MINI, and all 26 participants were below the 20-point exclusion criteria measured by the BDI. There was a wide variability of scores on the LSAS, ES, BPS and BTS-Q. Scores on the LSAS ranged from 9 – 73 (out of a theoretical maximum of 144), and most participants scored in the range of clinically insignificant social anxiety. Two participants fell above this insignificant level (scores of 52 and 54), one had moderate social anxiety (score of 65), and one had marked social anxiety (score of 73). Scores ranged from 43 – 93 (out of a theoretical maximum of 130) on the ES, 22 - 58 (out of a theoretical maximum of 70) on the BPS, and 0.86 – 7.48 (out of a theoretical maximum of 10) on the BTS-Q.

Table 1
Descriptive Statistics of Participants' (n =26) Scores on Administered Scales

Scale	Mean	*SD*
BDI	7.77	5.88
LSAS	34.23	15.60
ES	69.19	12.17
BPS	38.96	9.97
BTS-Q	3.82	1.85

Intercorrelations Between Scales and VAS

The BDI and ES were not correlated with any of the scales. The BTS-Q and BPS were found to be moderately correlated with each other, as were the BPS and LSAS (Table 2). These correlations accounted for 47% of the variance between BTS-Q and BPS scores, and 18% of the variance between BPS and LSAS scores. Significant strong inter-correlations with large effect sizes were found between all three subjective VAS (Table 2): The two VAS completed by the participants regarding their rating of embarrassment and perception of their blush response were inter-correlated, and the researcher's visual confirmation correlated with both the participants' rating of embarrassment, and participants' perception of their blush response.

Table 2
Inter-correlations between VAS and scale measures

Correlation	*r*	r^2	*p*
BPS : BTS-Q	0.69	0.47	0.000101
BPS : LSAS	0.43	0.18	0.028754
Researcher's visual confirmation of blush : Participants' rating of embarrassment	0.85	0.72	0.005070
Researcher's visual confirmation of blush : Participants' perception of blush	0.89	0.79	0.000004
Participants' rating of embarrassment : Participants' perception of blush	0.90	0.81	0.000002

Objective (Physiological) Confirmation of Blush Response

In the physiological data analysis, three participants were excluded, because of data collection error ($n = 23$). Table 3 shows the means, standard deviations, as well as the minimum and maximum values for ECG heart rate (HR) and galvanic skin response (GSR) across the control and elicitation conditions for both the 5-block and 3-block design. See Figures 1 and 2 (Appendix G) for a graphical representation of this comparison.

Repeated measures one-tailed *t*-tests on the mean HR and mean GSR data revealed a significant difference between the control and elicitation blocks for both measures for the 5-block design (Table 4). The effect size (r) calculations revealed that the difference between the control and elicitation HR was attributable to the elicitation protocol with moderate to large effect, and that 14% of the variance in HR (r^2) was accounted for by the manipulation (Table 4). Similarly, difference between the control and elicitation GSR was attributable to the protocol with moderate to large effect, and 33% of the variance was accounted for.

Repeated measures one-tailed *t*-tests performed on the 3-block design similarly indicated significant differences for both physiological measures (Table 4). When comparing the 3-block design to the 5-block design, the mean HR of the 3-block design was only 0.04 beats/min higher for the control condition and 0.36 beats/min higher for the elicitation condition, while the mean GSR of the 3-block design was only 0.04 μS[1] lower for the control

[1] μS = microSiemens

condition and 0.03 μS higher for the elicitation condition. The effect sizes and proportion of variance of both the 3- and 5-block designs were also similar, with the 5-block design HR *r* and r^2 both being 0.01 higher than for the 3-block design, and 5-block design GSR *r* and r^2 both being 0.03 higher (Table 4). Repeated measures one-tailed *t*-test comparing the 5-block to 3-block design confirmed that there was no significant difference between both HR and GSR control and elicitation conditions (Table 5).

Table 3
Descriptive statistics of HR and GSR for control and elicitation blocks (n = 23)

Design	Measure	Block	Mean	*SD*	Min	Max
5-block	HR (beats/min)	Control	75.75	10.15	49.30	93.40
		Elicitation	77.01	10.74	52.11	99.38
	GSR (μS)	Control	5.14	2.62	1.42	11.07
		Elicitation	5.24	2.68	1.47	11.61
3-block	HR (beats/min)	Control	75.79	10.66	49.08	95.38
		Elicitation	77.37	11.56	51.90	103.09
	GSR (μS)	Control	5.10	2.60	1.43	10.62
		Elicitation	5.27	2.66	1.49	11.18

Table 4
Repeated measures t-tests between control and elicitation physiological data

Design	Measure	Diff.	*SD*	*t*	*p*	*r*	r^2
5-block	HR (beats/min)	1.60	4.07	1.92	0.067	0.37	0.14
	GSR (μS)	0.18	0.27	3.33	0.003	0.57	0.33
3-block	HR (beats/min)	1.58	4.17	1.82	0.082	0.36	0.13
	GSR (μS)	0.17	0.27	3.05	0.006	0.54	0.30

Note. $n = 23$ and $df = 22$.

Table 5
Repeated measures t-tests comparing the control and elicitation physiological data for the 5-block and 3-block design

Measure	Block	Diff.	*SD*	*t*	*p*	*r*	r^2
HR (beats/min)	Control	0.04	0.96	0.19	0.427	0.00	0.04
	Elicitation	0.36	1.39	1.23	0.115	0.06	0.25
GSR (μS)	Control	0.04	0.20	0.99	0.166	0.04	0.21
	Elicitation	0.03	0.20	1.47	0.252	0.09	0.30

Note. $n = 23$ and $df = 22$.

Subjective (VAS) Confirmation of Blush Response

Table 6 shows the means, standard deviations, and minimum and maximum scores for the control and elicitation conditions of all VAS. Wilcoxon matched-pairs tests revealed significant differences between the control and elicitation conditions for all VAS: the researcher's visual confirmation VAS, $T = 0.0$, $Z = 4.46$, $p = 0.000008$; the participants' embarrassment rating, $T = 0.00$, $Z = 4.46$, $p = 0.000008$; and the participants' perception of blush VAS, $T = 0.00$, $Z = 4.46$, $p = 0.000008$[2]. The effect of the manipulation was large for all three VAS ($r = 0.87$), and 76% of the variance of all 3 VAS scores was accounted for by it ($r^2 = 0.76$). Figure 3 (Appendix G) graphically illustrates these marked differences between the control and elicitation conditions.

Table 6
Descriptive statistics of VAS scores for control and elicitation blocks (n = 23)

VAS Measure	Block	Mean	*SD*	Min	Max
Researcher's visual confirmation of blush	Control	0.41	0.38	0.12	1.40
	Elicitation	4.74	2.06	1.29	8.10
Participants' rating of embarrassment	Control	0.55	0.68	0.00	2.31
	Elicitation	4.21	1.75	0.53	6.41
Participants' perception of blush	Control	0.41	0.60	0.00	1.78
	Elicitation	3.34	2.01	0.10	6.41

[2] These Wilcoxon test statistics are correct. The values were identical for all three VAS.

Correlations Between Physiological Data, VAS and Scales

There was no significant correlation between the physiological data and the VAS. No overall significant correlations were found between the LSAS, ES, BPS or BTS-Q and the physiological data, or between the LSAS, ES and the VAS. There was, however, a strong significant correlation between the elicitation HR and BPS scores for participants in the first quartile (bottom 25%) of the HR data, and 68% of the variance in scores was explained by this correlation (Table 7). Running dependent measures *t*-test analysis without the individuals with first quartile BPS scores yielded a significant result for HR (control $M = 79.62 \pm 7.68$, elicitation $M = 81.44 \pm 7.99$), $t = 2.30$, $df = 16$, $p = 0.018$. Similarly, a significant result was yielded for GSR (control $M = 5.20 \pm 2.76$, elicitation $M = 5.35, \pm 2.84$), $t = 3.19$, $df = 16$, $p = 0.006$. The effect sizes for both HR ($r = 0.50$) and GSR ($r = 0.63$) and proportion of explained variance explained ($r^2 = 0.25$, and $r^2 = 0.39$ for HR and GSR respectively), were higher for this analysis than for that including participants who scored in the first quartile of the BPS.

There were significant moderate correlations between the BTS-Q and the embarrassment experienced by participants, the BTS-Q and participants' perception of their blush response, the BPS and the embarrassment experienced by participants, the BPS and participants' perception of their blush, and the BTS-Q and the researcher's visual confirmation (Table 7). These correlations explained between 18 – 45% of the variance in scores (Table 7).

Table 7
Correlations between VAS, HR and Scale scores (n = 26)

Measures correlated	***r***	***r*²**	***p***
Participants' rating of embarrassment VAS : BTS-Q	0.67	0.45	0.000167
Participants' perception of blush VAS : BTS-Q	0.58	0.33	0.002030
Researcher's visual confirmation VAS : BTS-Q	0.44	0.20	0.023204
Participants' rating of embarrassment VAS : BPS	0.60	0.35	0.001332
Participants' perception of blush VAS : BPS	0.43	0.18	0.029569
Elicitation HR (1st quartile) : BPS	0.82	0.68	0.043534

DISCUSSION

Success of the Elicitation Protocol

This research aimed to pilot a blushing elicitation protocol that was compatible with a scanner environment. Such a pilot was crucial in to evaluate the feasibility of the fMRI study (van Teijlingen & Hudley, 2001). If the protocol proved to be successful, it would be used in an fMRI study investigating the neural correlates of blushing. This neuroimaging research has the potential to inform the social and self-conscious emotion literature within the field of affective neuroscience, and may prove valuable in the development alternative treatments for blushing-fearful patients.

It was hypothesised that a reliable elicitation protocol would be achieved by following a design loosely based on the method used by Mulkens et al. (1999). The results from both the physiological data (HR and GSR) and subjective measures (participant and experimenter VAS) indicated that this aim was successful, and blushing was reliably elicited. The effect size obtained for the subjective measures of blushing indicate a highly successful protocol, with a large amount of the variance explained by it. The effect size obtained for the physiological data indicate a moderate to large success, with a moderate proportion of the variance explained. Thus, this protocol (like those used by Drummond, 1997; Gerlach et al., 2001; Mulkens et al., 1999; and Shearn et al., 1990) was an effective direct emotional elicitation paradigm.

The discrepancy between effects of subjective and physiological measures is not unusual. It has been found that objective measures of blushing do not correlate highly with subjective feelings of embarrassment (Drott et al., 2002). This may be because only a relatively small increase in physiological arousal is necessary to induce a salient blushing response in individuals who do not have a clinical fear of blushing (Drummond et al., 2007; Mulkens et al., 1999). Alternatively, it may indicate that subjective measures over-estimate the actual blush response. Thus, obtaining objective physiological confirmation of blushing is essential when doing blushing research (Drummond et al., 2007). In the pilot research, both subjective and objective measures were used to confirm the blush response, making it a reliable design.

With this design, however, there was concern over possible habituation of the participants to the elicitation conditions after more than 3 exposures to their singing performance. This concern was unfounded; no significant differences were found for HR and GSR between the 5- and 3-block designs, indicating that habituation had not occurred.

Differences in effect sizes were also negligible. Furthermore, the mean HR was slightly higher for the 3-block design, while the mean GSR was slightly higher for the 5-block design. If there was potential habituation, this increase in HR and decrease in GSR fail to indicate a clear directional effect.

The comparison between the 5-block and 3-block design was imperative, because it has bearing on the future fMRI design. In an fMRI study, it is imperative to have a number of repetitions of the blocks, because this increases the power of the design (Liu, 2004). While social emotion fMRI studies use up to 8 blocks (e.g. Finger et al., 2006; Moll et al., 2002; Takahashi et al., 2004), 5 blocks is considered a respectable number (E. Meintjes, personal communication, April 20, 2008). While a greater number of blocks should be used, this should not reduce the overall manipulation effect of the protocol. In this pilot protocol, decreasing the number of blocks reduced the power of the fMRI design, but having 5-blocks had the potential to induce habituation. It was, therefore, important to weigh up the advantages and disadvantages of using the 5- or 3-block design. Finding no reduced effect in the 5-block design indicates that it is the optimal choice for the future fMRI study.

Potential Pre-Screening Measures

Established scales were administered to participants in the anticipation that pre-screening measures could be identified in order to increase the success of blushing elicitation. The scores obtained on the these scales had a variable range, indicating that the sample group had widely different degrees of social anxiety (measured by the LSAS), embarrassability (measured by the ES), blushing propensity (measured by the BPS) and fear of blushing (measured by the BTS-Q fear of blushing subscale).

While no participant exhibited clinical levels of depression (measured by the BDI) or social anxiety disorder (measured by the MINI), a small number of participants exhibited mild to marked levels of social anxiety, according to the LSAS. The moderate correlation between the BPS and LSAS indicates that social anxiety and subjective blushing propensity are related, which is consistent with finds from the fear of blushing and social anxiety literature (e.g. Bögels & Lamers, 2002; de Jong & Peters, 2005). High or low scores on this scale, however, did not seem to affect participants' response to the elicitation conditions, as evidenced by the failure of LSAS scores to correlate with either the physiological or subjective data. Similarly, the embarrassability of the participants also did not affect their response. This lack of correlation between social anxiety, embarrassability and the blush response possibly indicates either that the elicitation protocol was sufficiently embarrassing

for all participants regardless of their pre-disposition to be embarrassed, or that both traits are not related strongly enough to blushing.

The lack of overt correlations between the physiological data and any of the administered scales initially suggested that there were no obvious pre-screening measures to exclude individuals who do not blush readily. A deeper look at the data, however, revealed that the first quartile HR data correlated with BPS scores. Analysing both the HR and GSR data, after eliminating participants who scored in the first quartile of the BPS, resulted in an increased manipulation effect. Furthermore, the correlations of the BPS and BTS-Q with the subjective VAS data indicated that these scales be useful as potential pre-screening measures.

That both these scales emerged as possible pre-screening measures can be attributed to the moderate inter-correlation between them. Correlations between the participant's subjective rating of embarrassment and blush response and the BPS and BTS-Q scales are not surprising, because effectively these VAS and the scale scores are both subjective ratings by the participant themselves. Correlations between the BTS-Q and the researcher's confirmation of visible blushing are more relevant, however, because the subjectivity of the researcher is not related to the subjectivity of the participants.

Thus, correlations with subjective data indicate the BTS-Q as a reliable measure, while correlations with physiological data indicate the BPS. Both the BTS-Q and BPS have been used in blushing elicitation studies (de Jong & Peters, 2005; Drummond et al., 2007; Mulkens et al., 1999). Previous blushing studies have used the blushing subscale of the BTS-Q as a pre-screening measure for identifying low- (bottom third of scores) and high- (upper third of scores) blushing fearful individuals (Bögels & Lamers, 2002; de Jong & Peters, 2005; Mulkens et al., 1999). While some blushing and social anxiety studies have used the ES (Gerlach et al., 2001; Klienknecht et al., 1997), the results from this pilot protocol suggest that this scale is not a useful correlate of the blush response. While the LSAS is an established test of social anxiety, it also did not demonstrate usefulness in this context, and is perhaps only useful in studies using clinically anxious individuals. Thus, both the BPS and BTS-Q were identified out of the range of administered tests as useful pre-screening measures.

Limitations of the Pilot Study

Although this protocol was successful overall, some weaknesses need to be revised for the fMRI study. Such weaknesses include the relatively older age of the participants, and the effectiveness of the deception. The onset of social anxiety is most likely to occur during

adolescence (Kleinknecht et al., 1997). Even though social anxiety is still high in early adulthood (Drott et al., 2002), it is probably higher in adolescents with less life experience. The mean age of participants in this study was 20.88 years. Other successful blushing studies have used participants with a slightly younger mean age of between 19 years (Mulkens et al., 1999) and 19.6 years (Bögels & Lamers, 2002; de Jong & Peters, 2005).

The young adult participants used for this pilot study appeared to be less concerned with the presence of the confederates than had been hoped. A few participants even doubted the deception, and this may be because a large proportion of them were psychology students who are not naïve to the types of deception practiced in behavioural research. In research of this nature, it is critical that participants are conscious of the confederates' presence, and believe the deception, in order to create the social context required to elicit embarrassment (Eisenberg, 2000).

Young adults receiving tertiary education were not the preferred sample group for this research, but were chosen because of logistical constraints; obtaining a high school sample proved too difficult, because permission had to be obtained from the schools and parents in order to recruit, and this was a time-consuming process. It is anticipated that using a younger, more naïve sample would increase the success of the deception, and that the protocol would thus elicit higher levels of embarrassment and physiological arousal.

Furthermore, weakness in the deception can be attributed to the use of a protocol designed for a scanner environment outside that environment. Because confederates will be unable to be in the same room as the participant when they are in the scanner, in this protocol they were placed in a separate room from the participants in order to simulate this constraint. This made their presence remote, and participants could easily forget that their performance was being 'watched'. In the scanner environment, however, the highly technical and invasive nature of the laboratory and the scanner, where researchers and confederates can communicate with the participant through a microphone, will make this deception appear more real. Thus, the success of the deception will most likely be enhanced when it is transferred to the scanner environment.

Recommendations for Future Research

This successful elicitation paradigm can be transferred to the scanner environment for use in an fMRI study to determine the neural correlates of blushing. It is recommended that the plethysmograph and ICG data be analysed prior to the commencement of the neuroimaging study, in order to ascertain whether those measures yield valuable information that may

influence protocol implementation. It will also be useful to determine whether there is value in using such measures in the neuroimaging study. The plethysmograph data may prove to be particularly important, because change in facial blood flow is a direct physiological measure of the blush response (Drott et al., 2002), and this method has been used in other successful elicitation studies (Gerlach et al., 2001; Mulkens et al., 1999; Shearn et al., 1990).

The neuroimaging study should recruit adolescent participants from high schools to increase the likely success of the elicitation manipulation. Potential participants should complete the BDI-II and MINI, as was done in the pilot protocol, to ensure the sample is free from clinical levels of depression and that the presence of social anxiety disorder is noted. In addition, the BTS-Q and BPS should be administered, and the lowest scorers (either the first quartile or third) should be excluded from the sample. This should increase the effect of the manipulation, by excluding individuals that are less likely to blush according to both subjective (VAS) and objective (HR) measures.

Conclusion

A pilot of the blushing elicitation protocol was conducted to increase the likelihood of success in the fMRI study. Given the high cost of neuroimaging research, it was essential that an effective protocol be tested, so it could be used with confidence in the scanner environment. This pilot research has provided valuable information about the effectiveness of a protocol designed specifically for transfer to a scanner environment. Results revealed that the elicitation paradigm was effective and that a 5-block design was appropriate. The study also identified the BTS-Q and BPS screening measures that can be used to select a sample with an increased probability of blushing.

While blushing has been investigated using subjective and physiological measures in the previous studies, no study has yet looked at the neural correlates of this phenomenon. Direct elicitation is the only way to clearly identify the neural correlates of any emotion by imaging the neural activity that occurs during the experience. Direct elicitation is, however, difficult to achieve, and thus much neuroimaging research relies on indirect elicitation methods. This protocol has successfully achieved direct elicitation, making it highly valuable for fMRI research. The essential confirmation of success, evaluation and suggestions provided by this pilot research can now be utilised in a pioneering fMRI study to determine the neural correlates of blushing, which will have implications for both affective and clinical neuroscience.

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APPENDIX A

EMBARRASSABILITY SCALE

Name:_____ Date:_____

These questions ask whether certain social situations would cause you embarrassment. To be sure that we mean the same thing by "embarrassment," let us say a few things about it. Generally, embarrassment involves feeling self-conscious, awkward, discomforted, or exposed because of the nature of the situation. Remember that you may feel embarrassed for yourself of for someone else. Remember also that mild embarrassment differs considerably from strong embarrassment, while still being a form of embarrassment. Mild embarrassment generally involves a very slight self-consciousness, a mild sensation of awkwardness and uneasiness, and a slight feeling of uncertainty about what to do or say next. On the other hand, strong embarrassment can be extremely unpleasant, involving blushing, fumbling, severe self-consciousness, strong sensations of awkwardness and discomfort, a panicky feeling of being unable to react appropriately to the situation that has been created, and a strong desire to escape the situation and the presence of others.

Read the items below. Try to imagine as vividly as possible that each of these events is happening to you. If they have occurred to you in the past, thing back to how you felt at the time. Then, rate how embarrassed you would feel if the event were actually happening to you by using the scale below to describe your reaction. Circle the most appropriate answer.

1 = I would not feel the least embarrassed: not awkward or uncomfortable at all.
2 = I would feel slightly embarrassed.
3 = I would feel fairly embarrassed: somewhat self-conscious, and rather awkward and uncomfortable.
4 = I would feel quite embarrassed.
5 = I would feel strongly embarrassed: extremely self-conscious, awkward and uncomfortable.

1. Suppose you were just beginning a talk in front of a class.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

2. Suppose you slipped and fell on a wet floor in a public place, dropping a bag of groceries.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

3. Suppose you were a dinner guest, and the guest seated next to you spilled his plate on his lap while trying to cut his meat.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

4. Suppose someone stopped you on the street by asking you something, and he turned out to be quite drunk and incoherent.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

5. Suppose a group of friends were singing "Happy Birthday" to you.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

6. Suppose you discovered you were the only person at a particular social occasion without a dress (or coat and tie –i.e. you are informally dressed).

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

7. Suppose you were watching an amateur show and one of the performers was trying to do a comedy act, but was unable to make anyone laugh.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

8. Suppose you were calling up a person you had just met for the first time in order to ask him or her for a date.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

9. Suppose you were muttering aloud to yourself in an apparently empty room and discovered that someone else was present.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

10. Suppose you walked into a bathroom at someone else's house and discovered it was occupied by a member of the opposite sex.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

11. Suppose you were watching a play from the audience when it suddenly became clear that one of the actors had forgotten her lines, causing the play to come to a standstill.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

12. Suppose you are unable to stop coughing while listening to a lecture.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

13. Suppose you were being lavishly complimented on your pleasant personality by your companion on your first date.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

14. Suppose you were in a class and you noticed that the teacher had completely neglected to zip his fly.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

15. Suppose you entered an apparently empty classroom, turned on the lights, and surprised a couple making out.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

16. Suppose you were talking to a stranger who stuttered badly due to a speech impediment.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

17. Suppose your mother had come to visit you and was accompanying you to all your classes.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

18. Suppose you were a dinner guest and could not eat the main course because you were allergic to it.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

19. Suppose you were alone in an elevator with a professor who had just given you a bad test grade.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

20. Suppose a shabbily dressed man accosted you on the street and asked you for a handout.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

21. Suppose you were walking into a room full of people you did not know and were being introduced to the whole group.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

22. Suppose you tripped and fell while entering a bus full of people.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

23. Suppose you were opening some presents while the people who bought them for you were sitting around watching.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

24. Suppose you asked someone on crutches if he had suffered a skiing accident and he blushed and replied that, no, he was crippled by polio when he was a child.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

25. Suppose you had forgotten an appointment with a professor, and remembered it as you met him in the hall the next day.

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

26. Suppose you were talking in a small group that included a blind student, when someone next to him unthinkingly made a remark about someone being "blind as a bat."

1	2	3	4	5
Not at all	Slightly	Fairly	Quite	Strongly

APPENDIX B

LIEBOWITZ SOCIAL ANXIETY SCALE

Name:_____ Date:_____

Indicate how often you feel fearful or anxious in each of the following situations and how often you avoid each of them using the scales below. Circle the most appropriate answer.

Fear or Anxiety:	Avoidance
0 = None	0 = Never (0%)
1 = Mild	1 = Occasionally (1-33%)
2= Moderate	2 = Often (33-67%)
3=Severe	3 = Usually (67-100%)

1. **Telephoning in public**

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

2. Participating in small groups

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

3. Acting, performing or giving a talk in front of an audience.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

4. Eating in public places

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

5. Drinking with others in public places.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

6. Talking to people in authority.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

7. Going to a party

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

8. Working while being observed.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

9. Writing while being observed.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

10. Calling someone you don't know very well.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

11. Talking with people you don't know very well.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

12. Meeting strangers.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

13. Urination in a public bathroom.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

14. Entering a room when others are already seated.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

15. Being the centre of attention.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

16. Speaking up at a meeting.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

17. Taking a test.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

18. Expressing a disagreement or disapproval to people you don't know very well.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

19. Looking at people you don't know very well in the eyes.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

20. Giving a report to a group.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

21. Trying to pick up someone.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

22. Returning goods to a store.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

23. Giving a party.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

24. Resisting a high pressure salesperson.

Fear or Anxiety	0	1	2	3
	None	Mild	Moderate	Severe
Avoidance	0	1	2	3
	Never	Occasionally	Often	Usually

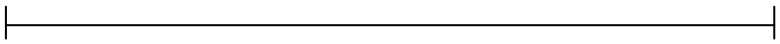
APPENDIX C

THE BLUSHING, TREMBLING, AND SWEATING QUESTIONNAIRE
Fear of Blushing Subscale

Name:_____ Date:_____

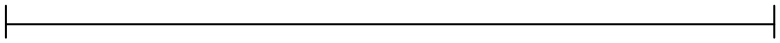
The following questions concern blushing in social situations. Please indicate what best applies to you by means of putting a vertical stripe on every line.

1. How afraid are you to start blushing?



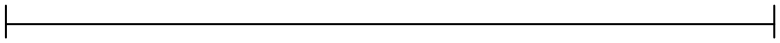
Not afraid at all — Very much afraid

2. How afraid are you while you blush?



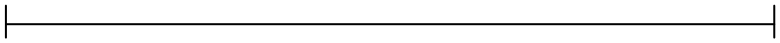
Not afraid at all — Very much afraid

3. How often do you blush?



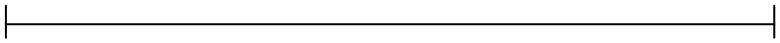
Never — All the time

4. To what extent are you hindered in your daily functioning by blushing?



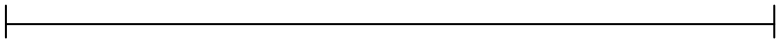
Doesn't hinder me at all — Hinders me very much

5. How often do you think in a certain situation: I hope I'm not going to blush?



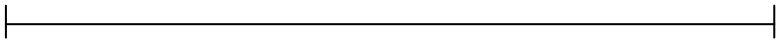
I never think that — I think that constantly

6. To what extent do you avoid situations in which you are likely to blush, or avoid others who might notice that you blush?



I do not avoid this at all — I avoid this constantly

7. How do people in your environment usually react when you blush?



Very negatively — Very positively

APPENDIX D

BLUSHING PROPENSITY SCALE

Name:_____ Date:_____

Indicate how often you feel yourself blush in each of the following situations using the scale below. Circle the most appropriate answer.

1 = I **NEVER** feel myself blush in this situation.
2 = I **RARELY** feel myself blush in this situation.
3 = I **OCCASIONALLY** feel myself blush in this situation.
4 = I **OFTEN** feel myself blush in this situation.
5 = I **ALWAYS** feel myself blush in this situation.

1. When a teacher calls on me in class

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

2. When talking to someone about a personal topic

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

3. When I'm embarrassed

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

4. When I'm introduced to someone I don't know

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

5. When I've been caught doing something improper or shameful

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

6. When I'm the center of attention

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

7. When a group of people sings "Happy Birthday" to me

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

8. When I'm around someone I want to impress

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

9. When talking to a teacher or boss

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

10. When speaking in front of a group of people

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

11. When someone looks me right in the eye

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

12. When someone pays me a compliment

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

13. When I've looked stupid or incompetent in front of others

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

14. When I'm talking to a member of the other sex

1	2	3	4	5
Never	Rarely	Occasionally	Often	Always

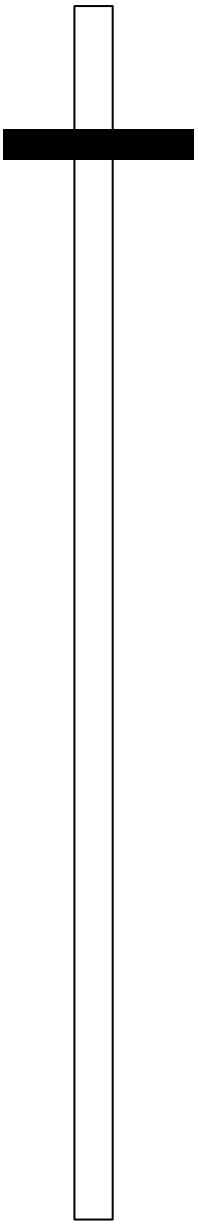
APPENDIX E

SELF-REPORT VAS IN E-PRIME TASK

In this task you will need to answer two questions. Please select your answer by moving the marker up or down on the scale using the UP and DOWN arrow keys.
Once you are satisfied with your answer, press enter.
Press the enter key to begin.

How embarrassed did you feel while watching this video clip?

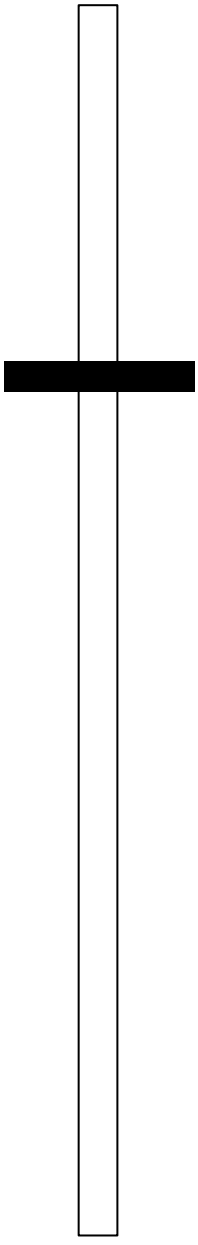
Very embarrassed



Neutral

How much do you think you blushed while you were watching this video clip?

Blushed very strongly



Did not blush at all

APPENDIX F

VAS OF VISIBILE BLUSHING OBSERVED BY RESEARCHER

Very strongly Neutral

_____ E5

_____ C5

_____ E4

_____ C4

_____ E3

_____ C3

_____ E2

_____ C2

_____ E1

_____ C1

APPENDIX G

RESULTS FIGURES

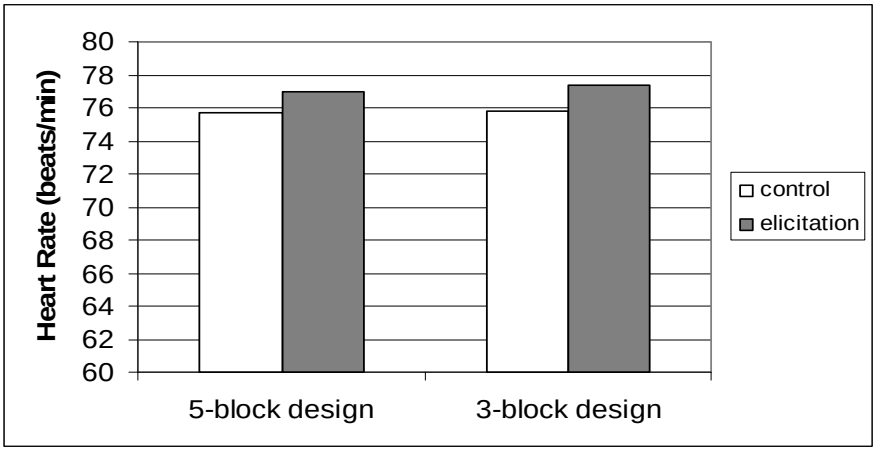


Figure 1. Differences between control and elicitation heart rate for 5 and 3 block designs

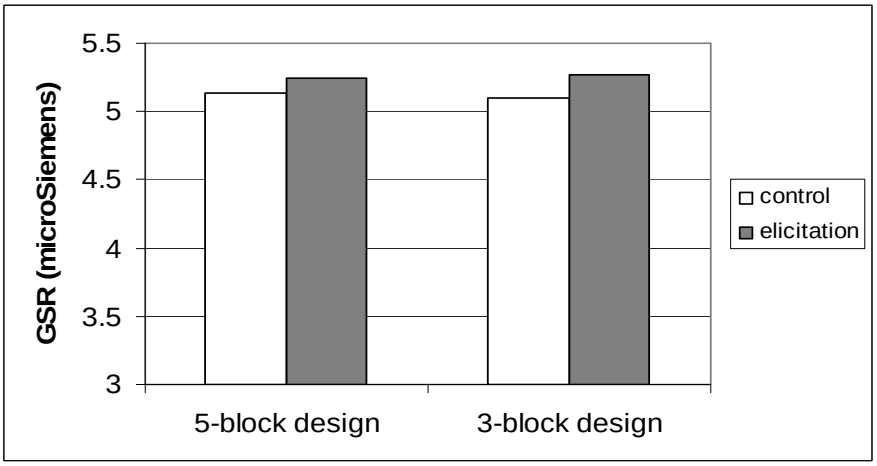


Figure 2. Differences between control and elicitation Galvanic Skin Response (GSR) for 5 and 3 block design

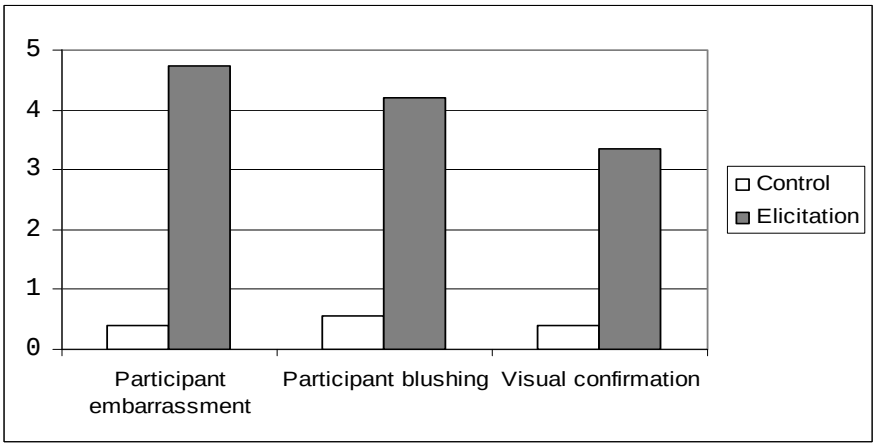


Figure 3. Scores on the visual analogue scales for the control and elicitation conditions

PLAGIARISM DECLARATION

1. I know that plagiarism is wrong. Plagiarism is using another's work and to pretend that it is ones own.

2. I have used the American Psychological Association (APA) as the convention for citation and referencing. Each significant contribution to, and quotation in, this research project from the work, or works of other people has been attributed and has cited and referenced.

3. This research project is my own work.

4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

5. I acknowledge that copying someone else's assignment or essay, or part of it, is wrong, and declare that this is my own work

SIGNATURE: _____

DATE: _____