PSYCHOPHYSIOLOGY
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Vol. 29, No. 4
Printed in U.S.A.

Blushing as a Function of Audience Size

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ABSTRACT

Almost no experimental analysis of blushing has been done since Darwin's observations in 1872. Forty-eight college women watched a videotape intended to elicit blushing, and a videotape not intended to elicit blushing, but elicit physiological responses. A subject was alone, or with one or four persons present. Blushing, which was measured directly with a photoplethysmograph probe on the cheek, was greater during the blushing than nonblushing stimulation. Blushing increased as audience size increased from one to four, but not from zero to one. Audience size and kind of stimulation interacted statistically. Similar results were obtained with ear coloration, cheek temperature, and skin conductance responses, although confidence levels were lower. Cheek coloration and temperature were significantly correlated during nonblushing stimulation, and the zero and one audience conditions, but not during the four audience condition, when blushing was greatest. These results may be placed within the context of emotional effects of audience size generally, including stuttering and speech disturbance, disruption of learning, and self-reported tension.

DESCRIPTORS: Blushing, Photoplethysmograph, Audience size, Skin temperature, Skin conductance response.

Over a century ago Charles Darwin (1872) asked, "How it has arisen that the consciousness that others are attending to our personal appearance should have led to the capillaries, especially those of the face, instantly becoming filled with blood" (p. 326). Darwin observed that facial reddening may be accompanied by various body movements, such as turning the face or the whole body away, and averting the eyes, which were ascribed to a sense of shame and a strong desire for concealment, and said that, "Blushing is the most peculiar and the most human of all expressions" (p. 309).

Blushing is an involuntary reflex elicited by social stimuli. According to Darwin (1872), blushing is not only involuntary, but if we wish to restrain it, we may call attention to ourselves and actually increase it. As an involuntary reflex seen by others, blushing "leaks" an emotional condition of the individual who may routinely mask other emotions with voluntary facial expressions such as smiling. Ekman (1985) discusses involuntary "leaks" by the facial striate musculature, which sometimes take the form of "micro expressions" lasting less than one-quarter of a second, and often requiring trained observers, replaying videotapes, to spot them. Unlike the striate musculature "leak," the blush may last several seconds and can be detected easily by anyone in the vicinity. How much one could learn to produce and inhibit one's own blushing to prevent "leaks" of one's emotional state is an open question falling under the rubric of the control of involuntary reflexes (Katkin & Murray, 1968; Shearn, 1972).

Given that blushing is a sign of embarrassment, we naturally ask questions about its purpose. As Buss (1980) put it, "What social need is satisfied by having others become aware of your embarrassment?" (p. 133). Edelmann (1987, p. 71), in an extensive analysis of embarrassment, asked whether blushing serves any function other than to decrease body temperature. He suggested that one uses one's own expressive behavior and physiological responses to perceive and label one's embarrassment (Edelmann, 1985). We do detect our own temperature increases readily when embarrassed, according to self reports (Edelmann, 1987, p. 69), yet the physiological event most clearly associated with the perception of our blushing by others is an increase in cheek coloration, as shown in experimentally induced blushing (Shearn, Bergman, Hill, Abel, & Hinds, 1990). The temperature rise occurs many seconds after cheek reddening. In short, the perception of our own blushing, based on temperature, may occur some time after it is seen by others. But questions remain about the utility of publicizing one's shame, disgrace, or breech of pri-

Supported by a Faculty Development Grant of The Colorado College.

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vacy with blazing facial coloration and conspicuous body movements. From the standpoint of impression management (Baumeister, 1982), where one's composure and self-control are foremost considerations, such noticeable involuntary displays are small catastrophes. One might think that the detection of one's own embarrassment could better be served by a direct, but surreptitious neural pathway within the brain, rather than such a circuitous and public route. These questions remind us of the long-standing debate about the origins of the emotions from the positions of the James-Lange and Cannon-Bard theories, which contrasted peripheral autonomic and central nervous system involvement (Cannon, 1927; Lange & James, 1922). Our conjecture about the evolutionary basis of blushing is that blushing communicates humility, just as the wolf's bared throat communicates submissiveness.

The eliciting stimulation for blushing is social in nature. In contrast, flushing is simply reddening of the face when the evoking state is not necessarily social or even psychological in nature, as in flushing induced by temperature or chemical means (Drummond & Lance, 1987; Wilkin et al., 1982). Reddening of the face may also be seen in anger or in exercise. Therefore, as is true of many psychological terms, blushing refers to both the conditions of stimulation and the nature of the behavior. Perhaps we might be able to specify the various stimulating conditions, and attendant autonomic and muscular behaviors associated with reddening of the face, downplaying traditional mentalistic constructs (Davis, Buchwald, & Frankmann, 1955).

Because the blushing reflex is social in nature we exploited one dimension of social stimulation, the size of an audience present during the time stimulation intended to evoke blushing was presented to a subject. We, therefore, examine briefly some related findings about the effect of an audience on performance and emotional behavior.

Martens (1969) found that an audience interfered with learning, but enhanced subsequent performance. He used palmar sweating as a direct measure of "arousal" and found that it too increased with an audience present. Audience size has been shown to interact with anxiety level, as measured by a questionnaire, when heart rate was the dependent variable (McKinney, Gatchel, & Paulus, 1983). Electromyographic activity recorded as a story was presented was greater with an audience than without, whether the audience was seen or concealed (Chapman, 1974). Similarly, stuttering was greater when the stutterer read aloud to an unseen audience, as compared with reading alone, but differed little from stuttering while reading directly to a visible listener (Hahn, 1940). Stuttering increased with audience size (Mullen, 1986; Porter, 1939), as did the frequency, amplitude, and duration of laughter generated by a humorous film (Butcher & Whissell, 1984). Subjective tension during imagined performance in the presence of pictures of various audiences was analyzed psychophysically, and was found to be a multiplicative power function of audience size and status (Latane & Harkins, 1976; Jackson & Latane, 1981). Recently it has been reported that a series of orienting tones presented to subjects who were told that they were being observed elicited skin conductance, heart rate, and electromyographic responses that were different from those exhibited by subjects who were told that they were not being observed, although baselines of the two groups were not different (Cacioppo, Rourke, Marshall-Goodell, Tassinary, & Baron, 1990).

In view of the general emotional effects of audience size on performance and emotional behavior, we speculated that blushing induced experimentally would increase as the size of an audience increased.

Method

Subjects and Design

Forty-eight undergraduate women, solicited in various classes, were paid to participate in the two-day study. No attempt was made to screen blushers from nonblushers. Women were used rather than men or a mixed group because earlier results suggested that some gender differences in blushing may exist (Shearn et al., 1990). The subjects were randomly assigned to one of three treatment groups of 16 each. The groups were defined by audience size: four persons present, one person present, or no persons present. The design consisted of a between-subjects variable—audience size—with three levels, and a within-subjects variable—stimulation—with two levels, stimulation intended to evoke blushing and stimulation intended to arouse, but not produce blushing. The dependent variables were cheek temperature, cheek coloration, ear coloration, and finger skin conductance.

Apparatus

Cheek temperature, cheek and ear coloration, and finger skin conductance responses were recorded using a Grass model 7 polygraph, YSI temperature probe, UFI photophlethysmograph probes, and 1-cm Ag/AgCl electrodes with paste of 0.05 M NaCl and Unibase. A video camera monitored the subject. Recording equipment was located in an adjacent room. A color video camera, recorder, and video editors were used to make stimulus materials. Details of these arrangements may be found elsewhere (Shearn et al., 1990).

Procedure

On Day 1 of the experiment, the subject stood in front of the experimenter and the video camera and sang the Star Spangled Banner. Words for the anthem were posted in front of the subject. The subject was asked to use generous arm movements while the recording was made.

On Day 2, the subject sat in front of a television set and adjusted a chin rest until it was comfortable. Either four experimenter confederates, two females and two males, or one experimenter confederate, half the sessions a female and half the sessions a male, served as the audience. They sat to the side, between the subject and the television set such that the subject could see their faces without head movement. In the zero audience condition the subject sat in the room alone. A temperature probe was attached to the left cheek, photoelectric probes to measure reddening to the left cheek and ear lobe, and skin resistance electrodes to the first digit of the index and middle fingers of the left hand of the subject. The subject was told that these probes would record physiological responses, and would not cause pain. A video camera monitor, and a second video recorder, which presented prerecorded material on the television set, were turned on, and the subject was instructed to watch the television set. No instructions were given to the subject about controlling or changing responses as the tape was played.

Stimulation

The stimulation intended to produce blushing was the subject's own prerecorded singing presented on the television set. In face-saving experiments singing has been used to induce embarrassment (Brown & Garland, 1971; Garland & Brown, 1972). When the prerecorded singing was presented, members of the audience smiled as they watched the television set. The stimulation intended to arouse, but not produce blushing, was the shower murder scene from Alfred Hitchcock's movie, *Psycho*. Prerecorded videotapes followed this sequence: 5 min of neutral baseline material (videotape of a steady brick wall), 1 min of one kind of stimulation, 5 min of neutral baseline material, 1 min of the other kind of stimulation, and finally, 5 min of neutral baseline material. The order of presentation of the two kinds of stimulation was counterbalanced over the three audience conditions.

Measurement

Polygraph records for cheek and ear photoelectric color probes, cheek temperature, and finger skin resistance responses were analyzed by subtracting a prestimulus value 5 s before stimulation onset from the point of greatest change for 3 min after stimulation onset. Each skin resistance value was converted to a skin conductance value before subtractions were made, to obtain skin conductance responses.

Results

Figure 1 shows the various response means as a function of audience size during stimulation intended to evoke blushing (singing) and stimulation intended to arouse, but not evoke blushing (movie). Statistically significant audience size effects were obtained for cheek coloration ($F(2,45)=3.37$, $p<.05$) and finger skin conductance responses ($F(2,45)=3.17$, $p<.05$), but not for ear coloration or temperature responses. All physiologic measures were reliably larger during the stimulation intended to evoke blushing, as compared with stimulation

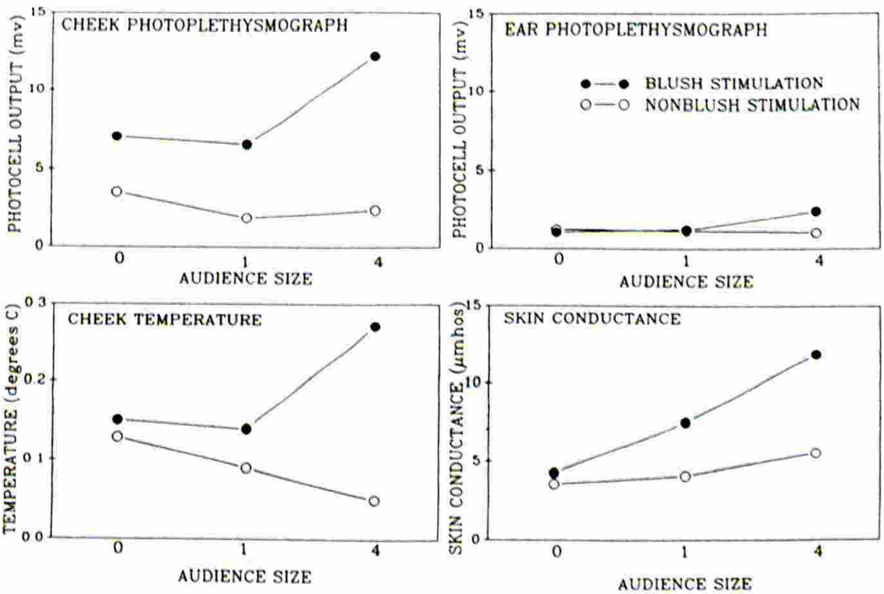

Figure 1. Mean responses for the four physiologic measures for the two kinds of stimulation as a function of audience size.

intended to arouse, but not evoke blushing: cheek coloration, $F(1,45)=83.11$, $p<.00001$; ear coloration, $F(1,45)=6.41$, $p<.01$; cheek temperature, $F(1,45)=12.87$, $p<.0001$; and skin conductance response, $F(1,45)=16.51$, $p<.0002$. Statistically significant interactions between audience size and kind of stimulation appeared for all measures: cheek coloration, $F(2,45)=9.00$, $p<.0005$; ear coloration, $F(2,45)=8.19$, $p<.001$; cheek temperature, $F(2,45)=5.81$, $p<.006$; and skin conductance response, $F(2,45)=3.57$, $p<.04$.

Cheek coloration for the combined audience groups during blush stimulation was considerably greater than ear coloration ($\overline{X}=8.58$ mV vs. 1.53 mV; $t(47)=10.60$, $p<.00001$).

We looked at the zero audience group's cheek coloration during stimulation intended to evoke blushing, and stimulation intended to arouse, but not produce blushing, to see if blushing occurred in those subjects sitting alone. It did. Blush stimulation evoked about twice as much cheek coloration ($\overline{X}=7.03$) as did nonblush stimulation ($\overline{X}=3.58$), $t(15)=4.56$, $p<.0005$.

Correlations between cheek coloration and cheek temperature responses, presumably affected by the same underlying event, skin blood volume, were examined at times when blushing was minimal, that is, during nonblush stimulation for combined groups and during blush stimulation in the zero and one audience size groups, and when blushing was maximal, that is, during blush stimulation in the four audience size group. When blushing was minimal, cheek coloration and temperature responses were correlated (during nonblush stimulation, $r=.54$, $p<.0001$; in zero or one size audiences, $r=.54$, $p<.002$). When blushing was maximal during blush stimulation with the four-person audience present, cheek coloration and cheek temperature responses were poorly correlated ($r=.27$). Skin conductance responses elicited by the blush stimulation were correlated with those elicited by nonblush stimulation ($r=.69$, $p<.005$), as were cheek temperature responses ($r=.51$, $p<.05$). Cheek coloration responses elicited by blush stimulation were not, however, correlated with those elicited by nonblush stimulation ($r=.25$), nor were ear coloration responses ($r=.16$).

Stimulus order effects were observed only during nonblush stimulation. Cheek temperature and ear coloration responses were greater then for subjects when they received nonblush stimulation first ($t(46)=3.01$, $p<.004$, and $t(46)=4.17$, $p<.0001$, respectively).

Discussion

The size of the blushing response does increase as the size of the audience increases from one to four persons, but not from zero to one person, according to the cheek coloration data of this study. Statistical interactions between audience size and the blushing or nonblushing stimulation in all response measures further strengthen this conclusion. Would the size of the blushing response increase steadily with increasing audience size? We think not, and would guess that the vasodilation underlying blushing would follow some sort of power function of audience size (Jackson & Latane, 1981; Latane & Harkins, 1976), until it gave way altogether to stage fright and blanching (vasoconstriction) in the presence of very large audiences.

Our data on the effects of audience size may be interpreted in at least two ways. First, there is the straightforward version that the size of the audience affects the subject directly, that is, the subject sees a smaller or larger audience and blushes accordingly. Second, there is a more circuitous version in which the size of the audience affects members of the *audience* directly, such that members of the four-person audience smiled more than members of the one-person audience, and that this difference in audience behavior produced differences in the amount of blushing. Our results do not allow us to favor one interpretation over the other.

That people blush when they are alone was acknowledged by Darwin in his chapter on blushing (Darwin, 1872). He says, "But when a blush is excited in solitude, the cause almost always relates to the thoughts of others about us" (p. 335). Clearly, the solitary subjects in our experiment gave facial coloration responses in the presence of stimuli intended to induce blushing that were considerably larger than those in the presence of stimulation intended to arouse, but not induce blushing. However, the issue of whether people blush alone was not resolved in our investigation, and may never be in an experiment in which the contrivances of recording apparatus, probes, video monitors, and nearby observers are known to the solitary subject. Fridlund (1989) observed that subjects who believed that a nearby unseen friend was watching the same amusing videotape smiled as much as if the friend was actually present, and more than if they believed they were alone, or that the friend was performing an irrelevant task. The effects of an unseen audience on stuttering (Hahn, 1940), skin conductance, heart rate, and electromyographic responses elicited by tones (Cacioppo et al., 1990), and electromyographic activity during story telling (Chapman, 1974) have already been noted.

Darwin (1872) reports that blushing commonly starts at the cheeks, spreading then to the ears and neck. The results of this experiment show that blushing of the cheeks is more than five times greater than the ears. Our data, of course, do not give an overall picture of the blushing topography or, indeed, a picture of vasomotor activity across the entire body surface, where vasoconstriction may appear in contrast to the vasodilation of the cheek and ear. For example, we do not know yet what vasomotor changes might occur in the finger as blushing stimulation is presented. The underlying anatomy and physiology of the blush reflex are sketchy, and the reader is invited to read elsewhere for hints (Drummond & Lance, 1987; Gelderman, 1985; Mellander, Andersson, Afzelius, & Hellstrand, 1982; Shearn et al., 1990).

Cheek coloration and cheek temperature responses were correlated when blushing was minimal or nonexistent, and uncorrelated when blushing was maximal, a finding that replicates earlier results (Shearn et al., 1990). Although it might seem reasonable that skin vascular and temperature changes would go hand-in-hand, we know that they do not always do so. For example, Bengtsson, Nilsson, and Löfström (1983) found that intrasubject changes in skin blood flow brought on by spinal analgesia were uncorrelated with skin temperature.

Cheek temperature and ear coloration responses were larger during nonblush stimulation when it was given first as compared with second in the stimulation sequence. We believe that larger cheek temperature values were obtained during the earlier part of the session because cheek temperature had not yet stabilized, and was increasing, making measures of response increases likely. When subjects received nonblush stimulation in the later part of the session, cheek temperature was more stable, giving measures of little or no change. These stimulus order effects in cheek temperature replicate earlier findings (Shearn et al., 1990), and remind us that drift is a formidable problem in skin temperature measurement (Yates, 1980). We have no suggestion to explain why ear coloration responses were larger during nonblush stimulation that was presented first rather than second as drift was not seen in this measure.

Our results replicate initial findings that blushing, measured by photoelectric colometry and thermometry of the face, can be induced in the laboratory using appropriate stimulation, and that facial coloration and temperature, which are correlated during minimal or undetected blushing, become uncorrelated during blushing. They show further that the amount of blushing increases when the size of the audience increases from one to four persons, and that blushing can occur when one is alone, but the meaning of "alone" resides in an experimental context.

Although Darwin (1872) devoted an entire chapter to blushing, Ekman and Oster (1979), a century later, reported in their review of the facial expression literature that, "Blood flow, skin temperature, and coloration changes in the face are measures that so far remain unexplored" (p. 540). Since that review we have seen renewed interest in facial vascular psychophysiology, in particular the rejuvenation of Waynbaum's theory of emotional efference (1907) by Zajonc (1985; Zajonc, Murphy, & Inglehart, 1989). Waynbaum's theory, in which the facial muscles act as ligatures that close off blood vessels emptying into the brain, thereby changing brain temperature and function, is a prophetic attempt to account for what is known today as the facial feedback hypothesis, a view that certain facial movements induce certain emotional states (Colby, Lanzetta, & Kleck, 1977; Ekman, Levenson, & Friesen, 1983; Izard, 1977; Levenson, Ekman, & Friesen, 1990; Matsumoto, 1987; Tomkins, 1962). Zajonc et al. (1989) argue that surfaces of the head and face are good indicators of the thermal status of the brain, a point made by Darwin (1872, p. 323) in accounting for the "confusion of mind" during intense blushing.

The present study supplements the social psychophysiology literature (Boyd & DiMascio, 1954; Cacioppo & Petty, 1983, 1986; Schwartz & Shapiro, 1973). In particular, it adds a new physiologic response measure that is highly specific to certain kinds of social stimulation, in contrast to response measures such as skin conductance, heart rate, or muscle activity which respond readily to a broad band of social or nonsocial stimulation. Further, it complements the facial electromyography literature in providing another dimension of facial efference with possible communicative features.

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(Manuscript received November 21, 1989; accepted for publication May 15, 1991)

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