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The relationship between blushing propensity, social anxiety and facial blood
flow during embarrassment

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Short title: Correlates of blushing

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evaluation; gender; embarrassment

Abstract

To investigate blushing in relation to blushing propensity scores and core elements of social anxiety, facial blood flow was monitored in 86 normal volunteers during an embarrassing task (singing a children's song). Increases in facial blood flow were greater in women than men, as were scores on the Blushing Propensity and Fear of Negative Evaluation scales. In addition, high scores on the Blushing Propensity and Social Interaction Anxiety scales were associated with large increases in facial blood flow during singing. However, this appeared to be due primarily to social anxiety because the association between blushing propensity scores and changes in facial blood flow disappeared when social interaction anxiety scores were taken into account. These findings suggest that people generally base their beliefs about blushing on cues other than changes in facial blood flow. Social anxiety may augment increases in facial blood flow during embarrassment, independently of expected or perceived blushing.

Introduction

People vary greatly in personal beliefs about how much they blush. To explore this issue systematically, Leary and Meadows (1991) developed a scale to measure self-reported estimates of blushing frequency in various social settings (e.g., when talking to someone about a personal topic or when speaking in front of a group). High scores on the Blushing Propensity Scale were found to be associated with self-focused attention and heightened social anxiety (Leary & Meadows, 1991; Edelman & Skov, 1993; Neto, 1996; Bögels, Alberts, & de Jong, 1996). Surprisingly, however, scores on this scale were found to be, at best, only loosely related to the intensity of blushing during embarrassment (e.g., Mulkens, de Jong, Dobbelaar & Bögels, 1999). For example, in a representative study from our laboratory, changes in forehead blood flow were assessed with laser Doppler flowmetry in 21 participants with high blushing propensity scores and another 21 with low blushing propensity scores during an embarrassing task (singing a children's song) (Drummond, 1997). Ratings of embarrassment, self-consciousness and negative affect were greater in the high than low blushing propensity group. However, increases in blood flow were similar in both groups, averaging around 35%.

Nonetheless, some exceptions have been noted. For example, when a biofeedback signal was adjusted to indicate the absence of blushing, facial blood flow did not change from baseline during an embarrassing task (singing a children's song) in people with low blushing propensity scores; however, blushing developed normally in people with high scores (Drummond, 2001). A similar effect was detected recently in people with high blushing propensity scores and a fear of blushing when feedback was delivered during a conversation with strangers (Dijk, Voncken, & de Jong, 2009). Likewise, facial blood flow increased progressively over the course of an experiment

in people with high blushing propensity scores when told that they had blushed during each experimental task (Drummond et al., 2003). Thus, people who regard themselves as blushers may blush more frequently or intensely than others in some situations.

A second line of research has shown that the thoughts and emotions associated with social anxiety may augment blushing (Voncken & Bögels, 2009). For example, increases in facial blood volume were found to be greater in social phobics than controls when they watched an embarrassing videotape of themselves singing (Gerlach, Wilhelm, Gruber, & Roth, 2001). Similarly, cheek coloration (measured with infrared plethysmography) was greater before, during and after a conversation in people with high than low social phobia scores (Bögels, Rijsemus, & de Jong, 2002). Furthermore, increases in facial blood volume were greater in shy than non-shy individuals while anticipating and then watching videotapes of themselves singing or giving a speech (Hofmann, Moscovitch, & Kim, 2006).

Taken together, the findings reviewed above suggest that social anxiety not only influences beliefs about blushing but may also affect changes in facial blood flow. If so, overlap between blushing propensity and social anxiety might explain why blushing is elevated in certain situations in people with high blushing propensity scores. To investigate this possibility in the present study, core elements of social anxiety (fear of negative evaluation, social interaction anxiety and discomfort in social settings) were explored in relation to changes in facial blood flow during an embarrassing task. It was hypothesized that controlling for social anxiety would account for any relationship between blushing propensity scores and changes in facial blood flow during this task.

We also wished to determine whether demographic variables such as age or sex moderate blushing during embarrassment. Despite the stereotype that young women blush more intensely than other people, there is comparatively little evidence to support this view. In the only study to directly compare physiological indices of blushing in women and men, Shearn, Bergman, Hill, Abel and Hinds (1990) noted greater increases in cheek temperature and observer ratings of blushing during peak facial coloration in women than men when they watched a videotape of themselves singing. However, physiological indices of cheek and ear coloration increased to the same extent in both sexes. Self-reported blushing declines with age (Shields, Mallory, & Simon, 1990), but whether this reflects a perceptual shift or is linked with a decrease in vascular reactivity is unknown. Therefore, changes in facial blood flow during embarrassment were explored in relation to age and sex in the present study.

Method

Participants

The sample consisted of 67 women and 19 men aged between 17 and 59 years ($M = 29.2$ years, $SD = 12.1$) recruited from undergraduate psychology classes, university colleagues and community newspaper advertisements. The gender imbalance reflects differences in the proportions of women and men enrolled in undergraduate psychology classes (the main source of participants in this study). Individuals who took prescribed medication for any medical condition were excluded from participation. Each participant provided informed consent for the procedures, which were approved by the University Ethics Committee.

Materials and Procedure

Participants initially filled out the Blushing Propensity Scale (Leary & Meadows, 1991), Fear of Negative Evaluation Scale (Watson & Friend, 1969),

and the Social Interaction Anxiety and Social Phobia Scales (Mattick & Clarke, 1998). Fear of Negative Evaluation is a cardinal feature of social anxiety and is associated with high blushing propensity scores (Chen & Drummond, 2008). Sample items include “I worry about what people will think of me even when I know it doesn’t make any difference” and “I am often afraid that I may look ridiculous or make a fool of myself”. The Social Interaction Anxiety Scale assesses anxiety associated with initiating and maintaining conversations (e.g., “I become tense if I have to talk about myself or my feelings”), whereas the companion Social Phobia Scale assesses anticipatory and performance-related social anxiety (e.g., “I get nervous that people are staring at me as I walk down the street”) (Mattick & Clarke, 1998). For each of these scales, the internal consistency and test-retest reliability over short intervals is high (Leary & Meadows, 1991; Watson & Friend, 1969; Mattick & Clarke, 1998).

Participants were tested individually in a small room maintained at $21 \pm 2^{\circ}\text{C}$. A female experimenter (DS) administered the procedures. After cleaning the forehead with Cetaphil Cleanser, a wide surface area laser Doppler flow probe was inserted into a probe holder and attached to the right side of the forehead approximately 2 cm above the eyebrow. Signals were relayed to an MBF3D Laser Blood Flow Monitor (Moor Instruments Ltd., Axminster, England), sampled at 200 Hz by a Biopac MP100 data acquisition system (Goleta, California, USA) and displayed and analyzed using Biopac AcqKnowledge software (Version 3.9.0) on a personal computer.

After sitting quietly for ten minutes, participants rated embarrassment and blushing on numerical scales ranging between 0 and 10 where 0 corresponded to “no embarrassment” or “not blushing at all”, 1-4 to grades of “mild”, 5-8 to “moderate”, and 9-10 to “extreme” embarrassment or blushing. Participants were

then asked to sing “Old Macdonald had a farm” while the experimenter monitored changes facial blood flow on a computer screen in an adjacent room. The door between the two rooms was left ajar so that the experimenter could hear the participant singing. To increase performance anxiety, participants were told that their singing would be recorded and replayed by the experimenter later on. To aid recall, a list of various animal noises was provided for each new verse of the song. After the participant had sung the children’s song for three minutes, the experimenter returned and asked the participant to rate embarrassment and blushing again.

Data reduction and statistical approach

As the strength of the laser Doppler signal depends both on the density of blood vessels immediately below the flow probe and on the degree of penetration of the laser beam into the skin, the signal cannot be calibrated in absolute units of flow. Therefore, mean blood flow during the three minutes of singing was expressed as the percent change from levels recorded during the final minute of baseline.

Preliminary analyses indicated that questionnaire scores, ratings, and changes in facial blood flow during singing were unrelated to the participant’s age, which was skewed toward younger age groups. Therefore, age was not considered further in statistical analyses.

Student’s t-test was employed to verify the observation that physiological signs of blushing are greater in women than men (Shearn et al., 1990). Differences between men and women in questionnaire scores were investigated in a multivariate analysis of variance, followed by tests of simple main effects.

Ratings before and after singing were investigated in Gender (men, women) by Time (before versus after singing) repeated measures analyses of variance.

Finally, the association between questionnaire scores, changes in embarrassment and blushing during singing, and changes in facial blood flow during singing was investigated in multiple linear regression analyses with gender as a covariate. The aim of these analyses was to determine whether questionnaire scores or ratings predicted changes facial blood flow during singing and, if so, to test that hypothesis that social anxiety would account for any relationship between blushing propensity and changes in facial blood flow.

Results are reported as the mean \pm standard deviation, and the criterion of statistical significance was $p < 0.05$.

Results

Differences between women and men

Increases in facial blood flow during singing were substantial, averaging $44.0 \pm 35.2\%$ above levels before singing ($p < .001$). The increase was greater in women ($49.5 \pm 35.8\%$) than men ($24.6 \pm 25.3\%$), $t(84) = 2.84$, standard error of the difference = 8.78, $p < .01$. In addition, questionnaire scores differed between women and men, multivariate $F(4,81) = 3.31$, $p < .05$. Tests of simple main effects indicated that blushing propensity scores and fear of negative evaluation were higher in women than men (for blushing propensity scores 36.8 ± 8.6 versus 31.1 ± 7.7 , $p < .05$; for fear of negative evaluation 13.4 ± 7.6 versus 9.5 ± 6.1 , $p < .05$). Social interaction anxiety scores averaged 17.8 ± 8.8 in women and 18.6 ± 10.4 in men (not significant), whereas social phobia scores averaged 11.3 ± 7.2 in women and 8.9 ± 6.5 in men (not significant). Ratings of blushing and embarrassment increased when participants sang [for blushing, ratings increased

from 1.5 ± 1.0 to 2.8 ± 1.9 , $F(1,84) = 32.1$, $MSE = 1.39$, $p < .001$; for embarrassment, ratings increased from 2.6 ± 2.0 to 3.7 ± 2.3 , $F(1,84) = 15.4$, $MSE = 2.30$, $p < .001$]. These increases were similar in women and men (none of the main effects or interactions that involved Gender was statistically significant).

Association between questionnaire scores, ratings, and changes in facial blood flow during singing

Questionnaire scores, rating changes and gender together accounted for 25% of the variance in facial blood flow during singing ($p < .001$). In particular, gender ($\beta = 0.33$, $p < .01$) and social interaction anxiety scores ($\beta = 0.41$, $p < .001$) each independently predicted changes in facial blood flow during singing (Table 1).

Blushing propensity scores overlapped moderately with social interaction anxiety scores ($r = 0.44$, $p < .001$), and both scores were associated with changes in facial blood flow during singing (Table 1). Therefore, each variable was entered into a hierarchical multiple regression analysis to further clarify their relationship with changes in facial blood flow.

In the first step of the analysis (Model 1 in Table 2), gender was entered as a covariate to control for differences in blushing between women and men. By itself, gender accounted for 8.7% of the variance in facial blood flow during singing, whereas all three predictors (gender, blushing propensity and social interaction anxiety scores) explained 22.1% of the variance in facial blood flow (Model 3 in Table 2). Entering blushing propensity scores in the second step (Model 2A in Table 2) accounted for 4.2% of the variance in facial blood flow ($p < .05$). By contrast, entering social interaction anxiety scores second (Model 2B in Table 2) accounted for virtually all of the variance that questionnaire scores

shared with changes in facial blood flow (13.1% of the shared total of 13.3%, $p < .001$). Together, these analyses indicate that the association between blushing propensity and social interaction anxiety scores almost completely accounted for the relationship between blushing propensity scores and changes in facial blood flow during singing.

Discussion

The main aim of this study was to determine whether social anxiety accounted for any relationship between blushing propensity and physiological signs of blushing during embarrassment. High scores on the Blushing Propensity Scale and the Social Interaction Anxiety Scale were associated with large increases in facial blood flow when participants sang. However, this appeared to be due primarily to social anxiety because the association between blushing propensity scores and changes in facial blood flow disappeared when social interaction anxiety scores were taken into account.

Leary and colleagues proposed that blushing is a response to undesired social attention (Leary, Britt, Cutlip, & Templeton, 1992). Crozier (2004) noted that blushing also develops in situations that involve risk of exposure of private thoughts or information. Together, this suggests that awareness of and self-consciousness about a discrepancy between one's own position or views and those of another may be a primary source of blushing. Self-consciousness based on beliefs about poor performance or negative appraisal by others may also evoke social anxiety. Thus, self-consciousness about singing might explain the association between social interaction anxiety scores and increases in facial blood flow in the present study. Self-consciousness could also account for the secondary association between facial blood flow and blushing propensity, because blushing

propensity scores reflect some aspects of self-consciousness (Leary & Meadows, 1991; Bögels et al., 1996).

In contrast to trait measures of social interaction anxiety and blushing propensity, ratings of blushing and embarrassment when participants sang were unrelated to increases in facial blood flow. The absence of these relationships is unlikely to be due to sample size limitations because the sample was large enough to allow for detection of medium-size effects at a power of 0.8. Moreover, similar findings have been reported previously (Chen & Drummond, 2008). Thus, it appears that people generally base their perception of blushing on cues other than changes in facial blood flow. What these cues might be is unclear but could include facial heat or sweating, symptoms of anxiety, emotions such as embarrassment, fear or shame, expecting to blush in particular situations, or cognitive appraisal of other people's reactions.

Blushing propensity and fear of negative evaluation scores were greater in women than men. In previous studies, blushing propensity scores were found to be greater in female than male Dutch and Portuguese university students (Bögels et al., 1996; Neto, 1996) but were similar in male and female American and British undergraduate students (Leary & Meadows, 1991; Edelman & Skov, 1993), possibly due to cross-cultural differences. In community surveys, social phobia was found to be more prevalent in women than men at a ratio of approximately 3:2 (Furmark, 2002). In support of previous findings (Shearn et al., 1990), women in the present study blushed more intensely than men when they sang. However, this difference was independent of questionnaire scores and ratings of blushing and embarrassment. The basis of the gender difference is uncertain, but possibilities might include differences in emotional response to the

task or differences in the physiological predisposition to blush. Estrogen promotes endothelium-dependent and thermoregulatory vasodilatation (Charkoudian, 2010). Thus, it would be interesting to determine whether blushing to an emotional stimulus varies with the change in estrogen levels across the menstrual cycle.

The strengths of our study include the size and diversity of the sample in terms of its population base (community members as well as university colleagues and undergraduate students). However, it would be interesting to further investigate the relationship between social anxiety, blushing propensity and physiological indices of blushing in clinically-defined groups, as preliminary work suggests that blushing dissipates slowly in people who are frightened of blushing (Drummond et al., 2007) and may be linked with concerns about blushing in people with social anxiety disorder (Voncken & Bögels, 2009). The source of this fear is not completely understood but could involve a conviction that blushing signals a loss of poise, incompetence, inferiority, embarrassment, guilt or shame (Leary et al., 1992), which results in negative appraisal by others (Dijk et al., 2009). People with social phobia generally are hypervigilant toward somatic symptoms of anxiety (Bögels & Mansell, 2004). In the case of blushing, hypervigilance toward somatic symptoms may not only increase anxiety but also provide a stimulus for blushing; if so, this might cause anxiety and blushing to spiral upward.

One of the limitations of our study was the relatively narrow age range of participants (two-thirds of the sample was aged between 17 and 30 years). Thus, it was not possible to establish with any certainty whether questionnaire scores or blushing varied with age. Most people report that blushing decreases in middle

age (Shields et al., 1990), but how accurate these reports are, or whether any change is due to psychological or physiological factors, remains uncertain.

In addition to sampling limitations, generalizations from this study are constrained by task characteristics. Although singing provoked blushing and embarrassment in most participants, tasks such as making a personal disclosure or speaking to someone whom participants wanted to impress might have been more appropriate than singing for investigating correlates of social anxiety. The experiment was administered in private, non-threatening surroundings by a female experimenter (DS). As the gender of the experimenter influences autonomic reactions during mental stress (Larkin, Ciano-Federoff, & Hammel, 1998), it would be interesting to investigate the effect of gender on blushing in socially anxious people.

In conclusion, the present findings suggest that social interaction anxiety predicts changes in facial blood flow during embarrassment more accurately than expected or perceived blushing or the intensity of embarrassment. If this also applies in clinical settings, anxiety management strategies such as applied relaxation, mindfulness exercises, task concentration training, graduated exposure, cognitive re-structuring and social skills training might not only decrease fear of blushing (Bögels, 2006) but could also decrease blushing itself.

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Table 1

Predicting changes in facial blood flow during singing from gender, questionnaire scores and rating changes

Relationship with changes in facial blood flow		
Predictor variables	Correlation	Beta Weight ^b
Gender ^a	0.30**	0.33**
Blushing propensity	0.28**	0.10
Fear of negative evaluation	0.13	-0.09
Social interaction anxiety	0.35***	0.41***
Social phobia	0.09	-0.16
Change in embarrassment rating	0.12	0.09
Change in blushing rating	0.07	-0.04

^aFemales = 1; males = 0.

^b R^2 (full regression model) = 0.252, $p < .001$.

** $p < .01$; *** $p < .001$

Table 2

Hierarchical multiple regression models to predict changes in facial blood flow during singing from gender, blushing propensity scores and social interaction anxiety scores

	Model 1	Model 2A	Model 2B	Model 3
R^2	0.087**	0.129**	0.219***	0.221***
<u>R^2 change</u>				
Model 1 to Model 2A or Model 2B		0.042*	0.131***	
Model 2A or Model 2B to Model 3		0.091**	0.002	
<u>Beta weights in each model</u>				
Gender	0.30**	0.24*	0.31**	0.29**
Blushing propensity		0.21*		0.05
Social interaction anxiety			0.36***	0.34**

^aFemales = 1; males = 0.

* $p < .05$; ** $p < .01$; *** $p < .001$