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A facial electromyographic investigation of affective contrast

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Abstract

Affective contrast refers to the tendency for stimuli to be judged as less evocative when preceded by more evocative same-valence stimuli. The authors used facial electromyographic (EMG) activity over *corrugator supercilii*, which is inversely related to affective valence, to determine if context influences underlying affective reactions. In Experiment 1, moderately pleasant pictures elicited less activity over *corrugator supercilii* when they were embedded among mildly pleasant, as opposed to extremely pleasant, pictures. In Experiment 2, moderately pleasant pictures elicited less activity over *corrugator supercilii* when they were embedded among mildly valent (i.e., pleasant and unpleasant), as opposed to extremely valent, pictures; moderately unpleasant pictures elicited comparable EMG activity regardless of context. Results indicate that context can influence affective reactions underlying affective judgments of moderately pleasant stimuli.

Descriptors: Emotion, Facial EMG, Context effects, Affective contrast, Judgment

People typically adapt to favorable life events and thereby derive less pleasure from them over time. This *hedonic treadmill* (Brickman & Campbell, 1971) is generally thought to operate in the long term. Brickman, Coates, and Janoff-Bulman (1978), for instance, found that lottery winners were less happy with their lives 1 year after winning the lottery than they had been immediately after the event. Other research suggests that adaptation can occur in the space of minutes rather than years. Participants in an early study by Sandusky and Parducci (1965) rated relatively neutral odors more pleasant when they were preceded by unpleasant odors as opposed to pleasant odors. In another study, men who were exposed to erotic pictures of especially attractive women subsequently rated their own wives as less sexually attractive than other men rated their own wives (Kenrick, Gutierres, & Goldberg, 1989).

Kahneman (1999) suggested that such evidence for *affective contrast* may be analogous to the form of adaptation known as brightness contrast.[1] A gray disk surrounded by a larger white disk is not only rated as darker than one surrounded by a larger black disk, it is actually perceived as darker due to lateral inhibition in the retinal ganglion cells. By this account, affective reactions are relative. That is, moderately pleasant stimuli are judged more pleasant when embedded among less pleasant stimuli because they actually elicit more positive affect in such contexts. As numerous theorists (e.g., Campbell, Lewis, & Hunt, 1958; Kahneman, 1999) have pointed out, however, self-report evidence for affective contrast cannot rule out more mundane explanations involving response biases, which are factors that systematically distort judgment (Colman, 2006). One possibility is that participants feel compelled to use the entire response scale (e.g., *extremely unpleasant* to *extremely pleasant*) to satisfy the conversational norm to provide informative answers. Consider an individual presented with a series of exceptionally pleasant stimuli. Rating all of these stimuli as extremely pleasant would convey no information about how pleasant they are relative to one another, so the individual may choose to rate the least pleasant of these exceptionally pleasant stimuli as only mildly pleasant. (For discussions of the role of conversational norms in survey responding, see Schwarz, 1990, 1996.) By this account, moderately pleasant stimuli elicit comparable levels of positive affect in mildly and extremely pleasant contexts even though they are judged more pleasant in mildly pleasant contexts.

These competing explanations for affective contrast, which we term the *affective relativity* and *response bias* accounts, respectively, can be conceptualized in terms of Birnbaum's (1978) model of psychophysical judgment (see Figure 1). In Birnbaum's model, the relationship between a physical stimulus (ϕ) and judgment is mediated by an intervening psychological representation of the stimulus (ψ). Birnbaum's model can be extended to affective processes by treating the affective reaction

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[1]Contrast occurs when a target stimulus is judged away from some comparison stimulus or stimuli. In a variety of well-delineated circumstances, judgment is assimilated toward, rather than contrasted away from, the comparison (for reviews, see Martin, Seta, & Crelia, 1990; Schwarz & Bless, 1992).

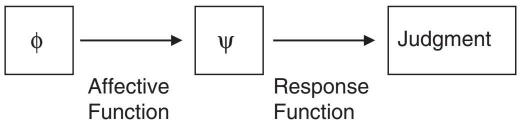

Figure 1. Adaptation of Birnbaum's (1978) model of psychophysical judgment. ϕ represents the physical stimulus and ψ represents the psychological representation of the stimulus.

to a stimulus as its psychological representation. The affective relativity account contends that context influences what we term the affective function, which relates the stimulus to the affective reaction it elicits. Conversely, the response bias account holds that context influences the response function, which relates the affective reaction to judgment (see Figure 1).

Testing the Competing Hypotheses

Manis (1971) suggested that it may be impossible to provide strong tests of the response bias and affectively relativity accounts because both can account for contrast effects on ratings. However, some data that speak to each account's viability have been collected. For instance, affective contrast effects grow weaker as the number of response options provided to participants increases from 3 to 7 to 101 (Wedell & Parducci, 1988). To the extent that affective contrast completely disappears as the number of response options increases even further, these data would seem to provide evidence for the response bias account.

Another strategy has been to test for contrast effects on subsequent behavior on the assumption that contrast effects on behavior would provide evidence for affective relativity. Simpson and Ostrom (1976) asked participants to write a paragraph describing their impression of a neutral target person after rating the target person in a context of unlikable or likable individuals. As predicted by the affective relativity account, participants who had rated the target in the context of unlikable individuals wrote more favorable paragraphs.

Sherman, Ahlm, Berman, and Lynn (1978), however, pointed out that context effects on behavior may be a result of context effects on judgment. They had participants rate the importance of recycling in the context of trivial social issues (e.g., leash laws for pets) or important social issues (e.g., capital punishment). In addition to rating recycling more important, participants in the trivial context condition agreed to distribute more pro-recycling pamphlets for a confederate who posed as a participant and allegedly worked at a recycling center. Nonetheless, the effect of context on recycling behavior was only obtained among participants whose attention had been called to their rating of the importance of recycling, which suggests that context effects on behavior may simply reflect self-perception processes (Bem, 1972).

Evidence from choice tasks provides the most provocative evidence for affective relativity. Cooke and Mellers (1994; cited in Mellers & Cooke, 1996) asked two groups of undergraduates to make a number of choices between pairs of apartments in which one apartment was closer to campus but also more expensive. One group made choices between apartments that had similar rents but varied widely in terms of proximity. In this context, the marginal cost of being one minute closer to campus was a mere $4. The other group made choices between apartments that varied widely in monthly rent but were similar in terms of proximity to campus. In this context, the average marginal cost of being one minute closer to campus exceeded $50. Embedded in both contexts was a subset of pairs in which the average marginal cost of being one minute closer to campus was $12.50. Participants in the latter group preferred more of the nearby apartments in this subset of pairs, presumably because they construed the added expense of being closer to campus as a relative bargain.

As Mellers and Cooke (1996) explained, it is unclear how such preference reversals across Cooke and Mellers' (1994) context conditions could be the result of response biases. Indeed, if participants in the two groups had valued proximity equally, they would have made the same choices. The most plausible explanation for the finding that the groups made different choices is that context affected participants' underlying evaluations of proximity (Mellers & Cooke, 1996). Cooke and Mellers' (1994) results provide provocative evidence for affective relativity, but it is important to note that they did not measure evaluative reactions to nearby and distant apartments directly. Rather, they made inferences about whether context affected evaluative reactions by investigating whether context affected the downstream consequences of those evaluative reactions (i.e., choices).

A Psychophysiological Approach

Because research involving self-reports and behavioral measures has provided indirect evidence for and against the affective relativity account, it may be useful to turn to psychophysiological measures, which can provide more proximal indices of evaluative and affective reactions than other tasks can (for a review, see Larsen, Berntson, Poehlmann, Ito, & Cacioppo, 2008). An event-related brain potential termed the feedback error-related negativity (fERN) is sensitive to monetary payoffs such that penalties elicit larger fERNs than rewards (Miltner, Braun, & Coles, 1997). Holroyd, Larsen, and Cohen (2004) demonstrated that the effect of payoffs on fERN amplitude is context dependent. Stimuli that informed participants that they had received no money elicited larger fERNs when participants expected to win money than when they had expected to lose money. These findings provide some evidence for affective relativity, but the fERN is only elicited by fairly simple stimuli and therefore cannot shed light on affective reactions to more complex affective stimuli.

In contrast, decades of research make clear that a wide variety of affective stimuli, including emotional imagery (e.g., Schwartz, Fair, Salt, Mandel, & Klerman, 1976), films (Hess, Banse, & Kappas, 1995), and pictures (Cacioppo, Bush, & Tassinary, 1992; Cacioppo, Petty, Losch, & Kim, 1986), influence facial electromyographic (EMG) activity. Relative to neutral stimuli, pleasant stimuli elicit greater activity over *zygomaticus major* (Lang, Greenwald, Bradley, & Hamm, 1993; Larsen, Norris, & Cacioppo, 2003), which traverses the cheek and pulls the corners of the mouth up into a smile. The effect of positive affect tends to be J-shaped, such that only extremely pleasant stimuli elicit activity over *zygomaticus major* (e.g., pictures of kittens, puppies, babies; Lang et al., 1993; Larsen et al., 2003). In contrast, moderately pleasant pictures typically elicit no more activity than neutral pictures. Thus, activity over *zygomaticus major* is insensitive to small differences in moderate levels of positive affect. Our point is not that activity over *zygomaticus major* is insensitive to positive affect. Indeed, extremely pleasant pictures elicit much more activity over *zygomaticus major* than neutral pictures do. We merely point out that moderately pleasant pictures do not typically elicit much activity over *zygomaticus major*. Two studies conducted by Cacioppo et al. (1986, 1992), for example, revealed that moderately pleasant pictures elicited no more activity over *zygomaticus major* than mildly pleasant or even mildly unpleasant pictures. Unless contextual manipulations have a pronounced effect on affective reactions to moderately pleasant pictures, which seems unlikely, activity over *zygomaticus major* is not especially well suited for indexing whether context influences affective reactions to moderately pleasant stimuli.

Activity over *corrugator supercilii*, which furrows the brow into a frown, may be more useful. Activity over *corrugator supercilii* is inversely related to valence such that pleasant stimuli elicit less activity and unpleasant stimuli more activity than do neutral stimuli (Cacioppo et al., 1986; Lang et al., 1993; Larsen et al., 2003). Moreover, the effect of valence on activity over *corrugator supercilii* is fairly linear. As a result, activity over *corrugator supercilii* is more sensitive to small differences in moderate levels of positive affect than is activity over *zygomaticus major*. In two experiments, we tested the affective relativity and response bias accounts of affective contrast by recording activity over *corrugator supercilii* in response to evocative pictures presented in different contexts. We also recorded activity over *zygomaticus major*, which may be sensitive to affective context in the unlikely event that affective relativity effects are especially pronounced.

EXPERIMENT 1

Participants viewed a common series of moderately pleasant target pictures embedded in a context of mildly pleasant or extremely pleasant pictures. In addition to asking participants to rate how pleasant they found each picture, we measured activity over *zygomaticus major* and *corrugator supercilii* as they viewed the pictures. Both the affective relativity and response bias accounts predict that the moderately pleasant target pictures would be judged more pleasant when embedded in the mildly pleasant, as opposed to extremely pleasant, context.

The two accounts make different predictions about EMG activity. According to the affective relativity account, moderately pleasant target pictures would be judged more pleasant in the mildly pleasant context because they actually elicit more positive affect. Thus, the affective relativity account predicts that moderately pleasant target pictures would elicit less activity over *corrugator supercilii* when embedded in a context of mildly pleasant, as opposed to extremely pleasant, pictures. Activity over *zygomaticus major* is less sensitive to small differences in moderate levels of positive affect (Larsen et al., 2003), but moderately pleasant pictures might elicit more activity over *zygomaticus major* in the mildly pleasant context. According to the response bias account, however, moderately pleasant target pictures would elicit no more positive affect in the mildly pleasant context than in the extremely pleasant context. Thus, the response bias account predicts that moderately pleasant target pictures would elicit comparable levels of activity over *corrugator supercilii* and *zygomaticus major* in the two contexts.

Method

Participants

Thirty-eight female psychology students at Texas Tech University participated and were compensated with course credit. Data from 4 participants were removed from the analyses due to excessive movement and EMG artifact in activity over *zygomaticus major* and *corrugator supercilii*, yielding a final sample size of 34. Data from an additional 2 participants, 1 in each condition, were removed from analyses of activity over *zygomaticus major* due to excessive artifact in those recordings. Participants with excessive artifact were equally distributed between the two context conditions.

Stimuli

Stimuli consisted of 35 mildly pleasant, 15 moderately pleasant, and 35 extremely pleasant pictures from The International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Pictures were selected on the basis of Ito, Cacioppo, and Lang's (1998) normative valence ratings with the primary constraint that the mean valence ratings of the moderately pleasant targets ($M = 6.79$, $SD = 1.66$) fell approximately midway between those of the mildly pleasant contextual pictures ($M = 5.57$, $SD = 1.31$) and the extremely pleasant contextual pictures ($M = 8.05$, $SD = 1.34$). The resulting set of pictures varied widely in content, though we avoided close-ups of people in order to minimize facial mimicry effects (e.g., Hess, Philippot, & Blairy, 1998). Illustrative moderately pleasant pictures included a sailboat, a violin, and a waterfall. Mildly pleasant pictures included an umbrella, a pole vaulter, and a tomato. Extremely pleasant pictures included flowers, gold bars, and babies.[2]

Procedure

The experimenter told participants upon their arrival that they would view a series of pleasant pictures and rate how pleasant they found each picture. To disguise the true nature of the experiment and divert participants' attention from their facial expressions, the experimenter placed an electroencephalography cap on participants' heads and told them that the EMG electrodes recorded brainwaves. Following procedures outlined by Fridlund and Cacioppo (1986), the experimenter then attached facial EMG electrodes over *zygomaticus major* and *corrugator supercilii* with 4-mm standard silver/silver chloride electrodes. Participants were then seated in a comfortable recliner in a small, private room.

After completing a 5-min relaxation exercise, participants viewed a subset of the IAPS pictures on a 21-in. monitor. Participants randomly assigned to the mildly pleasant context condition ($n = 17$) viewed the 15 moderately pleasant target pictures randomly distributed among the 35 mildly pleasant contextual pictures. Participants randomly assigned to the extremely pleasant context condition ($n = 17$) viewed the same 15 moderately pleasant target pictures randomly distributed among the 35 extremely pleasant contextual pictures. To strengthen the context manipulation, the first 5 pictures presented were contextual pictures. After participants pressed the space bar to initiate each trial, a fixation cross appeared for 3000 ms, followed by the stimulus picture for 6000 ms. Participants then rated how pleasant they found the picture on a scale from 1 (*not at all pleasant*) to 4 (*extremely pleasant*).

After participants had viewed all 50 pictures, they were asked to smile and then frown to confirm that the electrodes had been placed properly. The experimenter then removed the electrodes

[2]The following IAPS stimuli were included: extremely pleasant contextual pictures: 1440, 1460, 1463, 1590, 1601, 1602, 1610, 1620, 1710, 1750, 2040, 2080, 2091, 2160, 2260, 2340, 2501, 2530, 2540, 2550, 2660, 4700, 5010, 5200, 5201, 5220, 5600, 5760, 5830, 5870, 7280, 7390, 7580, 8210, and 8500; moderately pleasant target pictures: 2791, 4532, 5020, 5030, 5260, 5300, 5628, 5982, 7200, 7281, 7480, 7900, 8032, 8170, and 8460; and mildly pleasant contextual pictures: 1740, 1910, 2030, 2190, 4250, 4500, 4606, 4609, 4653, 5510, 5520, 6910, 7000, 7006, 7009, 7025, 7034, 7035, 7080, 7150, 7170, 7190, 7235, 7285, 7351, 7490, 7500, 7510, 7620, 8040, 8050, 8130, 8260, 8280, 8300.

and conducted a funnel debriefing. No participants suspected that we were interested in facial expression before they were asked to smile and frown at the end of the experiment.

EMG Data Collection and Reduction

EMG signals were relayed through shielded cable to Biopac amplifiers (Biopac Systems, Inc., Santa Barbara, CA), where signals were amplified 5000×. Signals were digitized at 1000 Hz, then recorded and displayed on a laboratory computer. To monitor artifact (e.g., due to movement), the experimenter inspected incoming data as well as a video feed of the participant's head from a camera mounted inside an inconspicuous 5-in. wall-mounted smoke-colored dome. Off-line, data were submitted to a 15-Hz high-pass filter to reduce movement and blink-related artifact, then full-wave rectified. Data were then visually inspected, and data with remaining artifact were excluded from subsequent analysis. Data were then collapsed across 100-ms bins. To correct for the positive skew inherent to EMG data, all values were submitted to a square-root transformation. Following standard practice (e.g., Lang et al., 1993; Schwartz et al., 1976; Vrana, 1993; Winkielman & Cacioppo, 2001), EMG reactivity was measured as change scores representing the difference between activity during each second of the 6-s picture period and the 1 s immediately preceding stimulus onset. For each site, data from trials with change scores calculated across the entire 6-s picture period that were 3 *SD* above or below the grand mean change score were considered outliers and removed.

Change scores can be misleading if experimental treatments affect baseline activity (Fridlund & Cacioppo, 1986). It is feasible that participants in the extremely pleasant context were in more positive moods because they generally saw more pleasant pictures than did those in the mildly pleasant context. It is therefore also feasible that participants in the extremely pleasant context would show more baseline activity in *zygomaticus major* and less baseline activity in *corrugator supercilii* in the moments preceding each picture, including the moderately pleasant target pictures. According to Wilder's (1967) law of initial value, stimuli typically produce smaller increases in physiological activity when preceded by high levels of physiological activity at baseline. Thus, even if context had no effect on affective reactions to the moderately pleasant target pictures, those moderately pleasant target pictures would have more ability to increase activity in *corrugator supercilii* in the extremely pleasant context condition than in the mildly pleasant context condition. In light of this possibility, we conducted preliminary analyses to assess for effects of context condition on EMG activity during the 1-s baseline period preceding stimulus onset.

Results and Discussion

Pleasantness Ratings

Not surprisingly, a *t* test indicated that extremely pleasant contextual pictures were judged more pleasant ($M = 2.50$, $SD = 0.41$) than mildly pleasant contextual pictures ($M = 1.62$, $SD = 0.38$), $t(32) = 6.53$, $p < .001$, J. Cohen's (1977) $d = 2.24$. More important, moderately pleasant target pictures were judged more pleasant when presented among mildly pleasant contextual pictures ($M = 2.53$, $SD = 0.59$), as opposed to extremely pleasant contextual pictures ($M = 2.03$, $SD = 0.34$), $t(32)$ 3.04, $p = .005$, $d = 1.04$. Thus, pleasantness ratings of moderately pleasant target pictures were characterized by affective contrast.

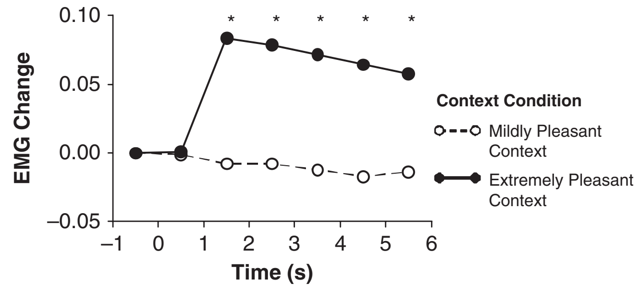

Figure 2. Change in EMG activity over *zygomaticus major* in response to Experiment 1's mildly pleasant contextual pictures (hollow circles) and extremely pleasant contextual pictures (filled circles). Asterisks represent simple effects of second that are significant after correcting for familywise error rate.

Facial EMG

Activity over Zygomaticus Major

Contextual stimuli. A between-subjects *t*-test revealed comparable levels of baseline activity over *zygomaticus major* in the 1 s preceding extremely pleasant contextual pictures ($M = 1.54$, $SD = 0.84$) and mildly pleasant contextual pictures ($M = 1.61$, $SD = 0.44$), $t(30) < 1$. Change scores in EMG activity over *zygomaticus major* in response to mildly and extremely pleasant contextual pictures are shown in Figure 2. These data were submitted to a 2 (Context Condition: mildly pleasant, extremely pleasant) × 6 (Second) mixed-model analysis of variance (ANOVA), where context was manipulated between subjects.[3] The ANOVA revealed a main effect of context condition, such that extremely pleasant contextual stimuli elicited more activity over *zygomaticus major* ($M = 0.06$, $SD = 0.06$) than mildly pleasant contextual stimuli ($M = -0.01$, $SD = 0.03$), $F(1,30) = 18.22$, $p < .001$, partial $\eta^2 = .38$ (see Figure 2). This main effect was qualified by a context condition × second interaction, $F(5,150) = 8.80$, $p < .001$, partial $\eta^2 = .23$. Follow-up analyses indicated that extremely pleasant contextual pictures elicited more activity over *zygomaticus major* than mildly pleasant contextual pictures during Seconds 2–6 after correcting for familywise error rate by dividing α by 6 ($.05/6 = .008$). These results indicate that extremely pleasant contextual stimuli elicited greater positive affect than mildly pleasant contextual stimuli.

Moderately pleasant target stimuli. A *t*-test revealed comparable levels of baseline activity over *zygomaticus major* in the 1 s preceding moderately pleasant target pictures in the extremely pleasant context condition ($M = 1.54$, $SD = 0.21$) and mildly pleasant context condition ($M = 1.59$, $SD = 0.45$), $t(30) < 1$. Change scores in EMG activity over *zygomaticus major* in response to moderately pleasant target pictures are shown in Figure 3. A 2 (Context Condition: mildly pleasant, extremely pleasant) × 6 (Second) mixed-model ANOVA on these data indicated that neither the main effect of context condition nor the Context Condition × Second interaction approached significance, both $ps > .2$ (see Figure 3). Thus, data from activity over *zygomaticus major* provide little evidence that moderately pleasant target pictures elicited less positive affect when embedded among extremely pleasant, as opposed to mildly pleasant, contextual pictures.

[3] The Huyn–Feldt correction was applied for all tests involving factors with more than two levels. Most ANOVAs on EMG data from both experiments revealed significant main effects of second, but we do not discuss them because they are conceptually unimportant.

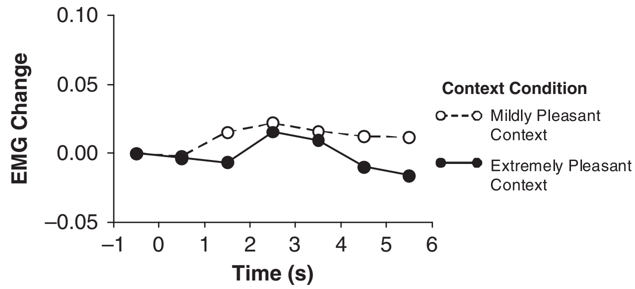

Figure 3. Change in EMG activity over *zygomaticus major* in response to Experiment 1's moderately pleasant target pictures in the mildly pleasant context condition (hollow circles) and extremely pleasant context condition (filled circles).

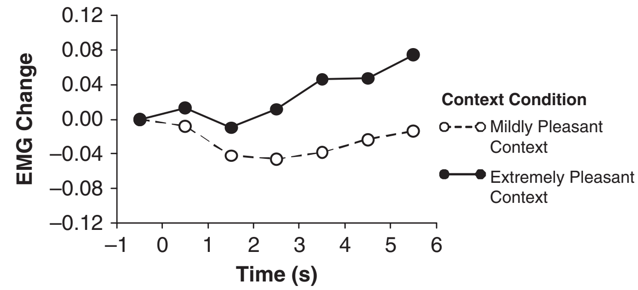

Figure 5. Change in EMG activity over *corrugator supercilii* in response to Experiment 1's moderately pleasant target pictures in the mildly pleasant context condition (hollow circles) and extremely pleasant context condition (filled circles).

Activity over Corrugator Supercilii

Contextual stimuli. Despite our concern that participants in the extremely pleasant context would show less baseline activity in *corrugator supercilii* than participants in the mildly pleasant context, baseline activity was actually marginally higher in the 1 s preceding extremely pleasant contextual pictures ($M = 3.01$, $SD = 0.85$) than in the 1 s preceding mildly pleasant contextual pictures ($M = 2.57$, $SD = 0.59$), $t(32) = 1.73$, $p = .09$, $d = 0.59$. Because task engagement has been shown to be associated with greater activity over *corrugator supercilii* (B. H. Cohen, Davidson, Senulis, Saron, & Weisman, 1992), one explanation for this marginally significant trend is that participants in the extremely pleasant context found the task more engaging because they came to expect more interesting pictures than did participants in the mildly pleasant context (e.g., cute animals as opposed to mundane household objects).

Change scores in activity over *corrugator supercilii* in response to mildly and extremely pleasant contextual pictures are shown in Figure 4. Mean values suggest that extremely pleasant contextual pictures tended to elicit less activity over *corrugator supercilii* ($M = -0.03$, $SD = 0.08$) than mildly pleasant contextual pictures ($M = 0.01$, $SD = 0.07$), but a 2 (Context Condition: mildly pleasant, extremely pleasant) $\times$ 6 (Second) ANOVA on these data revealed neither a main effect of context condition nor a Context $\times$ Second interaction, $p = .16$ and .13, respectively. The main effect of context condition did have a medium effect size ($d = 0.50$), so one explanation for the null effect is that our between-subjects design lacked sufficient power to detect differences between mildly and extremely pleasant contextual stimuli. We address this possibility in Experiment 2.

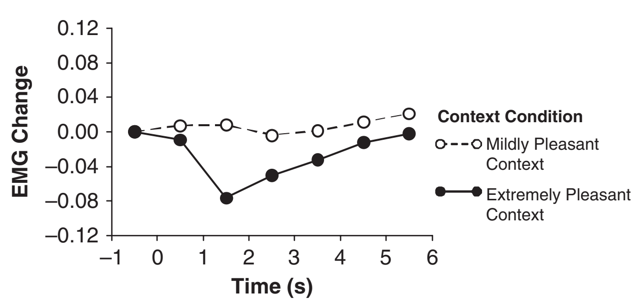

Figure 4. Change in EMG activity over *corrugator supercilii* in response to Experiment 1's mildly pleasant contextual pictures (hollow circles) and extremely pleasant contextual pictures (filled circles).

Moderately pleasant target stimuli. As with baseline activity preceding contextual pictures, moderately pleasant target pictures were preceded by marginally greater baseline activity over *corrugator supercilii* in the extremely pleasant context ($M = 3.07$, $SD = 0.88$) than in the mildly pleasant context ($M = 2.61$, $SD = 0.66$), $t(32) = 1.72$, $p = .10$, $d = 0.59$. Activity over *corrugator supercilii* was closer to its ceiling in the extremely pleasant context, so moderately pleasant pictures had less ability to increase activity in *corrugator supercilii* in the extremely pleasant context condition. This marginally significant baseline difference in activity actually works against the affective relativity account, which predicts that moderately pleasant pictures will elicit more activity over *corrugator supercilii* in the extremely pleasant context condition.

Change scores in activity over *corrugator supercilii* in response to moderately pleasant stimuli are shown in Figure 5. Consistent with the affective relativity account, the 2 (Context Condition: mildly vs. extremely pleasant) $\times$ 6 (Second) mixed-model ANOVA on these data revealed a main effect of context, such that moderately pleasant target pictures elicited less activity in the mildly pleasant context ($M = -0.03$, $SD = 0.07$) than in the extremely pleasant context ($M = 0.03$, $SD = 0.09$), $F(1,32) = 4.27$, $p < .05$, partial $\eta^2 = .12$. Inspection of Figure 5 suggests that facial EMG reactions to moderately pleasant pictures were initially context independent and that affective relativity only emerged over time, but the Context $\times$ Second interaction was only marginally significant ($p = .08$). We therefore set aside speculation about the time course of affective contrast, but will return to it in Experiment 2. In any event, the main effect of context condition on activity over *corrugator supercilii* indicates that moderately pleasant contextual pictures elicited more positive affect when embedded in a context of mildly pleasant pictures as opposed to extremely pleasant pictures. These results provide evidence for affective relativity.

EXPERIMENT 2

Experiment 2 had two goals. The first goal was to take a closer look at whether affective relativity takes several seconds to emerge. To do so, we maximized statistical power by manipulating context within subjects. The second goal was to extend Experiment 1 by examining whether both moderately pleasant and moderately unpleasant stimuli are susceptible to affective contrast. We did so by presenting moderately pleasant and unpleasant target stimuli either in a *mildly valent* context comprised of both mildly pleasant and unpleasant pictures or in an *extremely valent* context of extremely pleasant and unpleasant pictures. The affective relativity account's predictions for moderately pleasant stimuli are similar to those of Experiment 1. According to this account, they should elicit greater activity over *corrugator supercilii* in the extremely valent context than in the mildly valent context. If moderately unpleasant pictures are also susceptible to affective relativity, they should elicit more activity over *corrugator supercilii* in the mildly valent context than in the extremely valent context condition. Because there is little evidence that *zygomaticus major* is sensitive to small differences in moderate levels of positive or negative affect, there was little reason to expect context effects on activity in this site.

Method

Participants

Nineteen female Texas Tech psychology students participated. One participant failed to return for Session 2. Another participant's Session 2 was cut short by a hard drive failure. Both of these participants' data were removed from analyses, so EMG analyses included data from 17 participants. The hard drive failure also resulted in the loss of 4 additional participants' self-report data from Session 2, so self-report analyses include data from 13 participants.

Materials and Procedure

The materials and procedure mirrored that of Experiment 1 with several exceptions. Rather than completing a single session, participants completed a pair of sessions separated by 7 days. One group ($n = 8$) completed the mildly valent context condition during their first session and the extremely valent context condition during their second session. The other group ($n = 9$) completed the sessions in the reverse order. In the mildly valent context condition, participants viewed 12 moderately pleasant target pictures ($M = 7.00$, $SD = 0.16$) and 12 moderately unpleasant target pictures ($M = 3.04$, $SD = 0.20$) embedded among 24 mildly pleasant contextual pictures ($M = 5.58$, $SD = 0.25$) and 24 mildly unpleasant contextual pictures ($M = 4.39$, $SD = 0.31$). In the extremely valent context condition, participants viewed the same moderately pleasant and unpleasant target pictures embedded among 24 extremely pleasant contextual pictures ($M = 8.39$, $SD = 0.30$) and 24 extremely unpleasant contextual pictures ($M = 1.60$, $SD = 0.26$).[4] In addition, all moderately pleasant targets were preceded by one or two pleasant contextual stimuli and all moderately unpleasant targets by one or two unpleasant contextual stimuli. Finally, participants rated each picture on a bipolar scale from 1 (*extremely unpleasant*) to 7 (*extremely pleasant*). For ease of interpretation, we subtracted 4 from each rating so that the scale ranges from -3 to $+3$.

Table 1. *Valence Ratings of Experiment 2's Moderately Pleasant and Moderately Unpleasant Target Pictures as a Function of Context Condition and Context Condition Order*

	Context condition			
	Mildly valent context		Extremely valent context	
Target	*M*	*SD*	*M*	*SD*
Moderately pleasant	1.31_a	0.45	1.10_b	0.49
Moderately unpleasant	-1.56_a	0.65	-1.47_a	0.49

Note: Values range from -3 (*extremely unpleasant*) to $+3$ (*extremely pleasant*). Means within a row with different subscripts were significantly different.

EMG Data Collection and Reduction

EMG data were collected and reduced as in Experiment 1 with one exception. Manipulating affective context within subjects allowed us to identify outlier trials on a within-subjects basis, so we excluded data from trials with change scores 3 *SD* above or below each participant's mean change score.

Results

Valence Ratings

Valence ratings of contextual stimuli were submitted to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) mixed-model ANOVA, where order was manipulated between subjects. The ANOVA revealed a Context Condition × Stimulus Valence interaction, $F(1,11) = 297.21$, $p < .001$, partial $\eta^2 = .96$. Not surprisingly, follow-up ANOVAs indicated that extremely pleasant pictures were judged more positive ($M = 1.76$, $SD = 0.44$) than mildly pleasant pictures ($M = 0.56$, $SD = 0.24$), $F(1,11) = 104.17$, $p < .001$, partial $\eta^2 = .90$, and that extremely unpleasant pictures were judged more negative ($M = -2.20$, $SD = 0.37$) than mildly unpleasant pictures ($M = -0.52$, $SD = 0.32$), $F(1,11) = 353.79$, $p < .001$, partial $\eta^2 = .97$.

Valence ratings of moderately pleasant and unpleasant target stimuli are shown in Table 1. To assess for affective contrast, we submitted these data to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) mixed-model ANOVA. The ANOVA revealed a main effect of stimulus valence such that moderately pleasant targets were judged more pleasant than moderately unpleasant targets, $F(1,11) = 117.15$, $p < .001$, partial $\eta^2 = .91$. There was also a Context × Stimulus Valence interaction, $F(1,11) = 8.87$, $p = .01$, partial $\eta^2 = .45$. As in Experiment 1, a follow-up ANOVA revealed that moderately pleasant target pictures tended to be judged more pleasant when presented among mildly valent contextual pictures, as opposed to extremely valent contextual pictures, $F(1,11) = 4.68$, $p = .05$, partial $\eta^2 = .30$. A parallel ANOVA provided no evidence that moderately unpleasant target pictures were judged more unpleasant when presented among mildly valent contextual pictures, as opposed to extremely valent contextual pictures, $F(1,11) = 1.42$, $p = .26$,

[4]The following IAPS stimuli were included: extremely pleasant contextual pictures: 1440, 1463, 1710, 1750, 1920, 1999, 2080, 2091, 2150, 2160, 2260, 4533, 5600, 5621, 5626, 5760, 5830, 7340, 7350, 7390, 8162, 8490, 8501, and 8510; moderately pleasant target pictures: 1600, 1900, 4640, 5260, 5629, 5660, 5750, 7900, 8032, 8034, 8080, and 8460; mildly pleasant contextual pictures: 2030, 4500, 4535, 4606, 4609, 4653, 5510, 5990, 6910, 7009, 7010, 7025, 7034, 7140, 7284, 7285, 7351, 7490, 7500, 7510, 7550, 7620, 7820, and 8260; mildly unpleasant contextual pictures: 1560, 2130, 2200, 2210, 2410, 2590, 2810, 4150, 6010, 6930, 7002, 7030, 7040, 7050, 7060, 7090, 7224, 7700, 8010, 9010, 9080, 9190, 9210, and 9411; moderately unpleasant target pictures: 1230, 1274, 1301, 1390, 2700, 7361, 9001, 9110, 9120, 9330, 9390, and 9440: extremely unpleasant contextual pictures: 2205, 2710, 2800, 3160, 3170, 3180, 3220, 3350, 3530, 3550, 6212, 6230, 6570, 6830, 8230, 9050, 9220, 9290, 9320, 9410, 9415, 9430, 9910, and 9921. As in Study 1, we avoided close-ups of people.

partial $\eta^2 = .12$. Thus, ratings of moderately pleasant, but not moderately unpleasant, target pictures tended to be characterized by affective contrast.

Facial EMG

Activity over zygomaticus major

Contextual pictures. Baseline activity levels over *zygomaticus major* preceding contextual pictures were submitted to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) mixed-model ANOVA, where context condition order was manipulated between subjects. The ANOVA revealed a Context Condition Order × Context Condition interaction, $F(1,15) = 11.94$, $p = .004$, partial $\eta^2 = .44$, such that participants tended to show greater baseline activity during their first session. Participants who completed the mildly valent context condition first showed greater activity during the mildly valent context condition ($M = 1.58$, $SD = 0.09$) than during the extremely valent context condition ($M = 1.46$, $SD = 0.04$), $F(1,7) = 14.23$, $p = .007$, partial $\eta^2 = .67$; those who completed the extremely valent context condition first showed nonsignificantly greater activity during the extremely valent context condition ($M = 1.60$, $SD = 0.16$) than during the mildly valent context condition ($M = 1.54$, $SD = 0.14$), $F(1,8) = 2.44$, $p = .16$.

Change scores in EMG activity over *zygomaticus major* in response to pleasant and unpleasant contextual pictures are shown in the left and right panels of Figure 6, respectively. We submitted these change scores to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) × 6 (Second) mixed-model ANOVA, where context condition order was manipulated between subjects. The ANOVA revealed several main effects and interactions, all of which were qualified by a Context × Stimulus Valence × Second interaction.

To decompose the three-way interaction, we conducted separate ANOVAs on the data from the pleasant and unpleasant contextual pictures. The ANOVA on the data from pleasant contextual pictures revealed a main effect of context, such that extremely pleasant contextual pictures elicited greater activity ($M = 0.07$, $SD = 0.09$) than mildly pleasant contextual pictures ($M = 0.01$, $SD = 0.04$), $F(1,15) = 4.99$, $p = .04$, partial $\eta^2 = .25$ (see Figure 6, left panel). There was also a Context × Second interaction, $F(5,75) = 4.49$, $p = .01$, partial $\eta^2 = .23$, but no simple effects of second were significant after controlling for familywise error rate. In any event, the main effect of context indicates that extremely pleasant contextual stimuli elicited greater positive affect than mildly pleasant contextual stimuli. The ANOVA on the data from unpleasant contextual pictures revealed no effects.

Moderately valent target pictures. Baseline activity levels over *zygomaticus major* preceding target pictures were submitted to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) mixed-model ANOVA. Paralleling the results obtained with the contextual stimuli, the ANOVA revealed a Context Condition Order × Context Condition interaction, $F(1,15) = 11.73$, $p = .004$, partial $\eta^2 = .44$, such that participants tended to show greater baseline activity during their first session. Participants who completed the mildly valent context condition first showed greater activity during the mildly valent context condition ($M = 1.61$, $SD = 0.12$) than during the extremely valent context condition ($M = 1.48$, $SD = 0.05$), $F(1,7) = 10.33$, $p = .02$, partial $\eta^2 = .60$; those who completed the extremely valent context condition first showed nonsignificantly greater activity during the extremely valent context condition ($M = 1.62$, $SD = 0.19$) than during the mildly valent context condition ($M = 1.55$, $SD = 0.14$), $F(1,8) = 3.05$, $p = .12$, partial $\eta^2 = .28$.

Change scores in EMG activity over *zygomaticus major* in response to the moderately valent target pictures are shown in Figure 7. A 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) × 6 (Second) mixed-model ANOVA on these data revealed no effects. These null effects indicate that, as expected, moderately pleasant pictures elicited no greater activity over *zygomaticus major* than moderately unpleasant pictures and that the context manipulation had little effect on activity over this site.

Activity over corrugator supercilii

Contextual pictures. Baseline levels of activity were submitted to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) mixed-model ANOVA, where context condition order was manipulated between subjects. The ANOVA revealed a main effect of context condition such that participants showed greater baseline activity during the extremely valent context ($M = 3.44$, $SD = 1.35$) than during the mildly valent context ($M = 3.20$,

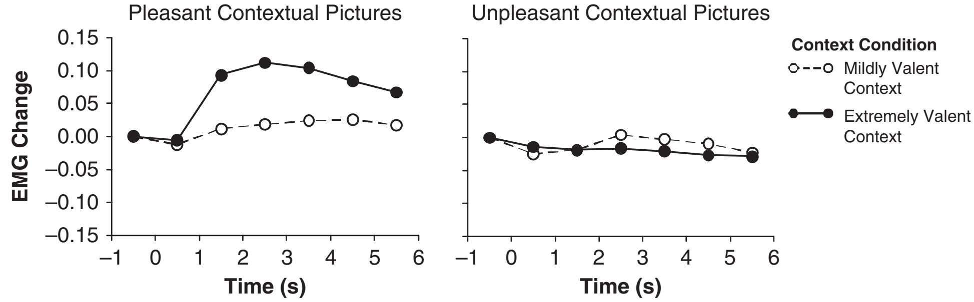

Figure 6. Change in EMG activity over *zygomaticus major* in response to Experiment 2's contextual pictures. The left panel shows reactions to mildly pleasant contextual pictures (hollow circles) and extremely pleasant contextual pictures (filled circles). The right panel shows reactions to mildly unpleasant (hollow circles) and extremely unpleasant (filled circles) contextual pictures.

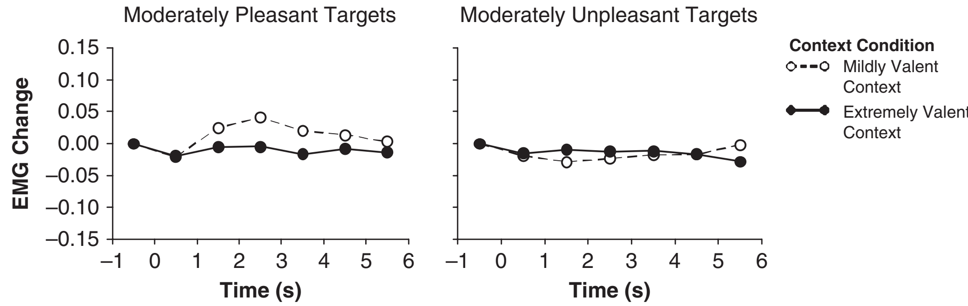

Figure 7. Change in EMG activity over *zygomaticus major* in response to Experiment 2's target pictures. The left panel shows reactions to moderately pleasant target pictures in the mildly valent context condition (hollow circles) and extremely valent context condition (filled circles). The right panel shows reactions to moderately unpleasant target pictures in the mildly valent context condition (hollow circles) and extremely valent context condition (filled circles).

$SD = 1.36$), $F(1,15) = 5.22$, $p = .04$, partial $\eta^2 = .26$. As in Experiment 1, one explanation for this difference in baseline activity is that participants found the extremely valent context condition more engaging than the mildly valent context condition.

Change scores in EMG activity over *corrugator supercilii* in response to pleasant and unpleasant contextual stimuli are shown in the left and right panels of Figure 8, respectively. We submitted these change scores to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) × 6 (Second) mixed-model ANOVA, where context condition order was manipulated between subjects. The ANOVA revealed several main effects and interactions, all of which were qualified by a Context × Stimulus Valence × Second interaction, $F(5,75) = 5.96$, $p < .001$, partial $\eta^2 = .28$.

To decompose the three-way interaction, we analyzed the data from the pleasant and unpleasant contextual stimuli separately. The ANOVA on the data from pleasant contextual stimuli revealed a main effect of context condition, such that extremely pleasant stimuli elicited less activity over *corrugator supercilii* ($M = -0.11$, $SD = 0.10$) than did mildly pleasant stimuli ($M = 0.00$, $SD = 0.10$), $F(1,15) = 17.53$, $p = .001$, partial $\eta^2 = .54$ (see Figure 8, left panel). There was also a Context × Second interaction, $F(5,75) = 6.28$, $p < .001$, partial $\eta^2 = .30$. Follow-up ANOVAs indicated that extremely pleasant contextual stimuli elicited less activity than mildly contextual stimuli during Seconds 1–5 after correcting for familywise error rate. The ANOVA on the data from the unpleasant contextual stimuli also revealed a main effect of context condition such that extremely unpleasant stimuli elicited greater activity over *corrugator supercilii* ($M = 0.16$, $SD = 0.25$) than did mildly unpleasant stimuli ($M = 0.05$, $SD = 0.07$), $F(1,15) = 5.09$, $p = .04$, partial $\eta^2 = .25$ (see Figure 8, right panel). There was also a Context × Second interaction, $F(5,75) = 3.85$, $p = .004$, partial $\eta^2 = .20$, but no simple effects of second were significant after correcting for familywise error rate. Taken together, these results indicate that extremely pleasant contextual stimuli elicited more positive affect than mildly pleasant contextual stimuli and that extremely unpleasant contextual stimuli elicited more negative affect than mildly unpleasant contextual stimuli.

Moderately valent target pictures. Baseline activity levels over *corrugator supercilii* preceding target pictures were submitted to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) mixed-model ANOVA. As with baseline activity preceding contextual pictures, there was a marginally significant main effect of context condition such that there was greater activity preceding targets in the extremely valent condition ($M = 3.37$, $SD = 1.30$) than in the mildly valent condition ($M = 3.16$, $SD = 1.34$), $F(1,15) = 3.20$, $p = .09$, partial $\eta^2 = .18$. As in Experiment 1, this baseline difference works against the affective relativity account's prediction that moderately pleasant pictures will elicit greater activity over *corrugator supercilii* in the extremely valent context condition. On the other hand, it works in favor of the affective relativity

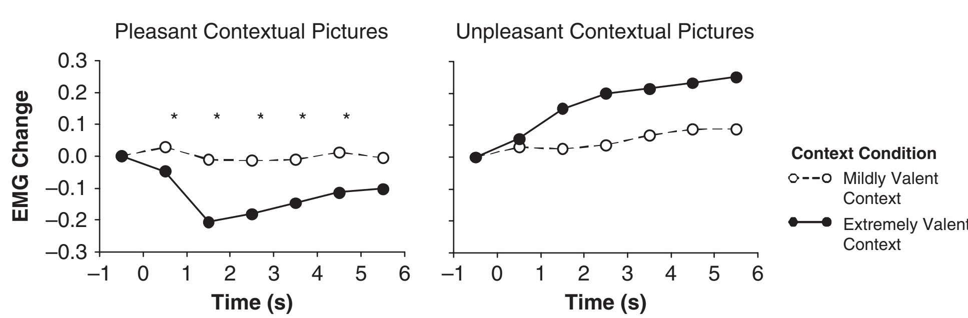

Figure 8. Change in EMG activity over *corrugator supercilii* in response to Experiment 2's contextual pictures. The left panel shows reactions to mildly pleasant contextual pictures (hollow circles) and extremely pleasant contextual pictures (filled circles). The right panel shows reactions to mildly unpleasant (hollow circles) and extremely unpleasant (filled circles) contextual pictures. Asterisks represent simple effects of second that are significant after correcting for familywise error rate.

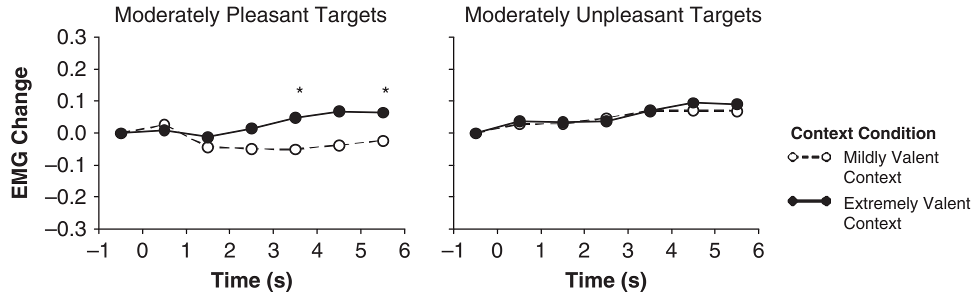

Figure 9. Change in EMG activity over *corrugator supercilii* in response to Experiment 2's target pictures. The left panel shows reactions to moderately pleasant target pictures in the mildly valent context condition (hollow circles) and extremely valent context condition (filled circles). The right panel shows reactions to moderately unpleasant target pictures in the mildly valent context condition (hollow circles) and extremely valent context condition (filled circles). Asterisks represent simple effects of second that are significant after correcting for familywise error rate.

account's prediction that moderately unpleasant pictures will elicit less activity over *corrugator supercilii* in the extremely valent context condition.

Change scores in EMG activity over *corrugator supercilii* in response to the moderately valent target pictures are shown in Figure 9. To determine if context influenced affective reactions to the moderately valent target stimuli, we submitted these data to a 2 (Context Condition Order: mildly vs. extremely valent context condition first) × 2 (Context Condition: mildly vs. extremely valent) × 2 (Stimulus Valence: pleasant vs. unpleasant) × 6 (Second) mixed-model ANOVA. The ANOVA revealed a main effect of stimulus valence, $F(1,15) = 5.32$, $p = .04$, partial $\eta^2 = .26$, which was qualified by a Context × Stimulus Valence × Second interaction, $F(1,75) = 3.22$, $p = .01$, partial $\eta^2 = .18$. To decompose the interaction, we analyzed the data from the pleasant and unpleasant targets separately.

The ANOVA on the data from the pleasant targets revealed a main effect of context condition such that moderately pleasant targets elicited less activity in the mildly pleasant context ($M = -0.03$, $SD = 0.10$) than in the extremely pleasant context ($M = 0.03$, $SD = 0.07$), $F(1,15) = 4.78$, $p = .04$, partial $\eta^2 = .24$. It also revealed a Context × Second interaction, $F(5,75) = 5.72$, $p < .001$, partial $\eta^2 = .28$ (see Figure 9, left panel). After correcting for familywise error rate, we found that moderately pleasant targets elicited less activity in the mildly pleasant context during Seconds 4 and 6. These results replicate Experiment 1's evidence that moderately pleasant pictures elicit more positive affect when embedded in a context of less pleasant pictures. They also indicate that affective relativity takes several seconds to emerge.

In contrast to the ANOVA on the data from the moderately pleasant targets, the ANOVA on the data from the moderately unpleasant target pictures revealed no significant effects (see Figure 9, right panel). This asymmetry provides initial evidence that moderately unpleasant pictures are less susceptible to affective relativity than are moderately pleasant pictures.

General Discussion

Replicating prior research, moderately pleasant pictures were judged more pleasant when they were the most pleasant pictures in the set than when they were not the most pleasant pictures. The more novel finding was that moderately pleasant pictures also elicited less EMG activity over *corrugator supercilii* when they were the most pleasant pictures in the set. Because activity over *corrugator supercilii* provides a psychophysiological marker of affective valence that is less sensitive to response biases than are affective ratings, these data help answer a question that Manis (1971) suggested may be unanswerable. Specifically, they indicate that context can influence both affective ratings and underlying affective reactions.

The hedonic treadmill is typically thought to operate in the long term in response to momentous life events (e.g., Brickman et al., 1978), but our data indicate that it can also operate in the short run in response to more commonplace events. Participants in Experiment 1's extremely positive context condition saw predominantly extremely pleasant pictures, and the EMG data over *corrugator supercilii* indicated that they consequently derived less positive affect from the occasional moderately pleasant target picture than did participants in the mildly pleasant context condition. In addition, Experiment 2 demonstrated that EMG activity to moderately pleasant target pictures was initially context independent and that context dependence only emerged in the latter half of the 6-s picture period. Thus, just as adaptation to momentous life events is a process, adaptation to more commonplace affective stimuli is also a process, albeit one that plays out over the course of seconds as opposed to weeks, months, or even years (cf. Diener, Lucas, & Scollon, 2006).

The finding that context dependence only emerged over time is also consistent with Larsen, McGraw, Mellers, and Cacioppo's (2004) evidence that context effects on emotional reactions to monetary outcomes take several seconds to emerge. In that study, participants continuously rated their emotional reactions to card games that lasted 12 s, including some games in which they won $5 but could have won an even larger amount (e.g., $12). Participants initially felt good about these *disappointing wins*, which suggests that their initial emotional reactions were governed entirely by the $5 win itself. Within several seconds, they also began to report feeling bad, which indicates that their subsequent emotional reactions were also governed by the context in which the $5 win occurred.

We investigated the hedonic treadmill by comparing EMG reactions to the same pictures collected during two sessions separated by 1 week in Experiment 2. We leave to future research the question of whether affective relativity can occur even within a single session. Parducci and Wedell (1986) have speculated that the "effective context" for judgment only includes the 12 stimuli immediately preceding the current stimulus (p. 515). Thus, a given moderately pleasant picture may elicit less activity over *corrugator supercilii* when preceded by 12 mildly pleasant pictures than when it is preceded by 12 extremely pleasant pictures elsewhere in the sequence of pictures. Such findings would indicate that affective reactions are remarkably malleable and that the hedonic treadmill can operate remarkably quickly.

Asymmetries of Valence

Despite numerous demonstrations that judgments of unpleasant stimuli are susceptible to affective contrast (e.g., Parducci, 1968), Experiment 2 provided little evidence for affective contrast in judgments of moderately unpleasant stimuli or evidence for affective relativity in facial EMG reactions to moderately unpleasant pictures. Taken together, these data suggest that moderately unpleasant targets elicited comparable levels of negative affect in the two context conditions. One possibility is that our context manipulation was less effective on the unpleasant portion of the valence dimension than on the pleasant portion. Valence ratings of the contextual stimuli indicate otherwise. The difference in valence ratings between mildly and extremely unpleasant contextual stimuli was, if anything, greater than that between mildly and extremely pleasant contextual stimuli. Drawing on the attitude strength literature (e.g., Krosnick & Petty, 1995), another possibility is that evaluations of moderately unpleasant pictures are more resistant to contextual factors than are evaluations of moderately pleasant pictures. If so, the finding that moderately unpleasant pictures were less sensitive to context than moderately pleasant pictures provides a demonstration of the *negativity bias*, which refers to the tendency for negativity to be more impactful than positivity (Cacioppo & Berntson, 1994;for a recent review, see Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001).

Possible Limitations and Directions for Future Research

The potential role of nonaffective determinants of activity over corrugator supercilii. As discussed above, greater task engagement is associated with greater activity over *corrugator supercilii*. We have already speculated that participants in Experiment 1's extremely pleasant context condition tended to be more engaged in the task than those in the mildly pleasant context condition, but here we address the separate issue of whether stimulus-dependent fluctuations in task engagement can account for our evidence for affective relativity.[5] Task engagement can only provide an alternative interpretation for our findings if the appearance of moderately pleasant target pictures prompted greater increases (or smaller decreases) in task engagement in the extremely pleasant context than in the mildly pleasant context. If that were the case, then moderately pleasant target pictures may have elicited more activity over *corrugator supercilii* in the extremely pleasant context even if they elicited no less positive affect. It is unclear, however, why the appearance of moderately pleasant target pictures would prompt greater task engagement in the extremely pleasant context. In fact, it is more plausible that moderately pleasant pictures would prompt greater task engagement in the *mildly pleasant* context because they were more evocative than the mildly pleasant contextual pictures. Thus, it does not appear that task engagement can account for our findings.

Confusion and concentration are also associated with furrowed eyebrows (Rozin & Cohen, 2003) and, by extension, with greater activity over *corrugator supercilii*. Thus, moderately pleasant target pictures may have elicited more activity over *corrugator supercilii* in the extremely pleasant context because participants found those pictures more confusing or concentrated on them more closely than did participants in the mildly pleasant context. Again, however, it is unclear why participants in the extremely pleasant context would have found moderately pleasant pictures more confusing or concentrated on them more closely.

Finally, it is plausible that moderately pleasant target pictures were more surprising in the mildly pleasant context because they were more evocative than the mildly pleasant contextual pictures. If surprise inhibits activity over *corrugator supercilii*, then our context effects on *corrugator supercilii* may have been due to surprise rather than affective relativity. There is little evidence, however, that surprise does inhibit activity over *corrugator supercilii*. Unexpected sounds nonsignificantly inhibited activity over *corrugator supercilii* in one of two studies conducted by Stekelenburg and van Boxtel (2002), but they significantly *increased* activity over *corrugator supercilii* in the other study. Reisenzein, Bördgen, Holtbernd, and Matz (2006) did find that an unexpected stimulus significantly inhibited activity over *corrugator supercilii*, but participants found the unexpected stimulus (i.e., a picture of the participant's own face embedded in a series of other people's faces) just as amusing as it was surprising. In light of Stekelenburg and van Boxtel's findings and the variety of evidence that positive affect inhibits activity over *corrugator supercilii*, the inhibition observed by Reisenzein et al. was probably due to amusement, not surprise. Thus, even if moderately pleasant target pictures were more surprising in the mildly pleasant context, surprise cannot account for our findings.

In sum, there is little reason to suspect that the context dependence of activity over *corrugator supercilii* was due to context effects on task engagement, confusion, concentration, or surprise. Context did influence self-reported positive affect, however, so there is good reason to conclude that the context dependence of activity over *corrugator supercilii* was a result of context effects on affective reactions.

The question of spontaneity. In addition to measuring EMG activity, we asked participants how pleasant they found each picture. Participants might have considered how they would rate each picture while it was still on the screen. Through what might be termed anticipatory self-perception (cf. Bem, 1972; Sherman et al., 1978), the ratings participants anticipated making after the picture disappeared may have influenced their affective reactions during the picture. For instance, response biases may have led an individual in Experiment 1's extremely pleasant context condition to decide early on in the picture period to rate a moderately pleasant target picture as *not at all pleasant* even though she actually found it moderately pleasant. During the remainder of the picture period, she might have convinced herself that it really was not at all pleasant. As a result, the picture would elicit more activity over *corrugator supercilii* than if she had been in the mildly pleasant context and had decided to rate the picture *extremely pleasant*. In light of Dimberg's (1997) finding that affective stimuli influence facial EMG even when participants are not asked to think about their affective reactions, we find it unlikely that such a complex mechanism resulted in affective contrast. Nonetheless, the fact that our task required participants to rate how pleasant they found each picture prevents us from concluding that affective relativity occurs spontaneously. A stronger case for spontaneity would come from evidence that affective relativity occurs even when participants are given a task that does not require them to rate how pleasant they find the stimuli.

[5]We focus on Experiment 1 in this section, but the logic applies just as well to Experiment 2.

Physiological and Functional Bases of Affective Relativity

Facial EMG provides a more proximal measure of affective reactions than self-reports do, but greater insight into affective relativity may come from investigating the neural circuits that actually generate those affective reactions. Reward processing in the mesencephalic dopamine system, which has been associated with positive affect (Ashby, Isen, & Turken, 1999), appears to be context dependent. For instance, dopaminergic neurons in the ventral tegmental area fire more in response to unexpected rewards than to expected rewards (for a review, see Schultz, 1998). Some of these neurons project to the nucleus accumbens, a component of the basal ganglia, which mediates affective influences on the facial musculature (Rinn, 1984). Thus, one possibility is that affective relativity in the facial musculature reflects context sensitivity in the mesencephalic dopamine system.

James (1907/1995) contended that thinking is for doing. Perhaps even more so, feeling is for doing (Zeelenberg & Pieters, 2006). From this perspective, affective relativity may be an adaptive feature of the affect system (Schwarz, 2007). Global environments can offer arrays of stimuli that vary widely in desirability, but local environments typically offer a narrower range of options. In impoverished environments, a moderately pleasant stimulus may be the most appealing option available. Thus, an intense positive affective reaction to that stimulus could foster adaptive behavior by facilitating approach. In more plentiful environments, however, the same moderately pleasant stimulus may be the least appealing option. In those environments, a muted affective reaction could foster adaptive behavior by *inhibiting* approach. Whatever future research on the functional bases of affective relativity reveals, our findings indicate that one of Ross and Nisbett's (1991) fundamental lessons of social psychology applies even when it comes to such basic phenomena as affective reactions. In short, context matters.

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