Eye contact evokes blushing independently of negative affect

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Abstract

To determine whether eye contact elicits blushing due to anxiety, forehead blood flow was measured during a stressful quiz and self-disclosure. The investigator maintained eye contact with 19 participants whereas, in another 40 cases, the investigator and/or participant wore sunglasses or the investigator left the room (the control group). Anxiety, embarrassment and forehead blood flow increased in both groups during the quiz, consistent with anxiety-evoked blushing. However, during self-disclosure, increases in forehead blood flow were greater in the eye contact than control group despite reductions in embarrassment and anxiety. These findings suggest that eye contact augments blushing over and above any influence of anxiety or general scrutiny during self-disclosure.

Keywords: blushing; anxiety; embarrassment; scrutiny; eye contact

Introduction

Blushing usually refers to a reddening of the face as a sign of shyness, embarrassment or shame (Leary et al. 1992), but might more generally be defined as an increase in facial blood flow during heightened states of arousal associated with negative emotional affect. This response forms part of a broad increase in sympathetic activity characterized by increases in heart rate, sweating in the hands and decreases in blood flow through the fingers (Shearn et al. 1990; Drummond 1994; Gerlach et al. 2001; Vassend and Knardahl 2005; Voncken and Bögels 2009) and is mediated, in part, by active sympathetic vasodilatation of blood vessels in the cheeks, forehead and elsewhere in the face (Drummond and Lance 1987; Drummond 1999; Voncken and Bögels 2009; Drummond 2013). Surprisingly, the subjective experience of blushing is often out of step with physiological changes (Mulkens et al. 1997; Drummond 1997; Mulkens et al. 1999; Drummond 2001), suggesting that people typically base their perception of whether or how intensely they are blushing on contextual or emotional factors rather than physiological cues.

Expecting to blush in embarrassing or stressful situations is a common source of anxiety (Gerlach et al. 2001; Bögels et al. 2002; Dijk et al. 2009a; Drummond et al. 2007; Su and Drummond 2012) that, in the extreme, may contribute to social anxiety disorder (Voncken and Bögels 2009). Although typically elicited by undesired social attention (Leary et al. 1992), direct eye contact may also evoke blushing. For example, Chen and Drummond (2008) reported that sweating and physiological signs of blushing increased during prolonged scrutiny, and that prior eye contact with the investigator augmented blushing during subsequent embarrassment. Although eye contact is usually interpreted as a sign of friendliness or intimacy (Kleinke 1986), in certain situations eye contact appears to be a threat cue that elicits signs of

physiological arousal (Emery 2000). As this applies particularly for people with social anxiety disorder (Wieser et al. 2009; Moukheiber et al. 2010; Schneier et al. 2011), the effects of eye contact on blushing may be due, at least in part, to anxiety when eye contact is made.

To investigate this in the present study, effects of eye contact on forehead blood flow (a physiological sign of blushing) and on self-reported ratings of anxiety, embarrassment and blushing were assessed during anxiety-provoking tasks. To induce anxiety, participants completed a stressful quiz and then answered personally-disclosing questions. Parallel increases in negative affect and forehead blood flow when eye contact was made would support the hypothesis that anxiety triggers blushing.

Blushing might also be evoked automatically by scrutiny without any necessity for direct eye contact. In support of this possibility, gazing at one side of the face was found to provoke greater increases in blood flow and facial temperature on that side than on the other, hidden side of the face (Drummond and Mirco 2004). These findings are consistent with the view expressed by Darwin (1872/1965) that "attention closely directed to any part of the body tends to interfere with the ordinary and tonic contraction of the small arteries of that part" (p. 337). To investigate this in the present study, the participant and/or investigator wore dark sunglasses to impede mutual eye contact or, in an additional control condition, the investigator relayed instructions from an adjacent room. We reasoned that if scrutiny triggered blushing directly, blushing would be greater in the presence than the absence of the investigator; in addition, blushing would be greater when the observer's eyes were visible than when they were hidden. On the other hand, if knowing the one was being

scrutinized evoked negative affect which, in turn, triggered blushing, it should not matter whether the observer's eyes were visible or hidden.

Method

Participants

Sixteen male and 43 female undergraduate psychology students aged between 17 and 54 years ($M \pm SD$ 25 ± 9 years) volunteered to participate in the experiment in exchange for course credit. This gender imbalance reflected differences in the proportions of women and men enrolled in the undergraduate psychology program. None of the participants were taking medications that might influence facial blood flow, and all had normal or corrected-to-normal vision. The study protocol was approved by the Murdoch University Human Research Ethics Committee, and each participant provided informed consent for the procedures.

Procedures

Participants were tested individually in an air-conditioned laboratory maintained at 24 ± 1°C. Shortly after they arrived, participants were given five minutes to read several pages of information from an undergraduate psychology textbook on how emotions contribute to heart disease (Ting and Fricchione 2006). This text was chosen as it was relevant to their course of study. They were told that they would later be asked some questions about this material.

To monitor blushing, a photoelectric pulse transducer (Biopac Instruments, Goleta, CA, USA) was attached to the left side of the forehead, 2-3 cm from the midline and 2 cm above the eyebrow. Blood flow was examined at this site because disruptions caused by facial movements during speech generally are smaller and less frequent in the forehead than in other parts of the face. To reduce interference caused by random illumination of the skin around the recording site, a black headband made

of light, flexible fabric was placed over the transducer and stretched slightly to hold it in place.

After the pulse transducer was attached, participants relaxed quietly by themselves in a small sound-attenuated cubicle for five minutes. At the conclusion of this baseline period, participants rated their mood in terms of how anxious and embarrassed they currently felt on a five-point scale (1 = not at all; 2 = a little; 3 = moderately; 4 = quite a bit; 5 = a lot), and also rated how intensely they were blushing on the same scale. They were then assigned to one of the following conditions: neither the investigator (a female psychology graduate student) nor the participant wore sunglasses (15 females and four males); either the investigator or participant, or both, wore sunglasses (22 females and eight males with 2-3 males in each subgroup of 10 participants); or the investigator communicated with the participant from an adjacent room through a two-way intercom system (six females and four males). The sunglasses were dark enough to hide the eyes, but participants were asked to look at the investigator throughout the procedures when the investigator remained in the room. Except for the final control condition, the investigator stayed in the room with the participant throughout the tasks described below. She interacted with participants in a friendly reassuring manner to minimize hostile responses that might otherwise mask embarrassment.

Participants were informed that they would be asked some questions relating to the emotions-heart disease material that they had read earlier, and that they would also be evaluated on their general knowledge of psychology. The investigator then read out ten questions relating to the emotions-heart disease material (e.g., “Name four of the eight heart-mind conspirators”; “What four risk factors increase the chance of a heart attack in hostile people?”; “Define and give one example of acute life

stress"), and gazed at the participant while they answered verbally. This was followed by ten questions that addressed their general knowledge of psychology (e.g., "Name Freud's psychosexual stages"; "What is consciousness?"; "What is the function of the autonomic nervous system?"; "List the five personality traits known as the Big Five"). To heighten anxiety, participants were told that their answer was incorrect after some of the questions regardless of whether their response was correct or incorrect. After the last question was answered, participants rated their mood and blushing again.

To generate anxiety via self-disclosure, the investigator then read out each item of the Fear of Negative Evaluation questionnaire (Watson and Friend 1969), and the participant was asked to verbally rate whether the item was characteristic of them (e.g., "I worry about what people will think of me even when I know it doesn't make a difference" or "I rarely worry about seeming foolish to others"). The investigator also read out each item of the Blushing Propensity Scale (Leary and Meadows 1991) and the participant rated verbally how often he or she blushed (e.g., "When talking to someone about a personal topic" or ""When I've been caught doing something improper or shameful"). Scores on the Blushing Propensity Scale correlate strongly with measures of embarrassment and social concerns (Leary and Meadows 1991). Participants rated their mood and blushing again at the end of this task.

Test length averaged 199 ± 94 seconds ($M \pm SD$) for the quiz and 232 ± 69 seconds for the questionnaires. Participants started answering the questionnaire items straight after finishing the quiz.

Data reduction and statistical approach

Initially, a 3 Hz low-pass filter was used to remove rapid excursions from vascular recordings caused by facial movements while speaking. The mean peak-to-trough height of vascular pulsations was measured during the quiz and questionnaires,

with a greater difference indicating greater vasodilatation (a physiological index of blushing). Pulse amplitude is influenced by the opacity of the skin at the site of measurement, the density and depth of cutaneous vessels, and slight changes in the position and pressure of application of the transducer against the skin. Therefore, changes in pulse amplitude (an index of blood flow) were standardized in relation to the level recorded for 90 seconds while participants rested quietly before the first task.

Changes in blood flow in the four control conditions were investigated in a Group (the four conditions) x Task (quiz versus questionnaires) repeated measures analysis of variance (SPSS version 17), to determine whether the method of interrupting eye contact influenced vascular responses. Similar analyses were carried out for mood and blushing ratings. As no significant differences among the four control conditions were found (Table 1), vascular responses and ratings were examined in Group (eye contact versus combined control group) x Task analyses of variance. Significant interactions were explored in simple effect analyses between the eye contact and combined control group for each task, and changes across tasks were investigated within each group with repeated contrasts. The association between blushing and changes in anxiety or embarrassment during the tasks was investigated with Pearson's correlation coefficient. All tests were two-tailed, and the criterion of statistical significance was $p < .05$.

Results

Increases in forehead blood flow were greater in the eye contact group than in the combined control group during the self-disclosure phase of the experiment [main effect for the intercept (difference between the grand mean and zero), $F(1, 46) = 11.7$, $p = .001$, partial $\eta^2 = .20$; main effect for Group, $F(1, 46) = 4.57$, $p = .038$, partial $\eta^2 =$

.09; Group x Task interaction, $F(1, 46) = 6.28$, $p = .016$, partial $\eta^2 = .12$] (Fig. 1A). These effects persisted when age and sex were entered as covariates.

Ratings of anxiety and perceptions of blushing also differed between the tasks and groups [for anxiety, main effect for Task, $F(2, 56) = 17.3$, $p < .001$, partial $\eta^2 = .38$; Group x Task interaction, $F(2, 56) = 3.86$, $p = .027$, partial $\eta^2 = .12$; for blushing, main effect for Task, $F(2, 56) = 14.5$, $p < .001$, partial $\eta^2 = .34$; Group x Task interaction, $F(2, 56) = 3.31$, $p = .044$, partial $\eta^2 = .11$] (Fig. 1B and 1D). In particular, anxiety increased significantly in the eye contact group but not in the combined control group during the quiz, then decreased in both groups during self-disclosure (Fig. 1B). Perceptions of blushing increased significantly in the combined control group during the quiz and then decreased significantly in both groups during self-disclosure; however, blushing ratings were significantly lower in the eye contact than the combined control group during self-disclosure (Fig. 1D). Ratings of embarrassment showed a similar trend [main effect for Task, $F(2, 56) = 23.0$, $p < .001$, partial $\eta^2 = .45$] (Fig. 1C), but the Group x Task interaction did not achieve statistical significance [Group x Task interaction, $F(2, 56) = 1.76$, $p = .18$, partial $\eta^2 = .06$].

Neither Blushing Propensity nor Fear of Negative Evaluation scores differed between the eye contact and combined control group [$M \pm SD$ for Blushing Propensity 38.2 ± 10.1 in the eye contact group and 37.5 ± 9.2 in the combined control group, $t(57) = .10$, not significant; for Fear of Negative Evaluation 13.6 ± 6.7 in the eye contact group and 13.4 ± 7.5 in the combined control group, $t(57) = .27$, not significant]. In the group as a whole, changes in forehead blood flow were unrelated to Blushing Propensity or Fear of Negative Evaluation scores during the quiz or self-disclosure, but were weakly associated with changes in anxiety, embarrassment and

blushing ratings during the quiz and with embarrassment ratings during self-disclosure (Table 2).

As noted above, forehead blood flow was greater whereas blushing ratings were lower in the eye contact than control group during self-disclosure (Fig. 1); furthermore, changes in forehead blood flow were associated with changes in embarrassment during this task (Table 2). To determine whether embarrassment or perceptions of blushing might mediate the effect of eye contact on forehead blood flow during self-disclosure, these ratings were entered as covariates in analyses of covariance. However, the effect of eye contact on forehead blood flow decreased only slightly after controlling for embarrassment and perceptions of blushing [main effect for Group: without covariates, $F(1, 46) = 6.41$, $p = .015$, partial $\eta^2 = .12$; with embarrassment as a covariate, $F(1, 45) = 5.12$, $p = .029$, partial $\eta^2 = .10$; with blushing ratings as a covariate, $F(1, 45) = 6.51$, $p = .014$, partial $\eta^2 = .13$; with both embarrassment and blushing ratings as covariates, $F(1, 44) = 4.02$, $p = .051$, partial $\eta^2 = .08$].

Discussion

Making eye contact with the investigator augmented forehead blood flow and anxiety, but at different phases of the experiment. In particular, increases in forehead blood flow were greater in the eye contact than control group during a task that aimed but failed to heighten anxiety through self-disclosure, whereas anxiety increased in the eye contact group but not in the control group during a stressful quiz. The facilitatory effect of eye contact on forehead blood flow during self-disclosure was similar to that reported previously (Chen and Drummond 2008), and was independent of embarrassment or perceptions of blushing. Together, these findings suggest that

negative affect is not essential for the facilitatory effect of eye contact on blushing, at least under conditions of self-disclosure.

Making eye contact with the investigator increased anxiety during a stressful quiz whereas anxiety did not change in control groups subjected to general scrutiny. Nevertheless, increases in forehead blood flow were similar in the eye contact and control groups during this phase of the study. Eye contact may have augmented anxiety by heightening concerns about blushing or negative evaluation, as there was a weak association between increases in anxiety during the quiz and scores on the fear of negative evaluation and blushing propensity scales. Increases in forehead blood flow during the quiz were associated with increases in anxiety, embarrassment and perceptions of blushing. Thus, blushing may have been driven, at least in part, by sympathetic arousal associated with negative affect (Shearn et al. 1990; Drummond and Su 2012; Drummond 2013). Even with effects on anxiety, eye contact had little additional influence on blushing under these conditions.

Perceptions of blushing decreased in the eye contact group during the self-disclosure phase of the study, despite elevated levels of forehead blood flow. In general, people with or without social anxiety disorder appear to base their perception of blushing and other symptoms of anxiety more strongly on emotional experiences than on physiological cues (Drummond 1997; Mulkens et al. 1997; Mulkens et al. 1999; Gerlach et al. 2001; Drummond 2001; Dijk et al. 2009b; Edelmann and Baker 2002; Mauss et al. 2004), and this was borne out in the present study (Table 2). This dissociation between subjective experiences and physiological activity presents challenges for theoretical views of emotion that posit a tight coupling between experiential, physiological and behavioural response systems. However, as people apparently have only a limited awareness of autonomic activity, the findings support

the use of cognitive therapy to help alleviate concerns about autonomic symptoms such as blushing (Bögels 2006).

The decrease in anxiety and embarrassment during self-disclosure suggests that participants did not think that they were being judged negatively by the investigator during this task. Furthermore, eye contact might have communicated nonverbal cues of reassurance rather than threat because perceptions of blushing decreased in the eye contact group despite elevated forehead blood flow. Both in humans and non-human primates, downcast eyes may initially deter aggression by signaling submission and appeasement (Kleinke 1986; Leary et al. 1992; Emery 2000); secondary appeasement signals such as blushing might then encourage affiliation rather than hostility when eye contact is made (Kleinke 1986). Dijk et al. (2009a) reported that characters in a vignette study who displayed a blush were judged more positively after a social transgression or mishap than characters who did not blush. Similarly, facial expressions of shame or embarrassment had a positive influence on observers' judgments. That is, blushing may have remedial value in situations that elicit shame or embarrassment. It would be interesting to determine whether blushing initiates cues of reassurance (e.g., a friendly smile or supportive tone of voice) during dyadic interactions, and whether eye contact evokes affiliative responses from others in the presence of blushing.

We did not find differences in blushing between experimental conditions where the investigator or participant wore sunglasses, or where the investigator conducted the experiment from another room. Thus, being observed seemed less important for blushing than making unimpeded eye contact. These findings do not endorse Darwin's view (1872/1965) that attention directed closely to any part of the body releases tonic vasoconstriction in that part. Nevertheless, there is some support

for Darwin's proposal as hypnotic suggestions that focus attention on one forearm over the other can evoke asymmetric changes in forearm blood flow (Zachariae et al. 1994); moreover, staring at one side of the face increases blood flow on that side (Drummond and Mirco 2004). However, the present findings suggest that making direct eye contact overshadows any additional effect of more general scrutiny on blushing.

An important limitation of this study was the relatively small number of males in our sample. Larkin, Ciano-Federoff and Hammel (1998) reported that the gender of a confederate observer influenced cardiovascular responses to mental stress in college men. Moreover, women often respond to provocation with embarrassment or distress whereas men typically respond with anger (Frost and Averill 1982). Thus, it would be interesting to compare blushing and other facets of emotional response in same- versus mixed-gender dyads during threatening and non-threatening interactions, to determine whether the gender composition moderates autonomic components of emotional responses.

An additional limitation is that participants were undergraduate psychology students whose anxiety may have been partly allayed by familiarity with the university setting and the constructs being investigated, and by expectations about participating in a psychology experiment. Thus, it is important to investigate effects of eye contact on blushing in additional target groups within the general population (e.g., those with social anxiety or other characteristics that might make eye contact aversive). Furthermore, eye contact was inferred, not measured, and a fixed task order was employed. Although the fixed order eliminated a potential source of variation, carry-over effects from the stressful quiz might have influenced blushing or subjective experiences during the questionnaire phase. Hence, it would be important in future

studies to monitor the direction of eye gaze, and to determine whether blushing has to be underway for effects of eye contact to be expressed during tasks that require an element of self-disclosure.

Despite these limitations, it is clear that effects of eye contact on forehead blood flow during self-disclosure were independent of negative affect or nonspecific scrutiny. Thus, it is tempting to speculate that eye contact automatically triggers increases in physiological arousal and blushing during self-disclosure. In particular, blushing might signify recognition of eye contact whereas other nonverbal signals (e.g., facial expression, return of gaze or posture) denote response intention (e.g., aggression or appeasement).

In summary, our findings suggest that blushing during threatening evaluative situations is driven primarily by negative affect. However, during self-disclosure, eye contact appears to trigger increases in forehead blood flow independently of negative affect. Unfortunately, concern about displaying a blush or other symptoms of physiological arousal may establish an escalating cycle of social discomfort and blushing in people troubled by this response (Dijk et al. 2009b). Although this cycle might be alleviated by an averted gaze, an accompanying loss of status or poise could reinforce social anxiety. If so, learning how to maintain eye contact despite blushing may provide therapeutic benefits for people who are frightened of blushing.

Conflict of interest statement

The authors declare that they have no conflict of interest.

References

Bögels, S. M. (2006). Task concentration training versus applied relaxation, in combination with cognitive therapy, for social phobia patients with fear of blushing, trembling, and sweating. *Behaviour Research and Therapy, 44,* 1199-1210.

Bogels, S. M., Rijsemus, W., & de Jong, P. J. (2002). Self-focused attention and social anxiety: the effects of experimentally heightened self-awareness on fear, blushing, cognitions, and social skills. *Cognitive Therapy and Research, 26,* 461-472.

Chen, V., & Drummond, P. D. (2008). Fear of negative evaluation augments negative affect and somatic symptoms in social-evaluative situations. *Cognition and Emotion,* 22, 21-43.

Darwin, C. (1872/1965). The expression of the emotions in man and animals. Chicago: University of Chicago Press.

Dijk, C., de Jong, P. J., & Peters, M. L. (2009a). The remedial value of blushing in the context of transgressions and mishaps. *Emotion, 9,* 287-91.

Dijk, C., Voncken, M. J., & de Jong, P. J. (2009b). I blush, therefore I will be judged negatively: influence of false blush feedback on anticipated others' judgments and facial coloration in high and low blushing-fearfuls. *Behaviour Research and Therapy, 47,* 541-7.

Drummond, P.D. (1994). The effect of anger and pleasure on facial blood flow. *Australian Journal of Psychology 46,* 95-99.

Drummond, P. D. (1997). The effect of adrenergic blockade on blushing and facial flushing. *Psychophysiology, 34,* 163-168.

Drummond, P.D. (1999). Facial flushing during provocation in women.

Psychophysiology, 36, 325-32.

Drummond, P. D. (2001). The effect of true and false feedback on blushing in women. *Personality and Individual Differences, 30,* 1329-1343.

Drummond, P. D. (2013). Psychophysiology of the blush. In W. Ray Crozier and Peter J. de Jong (Eds), The Psychological Significance of the Blush (pp. 15-38). Cambridge University Press.

Drummond, P.D., Back, K., Harrison, J., Helgadottir, F.D., Lange, B., Lee, C., Leavy, K., Novatscou, C., Orner, A., Pham, H., Prance, J., Radford, D., & Wheatley, L. (2007). Blushing during social interactions in people with a fear of blushing. *Behaviour Research and Therapy, 45,* 1601-1608.

Drummond, P. D., & Lance, J. W. (1987). Facial flushing and sweating mediated by the sympathetic nervous system. *Brain, 110 (Pt 3),* 793-803.

Drummond, P. D., & Mirco, N. (2004). Staring at one side of the face increases blood flow on that side of the face. *Psychophysiology, 41,* 281-287.

Drummond, P.D., & Su, D. (2012). The relationship between blushing propensity, social anxiety and facial blood flow during embarrassment. *Cognition and Emotion, 26,* 561-567.

Edelmann, R. J., & Baker, S. R. (2002). Self-reported and actual physiological responses in social phobia. *British Journal of Clinical Psychology, 41(Pt 1),* 1-14.

Emery, N.J. (2000). The eyes have it: the neuroethology, function and evolution of social gaze. *Neuroscience and Biobehavioral Reviews, 24,* 581-604.

Frost, W. D., & Averill, J. R. (1982). Differences between men and women in the everyday experience of anger. In J. R. Averill (Ed.), Anger and aggression; an essay on emotion (pp. 281–316). New York: Springer-Verlag.

Gerlach, A. L., Wilhelm, F. H., Gruber, K., & Roth, W. T. (2001). Blushing and

physiological arousability in social phobia. *Journal of Abnormal Psychology, 110,* 247-258.

Kleinke, C. L. (1986). Gaze and eye contact: a research review. *Psychological Bulletin, 100,* 78-100.

Larkin, K. T., Ciano-Federoff, L. M., & Hammel, D. (1998). Effects of gender of observer and fear of negative evaluation on cardiovascular reactivity to mental stress in college men. *International Journal of Psychophysiology, 29,* 311-318.

Leary, M. R., Britt, T. W., Cutlip, W. D., 2nd, & Templeton, J. L. (1992). Social blushing. *Psychological Bulletin, 112,* 446-460.

Leary, M. R., & Meadows, S. (1991). Predictors, Elicitors, and Concomitants of Social Blushing. *Journal of Personality and Social Psychology, 60,* 254-262.

Mauss, I. B., Wilhelm, F. H., & Gross, J. J. (2004). Is there less to social anxiety than meets the eye? Emotion experience, expression, and bodily responding. *Cognition and Emotion, 18,* 631-662.

Moukheiber, A., Rautureau, G., Perez-Diaz, F., Soussignan, R., Dubal, S., Jouvent, R., & Pelissolo, A. (2010). Gaze avoidance in social phobia: objective measure and correlates. *Behavour Research and Therapy, 48,* 147-151.

Mulkens, S., de Jong, P. J., & Bögels, S. M. (1997). High blushing propensity: Fearful preoccupation or facial coloration? *Personality and Individual Differences, 22,* 817-824.

Mulkens, S., de Jong, P. J., Dobbelaar, A., & Bogels, S. M. (1999). Fear of blushing: fearful preoccupation irrespective of facial coloration. *Behaviour Research and Therapy, 37,* 1119-1128.

Schneier, F.R., Rodebaugh, T.L., Blanco, C., Lewin, H., & Liebowitz, M.R. (2011). Fear and avoidance of eye contact in social anxiety disorder. *Comprehensive*

Psychiatry, 52, 81-87.

Shearn, D., Bergman, E., Hill, K., Abel, A., & Hinds, L. (1990). Facial coloration and temperature responses in blushing. *Psychophysiology, 27,* 687-93.

Su, D., & Drummond, P.D. (2012). Blushing propensity and psychological distress in people with rosacea. *Clinical Psychology & Psychotherapy, 19,* 488-495.

Ting, W., & Fricchione, G. (2006). The heart-mind connection: how emotions contribute to heart disease and what to do about it. New York: McGraw-Hill.

Vassend, O., & Knardahl, S. (2005). Personality, affective response, and facial blood flow during brief cognitive tasks. *International Journal of Psychophysiology, 55,* 265-78.

Voncken, M. J., & Bögels, S. M. (2009). Physiological blushing in social anxiety disorder patients with and without blushing complaints: two subtypes? *Biological Psychology, 81,* 86-94.

Watson, D., & Friend, R. (1969). Measurement of social-evaluative anxiety. *Journal of Consulting and Clinical Psychology, 33,* 448-457.

Wieser, M.J., Pauli, P., Alpers, G.W., & Muhlberger, A. (2009). Is eye to eye contact really threatening and avoided in social anxiety?—An eye-tracking and psychophysiology study. *Journal of Anxiety Disorders, 23,* 93-103.

Zachariae, R., Oster, H., & Bjerring, P. (1994). Effects of hypnotic suggestions on ultraviolet B radiation-induced erythema and skin blood flow. *Photodermatology, Photoimmunology and Photomedicine, 10,* 154–160.

Table 1 Changes in forehead blood flow and self-report scores during the quiz and self-disclosure in each of the control conditions (N = 10 in each condition)

		M ± *SD*	
	Baseline	Quiz	Self-disclosure
Forehead blood flow (% change)			
Participant wears sunglasses	-	8.3 ± 24.7	7.4 ± 38.8
Investigator wears sunglasses	-	7.8 ± 13.6	-.1 ± 28.6
Both wear sunglasses	-	28.1 ± 37.2	6.4 ± 28.9
Investigator in adjacent room	-	17.6 ± 36.4	6.6 ± 19.0
Anxiety (0-10)			
Participant wears sunglasses	2.0 ± 1.0	2.8 ± 1.0	2.4 ± .7
Investigator wears sunglasses	2.2 ± .6	2.0 ± .7	1.8 ± .6
Both wear sunglasses	2.1 ± .9	2.5 ± 1.0	2.2 ± 1.0
Investigator in adjacent room	2.3 ± .8	2.5 ± 1.3	1.7 ± .8
Embarrassment (0-10)			
Participant wears sunglasses	2.0 ± .8	2.7 ± 1.3	2.1 ± 1.2
Investigator wears sunglasses	2.1 ± 1.2	2.0 ± .9	1.4 ± .5
Both wear sunglasses	1.4 ± .8	1.9 ± .7	1.4 ± .7
Investigator in adjacent room	1.9 ± .9	2.9 ± 1.2	1.7 ± .8
Perception of blushing (0-10)			
Participant wears sunglasses	1.3 ± .9	2.3 ± 1.1	2.2 ± 1.0
Investigator wears sunglasses	2.1 ± 1.0	2.8 ± 2.1	2.2 ± 2.2
Both wear sunglasses	1.1 ± .3	1.8 ± .9	1.4 ± .5
Investigator in adjacent room	2.0 ± 1.2	2.8 ± 1.6	1.8 ± .9

Table 2 Correlation between changes in forehead blood flow and self-report variables during the quiz and self-disclosure in the group as a whole (N = 59)

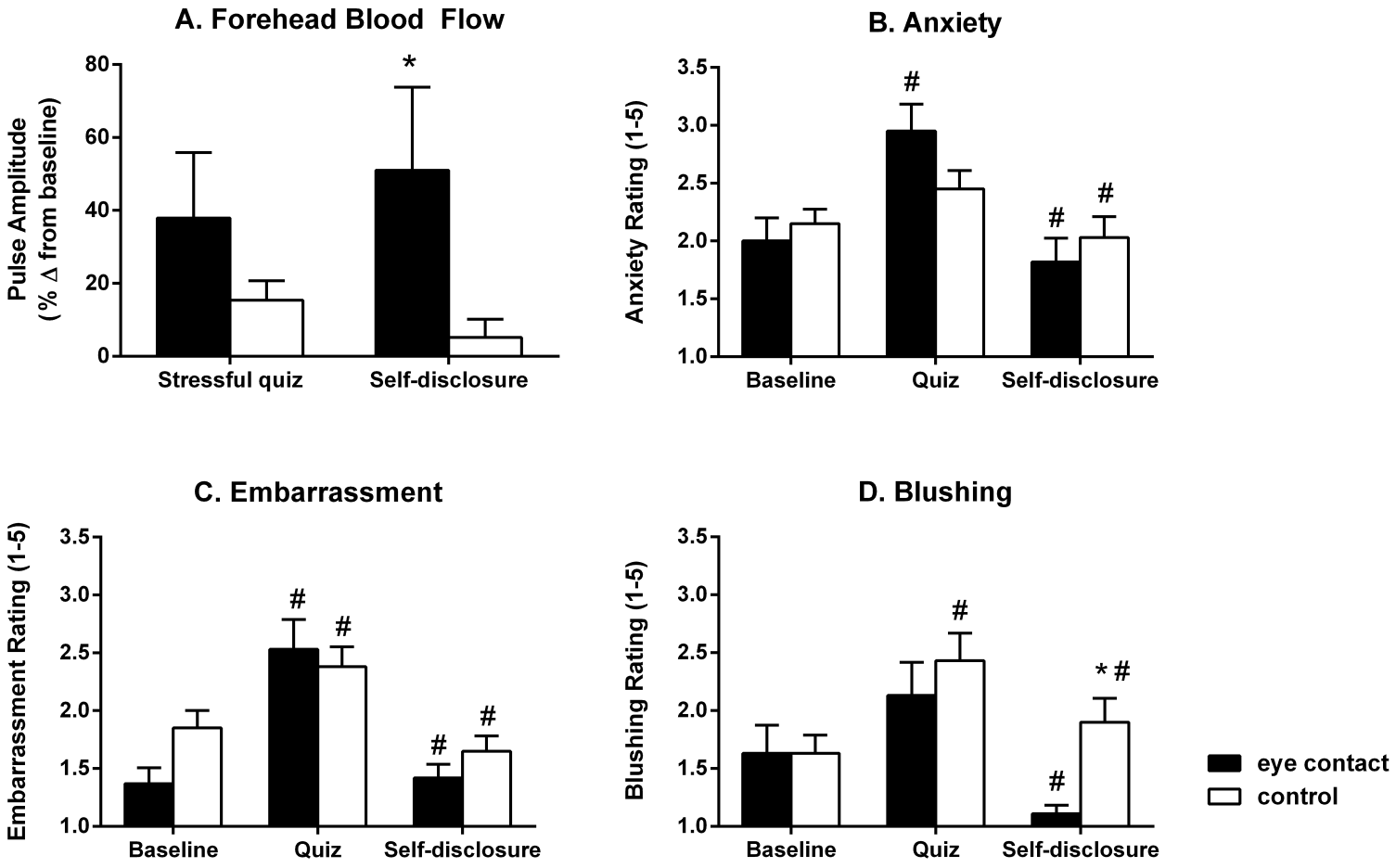
		Change from Baseline in:		
	Forehead Blood Flow[a]	Anxiety Ratings	Embarrassment Ratings	Blushing Ratings
Quiz				
Blushing Propensity	.16	.36**	.31*	.23
Fear of Negative Evaluation	.24	.29*	.02	-.07
Forehead Blood Flow	-	.31*	.30*	.32*
Anxiety Ratings		-	.53***	.38**
Embarrassment Ratings			-	.68***
Self-Disclosure				
Blushing Propensity	.20	.13	.09	-.03
Fear of Negative Evaluation	.20	.18	-.14	-.25
Forehead Blood Flow	-	.02	.30*	-.04
Anxiety Ratings		-	.34**	.34**
Embarrassment Ratings			-	.45***

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

[a]Forehead blood flow could not be measured in 11 participants due to excessive movement artifact.

Figure legend

Fig. 1 Mean (± *SE*) change in forehead blood flow and ratings in the eye contact and combined control groups during the quiz and self-disclosure. * indicates where differences between the eye contact and combined control group were statistically significant in simple effect analyses ($p < .05$). # indicates where differences in ratings between baseline and the quiz, or between the quiz and self-disclosure, were statistically significant ($p < .05$).


A. Forehead Blood Flow
Pulse Amplitude
(% Δ from baseline)
80
60
40
20
0
*
Stressful quiz
Self-disclosure
B. Anxiety
Anxiety Rating (1-5)
3.5
3.0
2.5
2.0
1.5
1.0
#
#
#
Baseline
Quiz
Self-disclosure
C. Embarrassment
Embarrassment Rating (1-5)
3.5
3.0
2.5
2.0
1.5
1.0
#
#
#
#
Baseline
Quiz
Self-disclosure
D. Blushing
Blushing Rating (1-5)
3.5
3.0
2.5
2.0
1.5
1.0
#
#
*#
Baseline
Quiz
Self-disclosure
eye contact
control