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Grin and Bear It: The Influence of Manipulated Facial Expression on the Stress Response

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Abstract

In the study reported here, we investigated whether covertly manipulating positive facial expressions would influence cardiovascular and affective responses to stress. Participants (N = 170) naive to the purpose of the study completed two different stressful tasks while holding chopsticks in their mouths in a manner that produced a Duchenne smile, a standard smile, or a neutral expression. Awareness was manipulated by explicitly asking half of all participants in the smiling groups to smile (and giving the other half no instructions related to smiling). Findings revealed that all smiling participants, regardless of whether they were aware of smiling, had lower heart rates during stress recovery than the neutral group did, with a slight advantage for those with Duchenne smiles. Participants in the smiling groups who were not explicitly asked to smile reported less of a decrease in positive affect during a stressful task than did the neutral group. These findings show that there are both physiological and psychological benefits from maintaining positive facial expressions during stress.

Keywords

emotions, facial expressions, well-being, health, stress reactions

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In the past decade, scientists have produced a wealth of research connecting positive affect to physical and psychological well-being (see Lyubomirsky, King, & Diener, 2005; Pressman & Cohen, 2005). Although most studies have focused on self-reported positive affect, observational methods have also shed light on these associations. For example, facial expressions indicating smiles of "nonenjoyment" have been shown to differentiate subjects with and without myocardial ischemia (Rosenberg et al., 2001). Similarly, smiling in photographs has been associated with well-being outcomes decades later (Abel & Kruger, 2010; Harker & Keltner, 2001), which raises the possibility that facial expression is a health-relevant emotion indicator.

Following the tradition of James (1890), many researchers have proposed that emotions are the consequence of facial expressions (and other behaviors) rather than the more commonly considered reverse direction. For example, self-perception theory states that acting as though one feels a certain way will lead to that feeling (Bem, 1972; Laird, 1974). Especially relevant to facial-expression research is the related facial-feedback hypothesis, which states that activating facial muscles leads to the psychological experience of emotion (Tourangeau & Ellsworth, 1979). In a classic study demonstrating the facial-feedback hypothesis, Strack, Martin, and Stepper (1988) had participants place pencils in their mouths in ways that activated facial muscles involved in smiling (or not smiling) while rating cartoons for funniness. Participants whose mouths were manipulated to smile rated cartoons as funnier than did participants in other conditions, despite a cover story linking the mouth-pencil to research on physical impairment.

Facial-expression researchers have long agreed that not all smiles are equal. Ekman (2001) suggested that as many as 50 kinds of smiles exist; however, most research focuses on the distinction between "genuine" and "standard" smiles based on activation of the orbicularis oculi muscle surrounding the eye. A "standard" smile engages the zygomaticus major muscles around the mouth, but only a "genuine" Duchenne smile engages both zygomaticus major and orbicularis oculi muscles (Duchenne, 1862/1990; Ekman & Friesen, 1982). Ekman, Davidson, and Friesen (1990) found that Duchenne smiling

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was seen more frequently when viewing pleasant films than when viewing unpleasant films and has been associated with activity in the left frontal and anterior temporal lobes, areas previously associated with positive affect (e.g., Davidson, 1992). Furthermore, Ekman and Davidson (1993) found that voluntarily producing a Duchenne smile activated the same brain regions responsible for positive affect as did involuntary Duchenne smiles stimulated by outside sources. This supports the facial-feedback hypothesis, given that the consequences associated with voluntary and involuntary activation of facial muscles were remarkably similar in the brain.

One important outcome that might be related to positive facial expressions is the cardiovascular stress response, a measure tied to future heart-health outcomes (e.g., Treiber et al., 2001). Although experimental facial manipulation has not been tied to this outcome directly, naturally occurring and manipulated positive affect has been linked to "healthier" cardiovascular stress recovery (i.e., quicker return toward resting heart function; Fredrickson & Levenson, 1998; Steptoe, Gibson, Hamer, & Wardle, 2007). It is notable that Fredrickson and Levenson (1998) also found that participants who spontaneously smiled during stress returned to resting levels of cardiovascular function more rapidly than did nonsmiling counterparts. This suggests that smiling may be particularly helpful in speeding stress recovery by reducing negative aftereffects of stress. This is consistent with Fredrickson, Mancuso, Branigan, and Tugade's (2000) "undoing hypothesis" of positive affect, which specifically postulates better recovery as a pathway connecting positive affect to well-being benefits. It is also in line with the more general stress-buffering model of positive affect and health (Pressman & Cohen, 2005), which asserts that positive feelings may guard against the negative physiological consequences of stress at a variety of times, including before, during, or after stress. Because smiling was not randomly assigned in the Fredrickson and Levenson (1998) study, it remains unclear whether this finding was due to facial expression directly or was simply the result of differences in emotional states or traits.

In the current study, we sought to better understand whether the facial changes that occur in smiling might be partially responsible for observed benefits connecting positive affect to improved stress recovery and whether smile types would have differential effects. Specifically, would "sincere" Duchenne smiling produce greater stress-recovery benefits than would standard smiling (or no smile)? Awareness of smiling was also manipulated to determine whether benefits were present when cognitive awareness of facial expression was absent. Past studies of the facial-feedback hypothesis and related self-perception work have purposely avoided awareness to prove the expression-feeling connection without cognition. In the case of stress, however, facial-muscle activation may not have the same power given the conflicting emotion and autonomic arousal signals (i.e., from pain and threat). Furthermore, studies have shown that purposely "faking" positive facial-emotion expression in customer service leads to increased burnout and employee error (e.g., Goldberg & Grandey, 2007), which suggests that awareness of artificial smiling may be harmful. Finally, emotion changes that occurred with condition assignment were assessed. On the basis of the facial-feedback hypothesis, we expected smilers to report greater positive affect than nonsmilers; however, in the stress context, it was anticipated that this would instead manifest as a lesser decrease in positive affect and a smaller increase in negative affect.

Method

Participants and procedure

One hundred seventy healthy participants (age = 18–25 years; 66% female, 34% male; 79% Caucasian, 21% other) were recruited from a large Midwestern university and screened for facial muscular disorder, lack of English fluency, and psychological disorder. Participants were randomly assigned to a neutral-expression control group (n = 58), a standard-smile group (n = 56), or a Duchenne-smile group (n = 56). Groups were asked to hold chopsticks in their mouths with their teeth by mimicking the holding pattern of a research assistant (who was blind to the study hypotheses) and a photo example (Fig. 1).

Participants in the Duchenne-smile group were trained to activate zygomaticus major and orbicularis oculi muscles, participants in the standard-smile group were trained to activate zygomaticus major muscles, and participants in the neutral group were simply instructed to hold the chopsticks gently in their mouths with their faces relaxed. Participants were given positioning assistance, image examples, experimenter instruction, and verbal correction during the study. To ensure that correct muscles were activated, two research assistants trained with the Facial Action Coding System (Ekman & Friesen, 1978) coded videos of participants. On a scale from 1 (*poor adherence*) to 5 (*excellent adherence*), the neutral group had the highest average adherence (3.35), with the standard-smile group averaging 1.90 and the Duchenne-smile group averaging 2.60.

Participants were given a cover story stating that this was a "multitasking study" (similar in nature to the cover story used by Strack et al., 1988) to prevent awareness or reactance to smiling. Because we were also interested in participants' awareness of smiling, half the participants in each smiling group (n = 28 per group) were additionally told to smile during the instruction period (the other half were given no additional instructions regarding their facial expressions).

After completing baseline questionnaires, participants' heart rate was monitored in beats per minute (bpm) using an automated cuff (Dinamap ProCare Auscultatory 400 Vital Signs Monitor, Lafayette Instrument Company, Lafayette, IN) that inflated approximately every 90 s over the course of the study. Heart rate was used as the primary outcome, as it is one of the most frequently measured variables in cardiovascular stress studies (e.g., Turner, 1994, p. 45). It is a reliable measure

Fig. 1. Examples of photographs shown to participants in the neutral group (left), standard-smile group (middle), and Duchenne-smile group (right) to help them form the appropriate expressions.

that is easily assessed, and it increases in response to a large range of stressors. Following a 10-min resting period, participants completed a 2-min star-tracing task. This stress-inducing task requires participants to place their nondominant hand inside a box and repeatedly trace a star while viewing only a mirror image of the star and their hand. If they strayed from the outline of the star, they received negative auditory feedback. Participants were strongly encouraged to be accurate and were also given incorrect information about performance standards to increase stress (i.e., they were told that the task average was eight tracings with fewer than 25 errors). They were promised an incentive (chocolate) if they could match this unattainable goal. Average participants could complete two tracings in 2 min with over 25 errors. This task was followed by a 5-min recovery period.

Next, participants completed a cold-pressor stress task in which their hand was submerged in ice water (2–3 °C) for 1 min. Participants then recovered again for 5 min. Tasks were not counterbalanced because of lasting pain from the cold. Chopsticks were held in the mouth only during the stress period (not during the recovery period), and verbal reminders were given when facial expressions lapsed. State affect, stress, task difficulty, and facial-muscle fatigue were measured at baseline and following each task. Participants were probed during debriefing for knowledge of study hypotheses. Only one individual identified that the study's purpose was to examine smiling.

Positive- and negative-affect change scores were calculated from baseline for each task using 16 items drawn from the factor-analyzed version of the Profile of Mood States (McNair, Lorr, & Droppleman, 1971; Usala & Hertzog, 1989). Baseline stress was measured using the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) and via momentary assessments throughout the study, in which participants rated how stressful they found each task on a 10-point scale. Behavioral variables known to correlate with cardiovascular functioning were measured at baseline, including body mass index, sleep, smoking, alcohol consumption, exercise, and drug use.

Statistical approach

For cardiovascular-recovery analyses, we used repeated measures analyses of covariance, with five time intervals, including the peak stress point of each task and four subsequent 90-s intervals following each task. This analysis accounted for differences from the final reactivity point to the end of the recovery period with between-subjects effects being conceptually similar to change scores from reactivity to recovery. To analyze state affect changes during tasks, we used univariate analyses of covariance. The main analyses of interest were comparisons between (a) the neutral versus the smiling groups, (b) the Duchenne-smile versus the standard-smile groups, and (c) the aware versus the nonaware groups. In all analyses, covariates significantly associated with the outcome of interest were controlled for. Variables included (when significant) were age, race, sex, body mass index, baseline stress, sleep, smoking, alcohol use, exercise, condition adherence, perceived task difficulty, self-reported facial-muscle fatigue, perceived task stress, and stress reactivity. Group differences in stress reactivity were not found for any contrasts of interest.

Results

An overall uncorrected analysis of variance of all five groups revealed significant differences during recovery following the star-tracer task, with aware standard smilers showing the lowest recovery heart rate levels (M = 65.75 bpm), followed by nonaware Duchenne smilers (M = 66.50 bpm), aware Duchenne smilers (M = 67.40 bpm), the neutral group (M = 71.36 bpm), and nonaware standard smilers (M = 72.73 bpm), $F(4, 139)$ = 4.68, $p < .01$. Uncorrected analyses found marginally significant differences between groups following the cold-pressor task, with aware standard smilers (M = 66.33 bpm) showing the lowest heart rate, followed by aware Duchenne smilers (M = 66.34 bpm), nonaware Duchenne smilers (M = 66.86 bpm), the neutral group (M = 70.91 bpm), and nonaware standard smilers (M = 71.43 bpm), $F(4, 142) = 2.27$, $p = .06$. After accounting for significant covariates, we found clear and consistent group differences overall and between individual contrasts, with smiling groups showing lower levels of heart rate during recovery than the neutral group. Average corrected means during recovery for individual contrasts are reported when main (between-subjects) effects are significant.

During recovery from the star-tracer task, the following groups had significantly lower heart rates than the neutral group: the two smile groups combined (M_{smile} = 68.19 bpm vs. $M_{neutral}$ = 71.45 bpm), $F(1, 117) = 3.95$, $p = .05$, Duchenne smilers only ($M_{Duchenne}$ = 66.40 bpm vs. $M_{neutral}$ = 71.69 bpm), $F(1, 74) = 6.71$, $p < .05$, and aware smilers (M_{aware} = 66.60 bpm vs. $M_{neutral}$ = 71.29 bpm), $F(1, 72) = 5.40$, $p < .05$. When comparing three groups, significant heart rate recovery differences were found between the neutral group, standard smilers, and Duchenne smilers, as well as between the neutral group, aware smilers, and nonaware smilers ($p < .05$; Fig. 2).

Results for recovery following the cold-pressor task were similar. The following groups had lower heart rates than the neutral group: the two smile groups combined (M_{smile} = 67.37 bpm vs. $M_{neutral}$ = 71.69 bpm), $F(1, 109) = 4.34$, $p < .05$, Duchenne smilers only ($M_{Duchenne}$ = 65.37 bpm vs. $M_{neutral}$ = 72.02 bpm), $F(1, 69) = 9.12$, $p < .05$, aware smilers (M_{aware} = 66.66 bpm vs. $M_{neutral}$ = 71.48 bpm), $F(1, 66) = 4.61$, $p < .05$, and nonaware smilers, who showed only marginally lower heart rates than the neutral group ($M_{nonaware}$ = 68.34 bpm vs. $M_{neutral}$ = 72.52 bpm), $F(1, 68) = 2.78$, $p = .10$. Duchenne smilers also had marginally lower heart rates than did standard smilers ($M_{Duchenne}$ = 64.98 bpm vs. $M_{standard}$ = 69.32 bpm), $F(1, 76) = 3.61$, $p = .06$. When the three groups were compared in one model, significant differences were again found between the neutral group, standard smilers, and Duchenne smilers, as well as between the neutral group, aware smilers, and nonaware smilers (Fig. 3).

Overall, uncorrected analyses of variance examining self-reported affect changes during tasks did not reveal significant group differences. However, when corrected individual contrasts were examined, affect changes were in the expected direction, although small, often nonsignificant, and only following the cold-pressor task. Specifically, following cold stress, nonaware smilers (M = –0.32) showed less of a decrease in positive affect from baseline than the neutral group did (M = –0.65), $F(1, 71) = 4.21$, $p < .05$, all smilers showed marginally less of a decrease in positive affect (M_{smile} = –0.36 vs. $M_{neutral}$ = –0.58), $F(1, 115) = 2.56$, $p = .1$, and Duchenne smilers had marginally less of a decrease in positive affect ($M_{Duchenne}$ = –0.36 vs. $M_{neutral}$ = –0.60), $F(1, 75) = 2.47$, $p = .1$. Further, nonaware smilers showed a marginal decrease in negative affect from baseline; in contrast, the neutral group showed an increase ($M_{nonaware}$ = –0.17 vs. $M_{neutral}$ = 0.07), $F(1, 73) = 2.78$, $p = .1$.

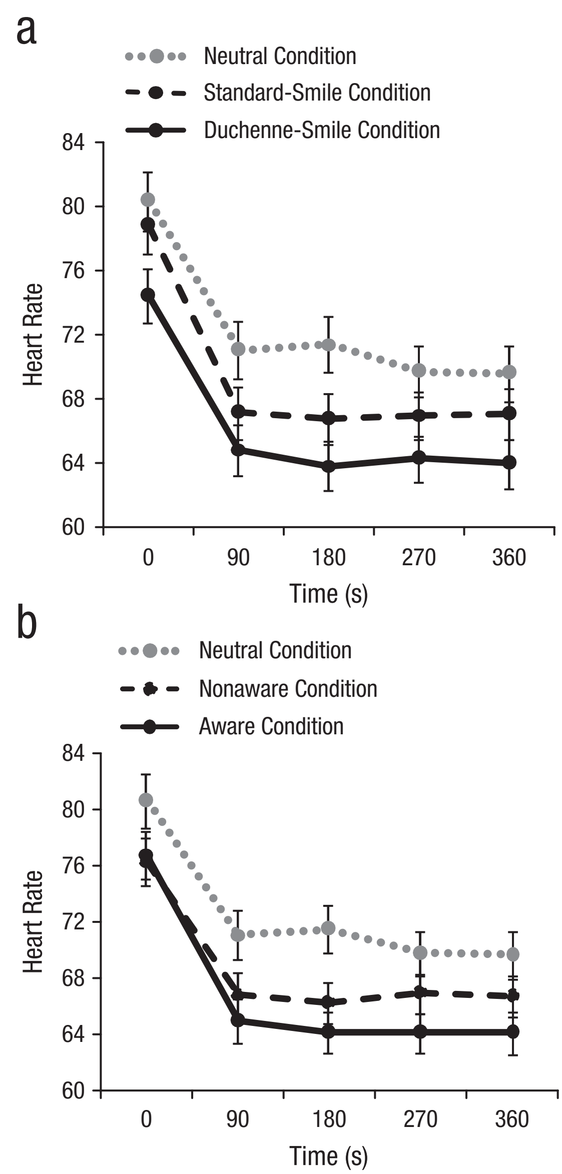

Fig. 2. Mean heart rate (in beats per minute) during the recovery period following the star-tracer task as a function of measurement occasion and condition. Results are shown separately for (a) the three facial-expression groups and (b) the aware and nonaware subgroups of the two smiling groups (collapsed across groups). The analysis controlled for sex, condition adherence, baseline perceived stress, perceived task difficulty, task stress, and facial-muscle fatigue. Error bars represent standard errors.

Discussion

This is the first study to show that experimentally assigned positive facial manipulation—with or without awareness of expression—has a direct impact on cardiovascular stress recovery. This may be relevant for health given that cardiovascular recovery is an outcome known to predict future disease (e.g., Steptoe & Marmot, 2005) and mortality (e.g., Cole, Blackstone, Pashkow, Snader, & Lauer, 1999). Duchenne smiling was particularly advantageous, which indicates that

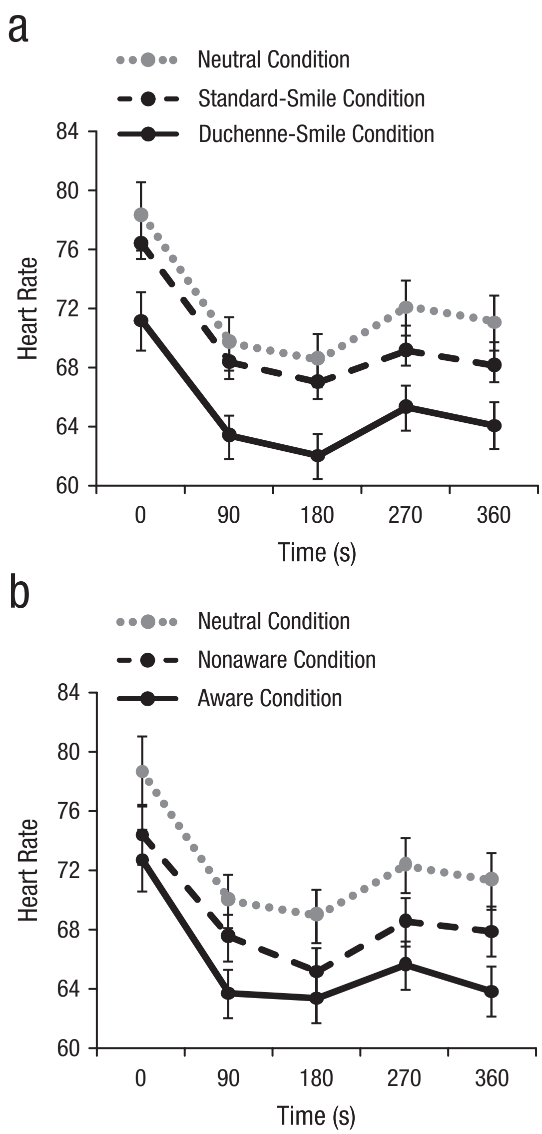

Fig. 3. Mean heart rate (in beats per minute) during the recovery period following the cold-pressor task as a function of measurement occasion and condition. Results are shown separately for (a) the three facial-expression groups and (b) the aware and nonaware subgroups of the two smiling groups (collapsed across groups). The analysis controlled for condition adherence, exercise, baseline perceived stress, perceived task difficulty, and facial-muscle fatigue. Error bars represent standard errors.

sincere smiles may be more effective for stress recovery than standard smiles. To our knowledge, this is the first indication that Duchenne smiling plays a role in the stress response. Note that the chopsticks were in place only during stress; thus, our results indicate that smiling was beneficial for a period of time after the stressors and facial-muscle activation had ended. These findings match the "stress undoing" predictions of Fredrickson et al. (2000) given that effects for smiling were found only after the stressors had occurred

Aware smiling did produce a small advantage in stress recovery as compared with nonaware smiling. Although results of the aware and nonaware groups were not different from each other, the results from those who heard the word "smile" during instruction were significantly different from the results of the neutral condition; however, nonaware individuals had only marginal or nonsignificant recovery advantages. This may mean that even though individuals were unaware that the study was examining smiling, awareness that their face was positioned like a smile offered some advantage, perhaps by priming the idea of positive affect prior to a stressful period. Nonetheless, nonaware smilers had similar but lesser heart rate benefits without this knowledge.

Small and marginal facial influences on affect were found for those smiling during cold stress, consistent with initial hypotheses. This was true for both smiling groups compared with the neutral group but only for those unaware of smiling. Unlike in past facial-feedback hypothesis manipulations, smiling did not increase positive affect but instead reduced the detrimental affect influences of stress. These findings are consistent with emotional blunting and affect-processing changes seen in participants told to inhibit facial-emotion expression (e.g. Duclos & Laird, 2001) and participants unable to manipulate facial muscles because of botulinum-toxin-induced paralysis (Davis, Senghas, Brandt, & Ochsner, 2010; Havas, Glenberg, Gutowski, Lucarelli, & Davidson, 2010). It is likely that the prevention of negative expressions during stress in addition to forced positive expression contributed to these results. It is interesting to note that, given the lack of affect findings for the star task, state emotion change may not be the mediator connecting facial expression to heart rate. Post hoc analyses testing positive affect, negative affect, and their arousal subcomponents as possible mediators of found effects revealed that reported changes accounted for a nonsignificant amount of variance (10% or less). If smiling is altering emotion in an important way, it is occurring outside the range of self-report awareness. It is also possible that emotion changes from artificial facial manipulation during stress are not easily tested by self-report, because of conflicting feelings. This also raises the intriguing possibility that there are pathways connecting facial-muscle activity to autonomic activity that do not require conscious emotion.

The generalizability of these findings to the real world is questionable given the artificiality of the setting and manipulation. Also, considering that long-lasting emotion-incongruent displays have been shown to be harmful (e.g., Goldberg & Grandey, 2007), it is important to consider other factors, such as duration, context, and frequency. More likely is the possibility that "fake" smiling may be useful for brief or painful stressors, such as receiving an injection (see Lanzetta, Cartwright-Smith, & Eleck, 1976, for a similar paradigm). Consistent with these ideas, our results showed affect advantages only in nonaware smilers. This may indicate that individuals who had some idea that their faces were in an incongruent emotion position did not receive the affect benefits. This study also looked at heart rate as the only dependent variable of interest. Blood pressure was assessed but not reported because of space constraints and lack of consistency in findings. Although blood pressure was sometimes consistent with heart rate (e.g., Duchenne smilers showed better results following the two stress tasks than either standard smilers or the neutral group did), many of the contrasts were not significant, which indicates that smiling may have less of an impact on vasculature changes. Future work should examine additional cardiovascular indicators, use more precise beat-by-beat measures of blood pressure, and explore possible pathways for why these outcomes have differential associations with smiling.

Overall, these results suggest that the adage "grin and bear it" does have proven value and that the benefits of smiling through stress should not be ignored. Given that facial expression is a ubiquitous part of everyday communication, future studies examining stress responses in individuals with facial paralysis or impairment are warranted, as are studies investigating the relative benefits of different smile types.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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