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Mind at Ease Puts a Smile on the Face: Psychophysiological Evidence That Processing Facilitation Elicits Positive Affect

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The affect system, in its position to monitor organismic–environmental transactions, may be sensitive to the internal dynamics of information processing. Hence, the authors predicted that facilitation of stimulus processing should elicit a brief, mild, positive affective response. In 2 studies, participants watched a series of neutral pictures while the processing ease was unobtrusively manipulated. Affective reactions were assessed with facial electromyography (EMG). In both studies, easy-to-process pictures elicited higher activity over the region of zygomaticus major, indicating positive affect. The EMG data were paralleled by self-reports of positive responses to the facilitated stimuli. The findings suggest a close link between processing dynamics and affect and may help understand several preference phenomena, including the mere-exposure effect. The findings also highlight a potential source of affective biases in social judgments.

Basic evaluative processes have long been of interest to psychologists. Such processes are central for theorists interested in attitudes (Eagly & Chaiken, 1998; Petty & Wegener, 1998), emotion (Niedenthal & Kitayama, 1994; Zajonc, 1998), and judgment (Clore, Schwarz, & Conway, 1994; Forgas, 1995). Traditionally, research focused primarily on descriptive determinants of evaluations. For example, attitude researchers explore how people integrate positive and negative features of a stimulus into an evaluative judgment (Skowronski & Carlston, 1989; Tesser & Martin, 1996). Emotion researchers study how feelings are determined by beliefs in the form of appraisals and attributions (Ellsworth, 1991; Frijda, 1988; Weiner, 1985). Researchers interested in automaticity investigate how a quick analysis of rudimentary stimulus features may result in automatic evaluative responses and affective priming (e.g., Bargh, Chaiken, Raymond, & Hymes, 1996; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Greenwald & Banaji, 1995; Murphy & Zajonc, 1993; Winkielman, Zajonc, & Schwarz, 1997). In contrast to these approaches, we build on earlier work to examine whether evaluations are sensitive to the dynamic aspect of mental operations, such as the ease of stimulus processing. To support this proposal, we present data showing that facilitation of stimulus processing leads to physiological responses indicative of positive affect as well as self-reports of higher liking.

Evaluations and Processing Dynamics

The notion that evaluations are sensitive to the dynamical aspects of information processing dovetails with a growing understanding that judgments reflect not only the descriptive factors, or what comes to mind, but also how things come to mind. This understanding informs a variety of research programs. Several researchers emphasize the role of subjective experiences such as the feeling of fluency or recall difficulty (Clore, 1992; Jacoby, Kelley, & Dywan, 1989; Jost, Kruglanski, & Nelson, 1998; Schwarz, 1998; Strack, 1992). These experiences not only are used by people to form a variety of judgments but can even override the implications of available descriptive information (Schwarz et al., 1991; Winkielman, Schwarz, & Belli, 1998). The focus on how things come to mind is also shared by the dynamical systems approach to social psychology (Nowak & Vallacher, 1998; Tesser, McMillen, & Collins, 1997) and connectionism (Eiser, 1994; Read & Miller, 1998; Smith, 1996). These approaches highlight that temporal and structural aspects of information processing may manifest themselves in subjective experiences and enter as input into a variety of judgments.

The central thesis of this article is that processing ease is associated with positive affect. This idea is consistent with several lines of evidence. For instance, people tend to prefer stimuli to which they are repeatedly exposed, a phenomenon known as the mere-exposure effect (Bornstein, 1989; Harrison, 1977; Zajonc, 1968). Research in cognitive psychology suggests that repeated exposure facilitates stimulus processing. This is reflected in faster stimulus recognition, higher judgments of stimulus clarity and duration, and a decrease in activation in relevant brain areas as a

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result of repetition (Desimone, Miller, Chelazzi, & Lueschow, 1995; Haber & Hershenson, 1965; Jacoby & Dallas, 1981; Whittlesea, Jacoby, & Girard, 1990; Witherspoon & Allan, 1985). In addition, people prefer stimuli that are average, prototypical, or symmetrical or that represent "good" figures (see Berlyne, 1974; Halberstadt & Rhodes, 2000; Langlois & Roggman, 1990; Martindale & Moore, 1988; Rhodes & Tremewan, 1996). Interestingly, averageness, prototypicality, symmetry, and pattern "goodness" are also associated with fast and efficient processing (Checkosky & Whitlock, 1973; Johnstone, 1994; Palmer, 1991; Posner & Keele, 1968; Rosch & Lloyd, 1978).

However, the most compelling evidence for the connection between ease and liking comes from studies that directly manipulated processing dynamics. In one study, processing of target words was manipulated by embedding them in a predictive or nonpredictive semantic context ("stormy seas tossed the *boat*" vs. "stormy seas tossed the *lamp*"). The words embedded in the predictive context were pronounced faster, indicating easier processing, and were judged as more pleasant (Whittlesea, 1993, Experiment 5). Although suggestive, it remains unclear whether participants' preference ratings reflected their reactions to the target word or to the congruity of the whole context. Fortunately, Reber, Winkielman, and Schwarz (1998) were able to demonstrate increases in preference judgments as a result of unobtrusive facilitation of processing. In several studies, participants were asked to evaluate a series of target pictures, ranging from everyday objects to abstract shapes. The processing of those targets was facilitated through various methods, such as subliminal visual priming or subtle increases in presentation duration and figure-to-ground contrast. Independent of the specific stimuli and manipulations used, the participants indicated higher preference for easy-to-process pictures.

Cognitive Accounts of Processing–Liking Connection

The studies just cited suggest that evaluations may be sensitive to processing dynamics. However, several popular models account for such findings without any reference to the affect system. Instead, these models suggest that changes in evaluations reflect a two-step cognitive process. The general logic of these models is as follows. As a first step, processing manipulations lead to a change in a cognitive experience of the stimulus. As a second step, participants explain the change in the experience by relating it to evaluative or other features of the stimulus. As reviewed later, there are several kinds of such "two-step" models. Although these models differ in their assumptions about the specific nature of the elicited cognitive experience, they are similar in two respects critical to the current project. First, they assume that changes in experience are affectively neutral and have no genuine affective consequences. Second, they assume that the process of explaining the change in the cognitive experience is equally likely to lead to more positive or more negative evaluations of the stimulus, depending on the context.[1] These assumptions contrast with our alternative model, as discussed shortly.

Nonspecific activation model. According to this model, processing manipulations do not elicit any affective reactions but "merely produce the greater accessibility of the activated representation" (Mandler, Nakamura, & Van Zandt, 1987, p. 646). Further, the nonspecific activation model assumes that processing manipulations can influence any judgment made about the stimulus, including judgments of liking and disliking. Specifically, "the hypothesis is that the prior exposure generates and activates the stimulus representations, and that such activation may then be related to any judgment about the stimuli that is stimulus relevant" (Mandler et al., 1987, p. 647).

Fluency-attribution model. This model proposes that processing manipulations lead to an affectively neutral experience of fluency (Bornstein & D'Agostino, 1994; Jacoby et al., 1989; Seamon, Brody, & Kauff, 1983). The fluency-attribution model also assumes that processing facilitation should enhance any judgment about the stimulus because participants try to arrive at "the most parsimonious and reasonable explanation" of "the experience of perceptual fluency, given situational constraints and the available contextual cues." In the process, participants will attribute the experience "to liking or, for that matter, to any variety of stimulus properties that the subject is asked to rate" (Bornstein & D'Agostino, 1994, pp. 106–107).

Familiarity-attribution model. Several researchers have proposed that processing manipulations elicit a vague feeling of familiarity (Bonanno & Stillings, 1986; Klinger & Greenwald, 1994; Smith, 1998). This experience is also assumed to be affectively neutral and able to influence a variety of judgments, depending on contextual factors. Specifically, "in the context of performing liking judgments, misattributions to liking and disliking are likely because the goal of the subject is to form a preference" (Klinger & Greenwald, 1994, p. 77). Such misattributions are likely because "subjects are highly susceptible to subtle suggestions as to the particular stimulus qualities that might be taken as the source of their subjective experience" (Smith, 1998, p. 416).[2]

Affective Account of Processing–Liking Connection

The cognitive explanations just discussed assume that the effects of processing facilitation on evaluations can be explained by the same mechanisms as effects of processing facilitation on other "nonaffective" judgments (e.g., fame, truth, clarity). This is a reasonable assumption, especially in light of the success of two-step models in the nonevaluative domain (for a review, see Kelley & Jacoby, 1998). However, the ease–liking connection might be more than just an "illusion" created by participants' attempts to explain their cognitive experiences. Instead, this phenomenon may reveal something interesting about the affect-cognition interface. Thus, as an alternative to the "cold," two-step accounts, we suggest an alternative "hot" account. We refer to this account as the hedonic fluency model (see also Winkielman, Schwarz, Fazendeiro, & Reber, in press). The model proposes (a) that processing facilitation elicits a genuine affective reaction and (b) that the affective reaction is hedonically positive. This proposal is consistent with theoretical and empirical considerations.

[1] The two-step models were primarily developed to account for the mere-exposure effect. Accordingly, they do not explicitly deal with the effects of manipulations other than stimulus repetition. However, their general logic extends to other manipulations of processing dynamics.

[2] Some versions of the familiarity model suggest that the feeling of familiarity is positively marked. We return to this issue in the General Discussion.

On a general theoretical level, the hedonic fluency model is grounded in the assumption that affective feedback is one of the ways organisms internally monitor changes in their cognitive processing and organization (Oatley & Johnson-Laird, 1987; Reisenzein, 1998; Simon, 1967). There is a clear anatomical basis for such a feedback mechanism: Many brain structures, including prefrontal cortex, amygdala, and hippocampus, are critically involved in both cognitive and affective processing, and both types of processing often occur simultaneously (Damasio, 1999; Fernandez-Duque, Baird, & Posner, 2000; Lane et al., 1998; LeDoux, 1996; Rolls, 1999). A more specific assumption of the model is that facilitation of processing leads to a positive affective reaction. There are several reasons for this assumption. First, easy processing may indicate good progress toward the goal of successful recognition and coherent interpretation of the target (Carver & Scheier, 1990; Simon, 1967; Vallacher & Nowak, 1999). Experiencing such progress as pleasant may be not only informative but also rewarding and hence play a motivational role in bringing a cognitive activity to completion (Ramachandran & Hirstein, 1999). Second, easy processing may be pleasant because it indicates the availability of appropriate knowledge structures to deal with a current situation (Bless & Fiedler, 1995; Schwarz, 1990). In summary, the prior theoretical considerations converge on the assumption that the fluency signal might be hedonically marked because it says something about a positive state of affairs either within the cognitive system or in the world.

On the empirical level, the hedonic fluency model predicts that manipulations that result in processing facilitation should lead to a brief positive affective reaction. Further, this positive reaction should be manifested in higher evaluative judgments as well as physiological indicators of the underlying affective response. Two-step models, in contrast, predict that any effects of fluency should be restricted to ratings and should not manifest as brief affective reactions on psychophysiological measures. Further, any observed effects on ratings should depend on the judgmental context. This is because the judgmental context determines what qualities of the stimulus participants see as responsible for their cognitive experience. Accordingly, processing facilitation in a "positive context" should enhance positive judgments, whereas processing facilitation in a "negative context" should enhance negative judgments.

Several previous studies tried to address the nature of evaluative responses elicited by fluency. This was primarily done by manipulating the judgmental context with different framing of evaluative judgments. Seamon, McKenna, and Binder (1998) used the mere-exposure paradigm and found that stimulus repetition enhances judgments of "liking" but not judgments of "disliking" (see also Mandler et al., 1987, for a similar finding). Reber et al. (1998) used figure-to-ground contrast and presentation duration as fluency manipulations and found that participants rated the easy-to-process stimuli as more "pretty" and less "ugly" or as more "likable" and less "dislikable." Although these findings are consistent with the hedonic fluency proposal, they are not definitive. Specifically, an objection can be raised that judgments of disliking or ugliness are less "natural" than judgments of liking and prettiness. In fact, Mandler et al. (1987) suggested that in their studies repeated exposure increased liking but not disliking because "disliking is a complex judgment, often based on the absence of a liking response. Linguistically, liking is the unmarked and disliking the marked end of the imputed continuum" (p. 647). Supposedly, participants asked to make disliking/ugliness judgments recode them into liking/prettiness judgments and simply reverse their responses, thus creating a context in which changes in the cognitive experience are linked to positive stimulus attributes. In sum, the available research is inconclusive regarding the positive marking of processing fluency.

The Present Research

The purpose of the current research was to provide evidence for the hedonic fluency model. This model predicts that processing facilitation should be accompanied by an increase in positive evaluations but should not be accompanied by an increase in negative evaluations, even if the rating context is negative. Further, processing facilitation should produce brief positive affective reactions, as revealed by incipient facial activity monitored by electromyography (EMG). These predictions cannot be derived from the two-step models, which suggest that processing facilitation has no affective consequences but leads only to context-dependent changes in ratings. In testing these predictions, we draw on two developments in theory and measurement of the affect system.

Positive and Negative Affect

Several conceptualizations of evaluative processes, such as the bivariate model of evaluative space proposed by Cacioppo and Berntson (1994), highlight that the mechanisms underlying the experience and processing of positive and negative affect are supported by separable neural substrates. Accordingly, a full characterization of an affective process requires going beyond traditional bipolar scales (Cacioppo, Gardner, & Berntson, 1997). Note that an increase in evaluation on traditional bipolar scales may reflect an increase in positive affect, a decrease in negative affect, or a combination of both. According to the hedonic fluency hypothesis, however, the effect of processing facilitation should be more evident in positive affect. Therefore, in the current studies, we used unipolar self-report and psychophysiological measures that selectively reflect the activity of positive and negative affect. For both the self-report and psychophysiological measures, we predicted that processing facilitation would selectively influence the unipolar component tapping into positive affect.

The use of proper unipolar measures can also address the criticisms of the "judgment framing" studies raised by proponents of the two-step models. As discussed, two-step models argue that participants find the "disliking" or "ugliness" framing unnatural and make the usual "liking" or "prettiness" rating and simply reverse their response. Accordingly, in our studies, we did not ask participants to focus on and report disliking (i.e., presumably liking reversed) but focused them selectively on their negative responses. As shown by previous research, participants are able to report such negative responses, if they are indeed present (e.g., Cacioppo et al., 1997; Ito, Cacioppo, & Lang, 1998). In sum, according to the two-step models, participants focused on their negative reactions should give more negative ratings to the easy-to-process stimuli. In contrast, according to the hedonic fluency model, there should be no effect of processing facilitation on negative reactions.

EMG Measurement

The current studies also reflect the growing appreciation among social psychologists for the value of psychophysiological measures (Cacioppo, Tassinary, & Berntson, 2000; Winkielman, Berntson, & Cacioppo, 2001). These measures allow researchers to evaluate theoretical accounts that differ on whether they predict a physiological manifestation of a psychological process. Psychophysiological measures also allow for nonverbal and implicit assessment of the underlying process. Further, in some domains, the psychophysiological measures offer sensitivity unmatched by more traditional measures, like self-reports or reaction times. In sum, psychophysiological measures are especially valuable if the purpose is to contrast theories that make different predictions regarding a process that is affective, nonlinguistic, and subtle, as is the case in the research on the affective consequences of processing dynamics.

Past research on the fluency–affect link was mostly based on self-reports. This leaves unclear whether the effects of processing facilitation have genuine affective consequences, as suggested by the current hypothesis, or are affectively neutral, as suggested by the two-step models. Further, despite the progress in affect measurement, the self-report data are vulnerable to complexities inherent to participants having to interpret the question and the response scale (Schwarz, 1999). Accordingly, in the current research, we used facial EMG (for a review, see Tassinary & Cacioppo, 2000). This measure can be useful as a marker of an affective response (Cacioppo, Martzke, Petty, & Tassinary, 1988). A large number of studies show that positive affective responses manifest themselves in incipient smiles, as reflected by higher activity over the region of zygomaticus major, or the cheek muscle, whereas negative affective responses manifest themselves in incipient frowns, as reflected by higher activity over the region of corrugator supercilii, or the brow muscle (Bradley, 2000; Cacioppo, Petty, Losch, & Kim, 1986; Dimberg, 1990; Lang, Greenwald, Bradley, & Hamm, 1993). Facial EMG can detect affective reactions to mild stimuli that produce only minute, brief facial muscle responses so fast and so small as to produce no facial movement or expression (Cacioppo, Bush, & Tassinary, 1992; Dimberg, Thunberg, & Elmehed, 2000). In sum, facial EMG is a useful technique for examining the hedonic fluency model, which predicts that processing facilitation should result in mild positive responses, as reflected in higher activity of the zygomaticus muscle.

Overview

Two studies investigated whether processing facilitation leads to selectively positive responses. In both studies, physiological manifestations of affective change were monitored with facial EMG. Following earlier research, we measured muscular activity over the cheek (zygomaticus major) region and over the brow (corrugator supercilii) region. We also measured activity around the left eye (orbicularis oculi) to monitor blinking (Cacioppo, Tassinary, & Fridlund, 1990).[3] To provide convergent evidence, we also collected participants' self-reports under two different evaluative orientations (Cacioppo et al., 1997). In Study 1, we induced a unipolar evaluative orientation by asking some participants to selectively focus and report their positive responses and asking others to selectively focus and report on their negative responses. However, we also wished to ensure that results of Study 1 were not contingent on the use of a unipolar orientation. Thus, in Study 2, we asked all participants to focus on both positive and negative reactions and gave them a bipolar scale that allowed for both positive and negative responses.

We studied the effects of fluency on evaluations with two different manipulations of processing dynamics. In Study 1, processing of some visual targets was facilitated with unobtrusive contour primes that matched the target picture. This manipulation was based on findings that briefly presented degraded visual contour initiates the process of visual recognition. The facilitation resulting from such priming is expressed in easier recognition of matched targets, as indexed by naming accuracy and recognition speed (Bar & Biederman, 1998; Reber et al., 1998). In Study 2, processing of targets was manipulated by subtle differences in presentation duration. This manipulation was based on findings that longer presentation facilitates extraction of information (Mackworth, 1963). The use of duration manipulation allows for a conceptual replication of Study 1. It also addresses an interesting side issue of whether positive affect can be elicited by enhancing fluency with means other than stimulus repetition. We return to this issue in the Discussion section.

Study 1

Method

Overview. Participants watched a series of neutral pictures of everyday objects. The processing ease of these pictures was manipulated by a subliminally presented contour prime that either matched or mismatched the target. Participants' facial EMGs and self-reports of liking were collected. We expected that easy-to-process targets would elicit physiological responses and self-reports indicative of positive affect.

Participants and procedure. Sixteen undergraduate students gave informed consent and participated in exchange for partial credit toward a psychology course requirement. On arriving in the lab, participants were told that the study was concerned with "how people form impressions of various stimuli and how the body and the brain respond to those stimuli." The brain was mentioned to distract participants from focusing on their facial responses. After the attachment of the electrodes, the participant was taken to an electrically and acoustically shielded room. In this room, the EMG electrodes were connected to a headbox that amplified the signals and relayed them to an amplifier located in a control room. Once the participant was connected to the EMG equipment, he or she was left alone for several minutes to adjust to the room and the electrodes. After this adjustment period, the experimenter returned to the room with instructions for the task (see later discussion). After five practice trials, the experiment began. After the experiment was completed, all participants were debriefed, thanked, and dismissed.

Stimulus presentation. Target pictures were 20 black-and-white line drawings of various neutral objects (e.g., horse, airplane, bird, dog, house) standardized on name agreement, image agreement, familiarity, and visual complexity (Snodgrass & Vanderwart, 1980). To slow target recognition, a random pattern consisting of small dots was added to each picture by using the "add random noise function" in Adobe Photoshop. As determined

[3] EMG activity over the medial frontalis region was also monitored, but because activity over this site is irrelevant to the test of the experimental hypotheses, data from this site are not reported. Results are available from Piotr Winkielman.

in pretests, the presence of this pattern does not prevent identification of any target. The pictures were approximately 10 × 10 cm in size and were shown on a 15-in. (38.1 cm) monitor located approximately 80 cm away from the participant. Each target was preceded by a prime consisting of a visual contour. The contours were constructed by deleting the inside details of the target picture and degrading it with a visually dense random pattern. Half of the targets were preceded by contours that matched the targets and half by contours that did not match the targets. As shown in earlier research, matched contours facilitate target recognition (Bar & Biederman, 1998; Reber et al., 1998).

A trial started with a fixation cross shown for 4 s. Next, a prime was presented for approximately 16 ms (one screen refresh) and immediately followed by a target presented for 600 ms. After a 6-s pause, the participant was prompted to rate the stimulus. This rating was made on a response box with four buttons. Some participants rated the degree of their positive response to the stimulus on a scale ranging from 1 (*no positive reaction*) to 4 (*very positive reaction*), whereas others rated their negative response to the stimulus (1 = *no negative reaction;* 4 = *very negative reaction*). After the judgment, there was a 3-s pause and the next trial began. Presentation of pictures, collection of responses, and integration with the EMG measurement were controlled by the STIM package (Neuroscan Corporation, Sterling, VA).

Design. The study represented a 2 × 2 mixed design. The within-subject factor was the type of prime presented before the target picture (matched vs. mismatched). The between-subject factor was the participants' evaluative orientation (positive vs. negative). The assignment of participants to the between-subject conditions was random. The match between targets and primes was counterbalanced so that the same targets were preceded by matching primes for some participants and by mismatching primes for other participants.

EMG measurement. Facial EMGs were recorded with pairs of silver/silver chloride surface electrodes placed on the left side of the face. Two adjacent electrodes referenced to one another were each placed over the region of the zygomaticus major (cheek), corrugator supercilii (brow), and orbicularis oculi (eye corner). An additional ground electrode was placed on the upper forehead region. The impedances of all electrodes were reduced to less than 10 kΩ. The location of the electrodes and the recording technique conformed to the standards for EMG recording (Cacioppo et al., 1990). The acquisition of the EMG signals was controlled by the Synamps Amplifier and the SCAN software manufactured by Neuroscan Corporation. The signals were immediately amplified by a factor of 150 at the headbox located near the participant and by a factor of 500 at the amplifier. The signals were filtered on-line with a low pass of 500 Hz and a high pass of 10 Hz and sampled at 2048 Hz.

The raw EMG signals can be viewed as a voltage-time function, in which the ordinate represents signal amplitudes scaled in terms of microvolts and the abscissa represents discrete intervals of time of width 1/sampling rate. On such raw signals, several data-processing steps were performed off-line (for details, see Fridlund & Cacioppo, 1986; Tassinary & Cacioppo, 2000). First, the signals were integrated, rectified, and screened for movement artifacts. Second, the data were logarithmically transformed, which reduces the impact of extreme values. Third, the data were standardized (i.e., expressed as Z scores) within subjects and muscle sites, which attenuates the undue impact of highly reactive individuals on group scores and allows meaningful comparisons across sites.

After these initial processing steps, the average EMG activity in periods of interest was derived. First, we calculated the activity in the prestimulus level and used it as a baseline (for discussion of baselines, see Fridlund & Cacioppo, 1986). This was done by taking the average of EMG activity during the last 3 s while participants viewed the 4-s fixation cross before target presentation. We excluded the first second to avoid artifacts resulting from muscle action associated with visual orienting. Next, we calculated the poststimulus level by taking the average activity during the 2-s period after the target offset. Again, we excluded the initial period to avoid artifacts resulting from visual orienting. Finally, we calculated change scores by subtracting the baseline level from the poststimulus level and used those scores in statistical comparisons, as presented later. In sum, the numbers used in statistical analyses and presented in the tables represent a difference in the level of standardized EMG activity between the 3-s prestimulus baseline period and the 2-s poststimulus period.

Manipulation check. After the main part of the experiment, all participants were asked whether they noticed any differences in how various pictures were presented or whether they had noticed any "flashing" pictures. None of the participants answered affirmatively to these questions, indicating that the priming manipulation was indeed unobtrusive.

Results

EMG data. Table 1 shows participants' EMG activity as a function of the processing manipulation, evaluative orientation, and facial site. As discussed in the Method section, the numbers represent the change in standardized scores from the baseline period to the 2-s period immediately after the offset of the stimulus. The primary analyses focused on the EMG activity over the facial region associated with positive reactions (zygomaticus) and the region associated with negative reactions (corrugator). A mixed measures multivariate analysis of variance (MANOVA) with prime (matched/mismatched), muscle (zygomaticus/corrugator), and evaluative focus (positive/negative) revealed a three-way interaction, $F(1, 14) = 5.05$, $p = .04$. Decomposing this interaction revealed a two-way interaction between muscle and prime in the positive focus condition, $F(1, 7) = 10.30$, $p = .01$, and no significant effects in the negative focus condition ($Fs < 1$). Analyses of simple effects revealed only the predicted effect of processing facilitation on the zygomaticus region. Specifically, in the positive focus condition, the activity over the zygomaticus region was greater when targets were preceded by matched primes rather than mismatched primes, $t(7) = 2.51$, $p = .04$. The selective effect of processing facilitation on the physiological measure of positive affect is consistent with our predictions and inconsistent with the

Table 1
Electromyographic (EMG) Activity and Self-Reports as a Function of Evaluative Focus and Prime

	Evaluative focus			
	Positive		Negative	
Prime	Matched	Mismatched	Matched	Mismatched
Measure				
EMG site				
Zygomaticus	.31	−.78	−.13	−.09
Corrugator	−.45	.09	.30	−.12
Orbicularis	.51	.05	.83	.63
Self-report	2.46	2.19	2.07	1.95

Note. EMG data represent change in the average level of standardized activity between the prestimulus baseline (looking at a fixation cross) and the period immediately after the stimulus offset. Self-reports represent ratings on a scale ranging from 1 (*no positive/negative reaction*) to 4 (*very positive/negative reaction*).

prediction of two-step models that processing facilitation has no affective consequences.[4]

Additional analyses revealed that the effect of processing facilitation on the activity over the zygomaticus region was only significant in the period immediately after the stimulus but not in later periods (Seconds 3, 4, or 5 or any combination thereof). This suggests that the zygomaticus activity reflects a spontaneous affective response to the stimulus and not strategic processes or anticipation of the explicit judgment. Analyses of the activity over the orbicularis oculi, associated with blinking, confirmed that activity did not vary as a function of the prime or evaluative orientation.

Judgment data. Table 1 also shows participants' judgments of target pictures. Participants focused on positive reactions gave higher ratings to easy-to-process stimuli ($M = 2.46$ vs. 2.19), $t(7) = 2.2$, $p = .03$.[5] On the other hand, processing manipulation had no effect on judgments of participants focused on their negative reactions ($t < 1$). These data are again consistent with the hedonic fluency model, which predicts a selective increase of positive responses to easy-to-process stimuli. On the other hand, the data are inconsistent with the two-step models, which predict that processing facilitation increases both positive and negative responses depending on the judgment context.

Discussion

Study 1 supported the predictions derived from the hedonic fluency model. The general hypothesis that changes in processing dynamics have genuine affective consequences was supported by the presence of EMG reactions indicative of affective change. This observation is incompatible with the predictions of the two-step models that effects of processing facilitation should be restricted to the level of self-reports. The specific hypothesis that processing facilitation selectively influences positive affect was also supported across two convergent measures. Easy-to-process targets were associated with higher EMG activity over the zygomaticus region. Further, participants' self-reports indicated a selective increase in positive reactions. Contrary to the prediction of the two-step models, processing facilitation did not influence self-reports of negative affect, even when participants were exclusively focused on their negative reactions.

Study 2

Study 2 was designed to replicate and extend the results of Study 1. Again, participants watched a series of pictures of neutral everyday objects. In this study, however, processing was facilitated by subtle increases in presentation duration of some pictures. We expected that pictures presented slightly longer would elicit more positive responses, as reflected in an increase in the zygomaticus activity and self-reports indicating positive affect. This prediction is based on findings showing that longer presentation facilitates extraction of information (Mackworth, 1963). The use of the duration manipulation offers a conceptual replication of our hypothesis that processing ease is hedonically positive. Further, it bears on an interesting side issue of whether affective consequences of fluency can be demonstrated with a manipulation that does not rely on repetition of any aspect of the target stimulus.

The use of duration manipulation can clarify the meaning of the zygomaticus pattern from Study 1. Specifically, because Study 1 did not have a "no-prime" condition, it is unclear whether the obtained zygomaticus effect reflected an increase in positive affect as a result of facilitatory influences of the matched prime or perhaps a decrease in positive affect as a result of inhibitory influences of the mismatched prime. Further, the design of the study required a baseline period during which participants looked at a familiar, simple stimulus: a fixation cross. This may elevate the baseline level of zygomaticus activity and make the change scores difficult to interpret. However, if in Study 2, which uses an identical baseline measure, the facilitatory duration manipulation progressively elevates zygomaticus activity, this will suggest an increase in positive reactions.

In Study 2, we also made several other changes aimed at clarifying other potential ambiguities from Study 1. First, we changed the instructions for the evaluative orientation and asked participants to focus on both positive and negative responses. This change addresses a possibility that the effect of processing facilitation on the zygomaticus activity requires that participants exclusively focus on positive aspects of the stimulus and ignore negative aspects of the stimulus. If a selective effect on the zygomaticus response can be obtained when participants simultaneously focus on both positive and negative aspects of the stimulus, this will strengthen our hypothesis that processing ease elicits positive affect. Second, we further separated the collection of EMGs from self-reports by increasing the time between the presentation of the target and the judgment from 6 s to 15 s.

Method

Twenty-two undergraduate students gave informed consent and participated in exchange for partial credit toward a psychology course requirement. Except for the changes listed previously, the procedures were similar to those for Study 1. Study 2 represented a within-subject design with four levels of presentation duration randomized for each participant. Each trial started with a fixation cross presented for 4 s. Then the target picture appeared for 300, 500, 700, or 900 ms. The duration of each picture was randomized across participants, so that each picture was presented for a different duration an approximately equal number of times. After the target picture, there was a 15-s break followed by a prompt asking participants to indicate their rating for the target. This rating was made on a response box with four buttons (1 = *I don't like it at all;* 2 = *I don't like it;* 3 = *I like it;* 4 = *I like it a lot*). After the judgment, there was a 5-s pause and the next trial began.

After the main part of the experiment, participants were asked several control questions designed to test the unobtrusiveness of the duration manipulation. Specifically, we first asked whether participants noticed any systematic difference in the way the stimuli were presented. Next, we asked whether participants noticed any differences in the presentation duration. All of the participants denied noticing any differences, suggesting that the processing manipulation was unobtrusive. On completion of the postexperimental interview, all participants were debriefed, thanked, and dismissed.

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[4] The design of Study 1 makes it difficult to determine the specific direction of the influence of processing facilitation on positive affect. We address this issue in Study 2.

[5] Because both the hedonic fluency and the two-step models predict more favorable ratings in a positive context, a one-tailed test was used.

Results

EMG data. The means of EMG activity are presented in Table 2. A repeated measures MANOVA revealed that the manipulation of presentation duration influenced the activity in the zygomaticus region, $F(3, 63) = 3.30, p = .03$. As expected, longer presentation durations were associated with higher zygomaticus activity, as revealed in a significant linear contrast, $F(1, 21) = 5.64$, $p = .03$. No overall or specific differences in the activity of other muscles were significant.

Similar to Study 1, we also analyzed the timing of the influence of processing facilitation on the activity over the zygomaticus region. Again, the effect was significant only in the immediate poststimulus period and not in later periods (Seconds 3, 4, or 5 or any combination thereof). This suggests that the observed change in zygomaticus activity reflects an early, affectively positive response to the stimulus, and not an anticipation of the explicit judgment or other strategic processes.

Self-reports of liking. The mean self-reports of liking are also presented in Table 2. It is noteworthy that the lowest rating, associated with the shortest presentation, is near the middle of the four-point bipolar (positive–negative) response scale ($M = 2.45$) and that, with increasing presentation duration, the ratings systematically move toward the positive end of the scale, suggesting an increase in positive affect. A repeated measures MANOVA revealed that the manipulation of presentation duration influenced participants' judgments of target pictures, $F(3, 63) = 3.82$, $p = .01$. As expected, longer presentation duration was associated with higher evaluations, as indicated by a significant linear contrast, $F(1, 21) = 11.70, p = .003$.[6]

Discussion

The results of Study 2 replicated the critical results of Study 1. Specifically, easier processing was associated with physiological responses indicative of positive affect, as reflected by higher activity over the zygomaticus region. Because the study only relied on processing facilitation, we suggest that this EMG effect represents an increase in positive affect. Convergent evidence was obtained with self-report measures in which easier processing was associated with responses on the positive end of the bipolar rating scale. Again, these findings are inconsistent with the two-step models that predict no effects on EMG measures and no selective increase in self-reports of positive affective responses. These results were obtained with a manipulation of processing that did not involve any previous exposure to the stimulus and with an evaluative orientation that focused participants on both positive and negative reactions.

Table 2
Electromyographic (EMG) Activity and Self-Reports as a Function of Presentation Duration

	Target duration (ms)			
Measure	300	500	700	900
EMG site				
Zygomaticus	−0.45	0.23	0.17	0.30
Corrugator	−0.41	−0.07	−0.13	−0.04
Orbicularis	0.30	0.69	0.42	0.39
Self-report	2.45	2.67	2.69	2.87

Note. EMG data represent change in the average level of standardized activity between the prestimulus baseline (looking at a fixation cross) and the period immediately after the stimulus offset. Self-reports represent ratings on a scale ranging from 1 (*don't like it at all*) to 4 (*like a lot*).

General Discussion

Results of both studies revealed that easy-to-process stimuli were associated with higher activity over the zygomaticus region. These findings were obtained with two different processing manipulations (visual priming in Study 1 and presentation duration in Study 2) and with two different evaluative orientations (unipolar, selectively on positive or negative affect in Study 1, and bipolar, on both positive and negative affect in Study 2). Evidence convergent with the physiological findings was obtained on self-reports. In Study 1 processing facilitation selectively increased the ratings of positive reactions on the unipolar scale, whereas in Study 2 processing facilitation increased the ratings on the positive end of the bipolar scale. These findings are consistent with the hedonic fluency model, which predicts processing facilitation to result in a brief affective reaction that is selectively positive. On the other hand, the results are inconsistent with the two-step models, which predict that processing facilitation has no genuine affective consequences and that processing facilitation should increase positive and negative ratings of stimuli, depending on the judgment context.

One possible concern may be our interpretation of the increase in zygomaticus activity as reflecting a positive affective reaction rather than a decrease in mental effort. However, low mental effort is typically associated with reduced EMG activity over the corrugator supercilii and orbicularis oculi muscle regions, a pattern we did not observe (Cacioppo et al., 1990; Van Boxtel & Jessurun, 1993). Another possible concern may be our interpretation of the EMG findings as a measure of spontaneous affective reactions to stimuli. For example, participants could have generated faint smiles as they were thinking of making a positive judgment. However, it is worth noting that in other research facial EMG was shown to mark affective responses to stimuli even when participants did not make any explicit judgments (Cacioppo et al., 1988) or when participants could not even see the affective stimuli (Dimberg et al., 2000). Further, in the current studies, the EMG responses were observed in the period proximal to the stimulus, not in the period proximal to the behavioral expression of their judgment. Future studies may address the relation of EMG activity to fast, spontaneous, implicit judgments of easy-to-process stimuli.

The current results, therefore, support a connection between high fluency and positive affective reactions. As discussed early in this article, prior studies suggested that processing facilitation increases ratings of liking or prettiness but not ratings of disliking or ugliness (Reber et al., 1998; Seamon et al., 1998; also compare Mandler et al., 1987). However, this early evidence was limited. First, these studies relied on self-reports and thus could not show whether changes in processing dynamics have genuine affective

[6] In both tests using linear contrast, the quadratic and cubic terms were not significant.

consequences. Second, these studies could not determine whether processing facilitation enhances liking or decreases disliking, despite using scales worded as "disliking" or "ugliness." As Larsen and Diener (1992) noted, sometimes the rating dimensions have unipolar names but function in a bipolar fashion. Third, the previous studies were vulnerable to criticism that participants reframe their judgments of disliking or ugliness into judgments of liking or prettiness. The current research clarifies these issues. Using EMG measures, we were able to obtain evidence that processing facilitation is associated with genuine affective change. Further, using convergent evidence from EMGs and self-reports, we obtained evidence that processing facilitation indeed selectively increases positive affect. This interpretation is suggested by the fact that, across two studies, easy-to-process stimuli led to higher zygomaticus activity but had no effect on corrugator activity, a sensitive marker of negative affect (Bradley, 2000). Further, our participants reported positive affect both on the unipolar scale in Study 1 and on the higher end of the bipolar scale in Study 2. Finally, the current studies are not subject to the criticism based on reinterpretation of the "disliking" response. Note that Study 1 did not ask about "disliking" but selectively focused participants on negative affective reactions and provided them with unipolar scales to report such reactions, if there were any (e.g., Ito et al., 1998). However, our participants only reported a change in positive reactions.

It is worth pointing out that our methodological approach to examining the predictions of the hedonic fluency model against the two-step models was grounded in two developments in thinking about the affect system. First, the bivariate model proposed by Cacioppo and Berntson (1994) encourages researchers to look at selective manifestations of positive and negative affect. This can provide a more comprehensive characterization of underlying processes as well as help distinguish between competing theoretical models. Second, the growing appreciation for the biological substrates of social phenomena encourages researchers to use tools of psychophysiology. These tools can help build theoretical accounts that integrate across multiple levels of analysis as well as test between theories that predict different biological manifestations of a psychological process (Cacioppo et al., 2000; Winkielman et al., 2001).

The current studies were not focused on the specific mechanism underlying the processing-liking connection. Nonetheless, our work speaks to this question. There are several reasons why processing facilitation may elicit positive affect. One set of considerations suggests that easy or coherent processing is positive because it signals successful progress toward recognition or improvement in cognitive organization (Carver & Scheier, 1990; Ramachandran & Hirstein, 1999; Simon, 1967; Vallacher & Nowak, 1999). Related considerations suggest that easy processing is positive because it indicates the availability of appropriate knowledge structures to deal with a current situation (Bless & Fiedler, 1995; Schwarz, 1990). Finally, the ideas just presented converge with observations that mental states characterized by low coherence, such as cognitive dissonance, tend to be experienced as hedonically negative, as reflected in self-reports and physiological indexes (Festinger, 1957; Devine, Tauer, Barron, & Elliot, 1999; Harmon-Jones, 2000; Losch & Cacioppo, 1990; Shultz & Lepper, 1996).

As discussed, the present data are incompatible with the assumption that processing facilitation solely produces a neutral cognitive experience that can be easily linked to any evaluative dimension depending on the judgmental context.[7] As such, our data argue against accounts that explain changes in evaluative judgments by inferences from either a neutral feeling of fluency (Bornstein & D'Agostino, 1994; Jacoby, Kelley, & Dywan, 1989) or a neutral feeling of familiarity (Klinger & Greenwald, 1994; Smith, 1998). However, the familiarity model has been revised to suggest that the feeling of familiarity is positively marked, probably because familiarity informs the organism that a situation is known and thus likely to be comparatively harmless (Garcia-Marques & Mackie, 2000; Smith, 2000). Such a "hedonic familiarity" model is consistent with Tichener's observation (1910) that familiar objects elicit a "glow of warmth, a sense of ownership, a feeling of intimacy" (p. 411). Further, a detection of stimulus familiarity, and thus its likely valence, must not require any complicated mechanisms and can occur very quickly. Specifically, computer simulations suggest that, by monitoring the coherence of very early dynamics of stimulus recognition, the organism can assess stimulus familiarity even before recognizing stimulus identity, which requires additional processing steps (Beeman, Ortony, & Monti, 1995; Lewenstein & Nowak, 1989; Norman, O'Reilly, & Huber, 2000). These computer simulations are consistent with human studies showing that stimulus familiarity can be detected faster than stimulus identity, as reflected in judgments and evoked potentials (Curran, 2000; Hintzman & Curran, 1994). Human studies also support a correspondence between familiarity and positive affect. For example, subliminal positive primes increase judgments of previous occurrence (Phaf, Rotteveel, & Spijksma, 1998), whereas induction of positive mood increases familiarity-based judgments of truth (Garcia-Marques & Mackie, 2000). Finally, patient data suggest that detection of familiarity may depend on the integrity of the positive affect system. For example, some neurological patients lack the ability to integrate successive encounters with the same person into a single representation (Capgrass syndrome). Ramachandran and Hirstein (1999) suggested that this deficit may be due to amygdala damage that prevents Capgrass syndrome patients from experiencing "a warm fuzzy emotional response" to a familiar face and that "in the absence of limbic activation—the 'glow' of recognition—there is no incentive for the brain to link successive views of a face, so that the patient treats a single person as several people" (p. 31).

Although such a hedonic familiarity model offers a good explanation of available data, the present findings are more parsimoniously explained with the assumption that positive affect is related directly to processing ease without the mediation of the feeling of familiarity. After all, in Study 2, we elicited positive responses to targets shown only once by simply increasing presentation duration. Similarly, preferences were increased in other studies by facilitating processing with manipulations such as figure-to-ground contrast or symmetry (Reber, Schwarz, & Winkielman, 1999; Reber et al., 1998). The assumption that positive affect is

[7] Our position is compatible with observations that experiences of ease or difficulty, such as those encountered during recall tasks, can be used in further inferences about the target (Skurnik, Schwarz, & Winkielman, 2000; Winkielman & Schwarz, 2001).

directly related to processing ease may also explain why, in the mere-exposure studies, covarying out participants' judgments of familiarity did not fully eliminate the effects of repetition on liking (Zajonc, 2000). After all, familiarity judgments are an imperfect measure of fluency (Poldrack & Logan, 1998; Whittlesea & Williams, 2001). Nevertheless, it is also possible that different processing manipulations that increase preferences (priming, presentation duration, repetition, figure-to-ground contrast, prototypicality) feed into the same mechanism designed to monitor novelty/familiarity by dynamics of the recognition process (Winkielman, Schwarz, & Nowak, in press). In sum, although the specific mechanisms underlying the processing-affect connection remain speculative, it seems likely that the affect system is intimately linked to rudimentary processes of stimulus recognition.

The relation between fluency and positive affect probably has several boundary conditions. Sometimes people prefer novel rather than familiar stimuli, faster rather than slower presentations, incongruent rather than congruent patterns, and so on. These observations are not inconsistent with our findings and reflect the importance of additional factors such as (mis)attribution of cognitive-affective reactions, boredom, saturation, and other variables that have little to do with rudimentary affective responses explored in the current studies (see Bornstein, Kale, & Cornell, 1990; Kruglanski, Freund, & Bar-Tal, 1996; Van den Bergh & Vrana, 1998). Indeed, our proposal that the organism detects subtle changes in its own cognitive processes by affective feedback fits well with reports that manipulations such as mere exposure have the strongest influence on liking when target stimuli are novel and presented for relatively short durations (Bornstein, 1989). After all, such conditions are likely to promote reliance on the "feeling-as-information" heuristic and enhance the use of affective signals generated by processing dynamics (Schwarz, 1990).

The current studies differ in important ways from other research on physiological reactions to affective stimuli. Affective reactions to survival-relevant stimuli, such as a snake or a scowl, tend to be strong and extended. Further, their physiological manifestations are fairly independent of the current goals of the organism (e.g., Lang et al., 1993; LeDoux, 1996). On the other hand, affective reactions to changes in processing dynamics of mild, everyday stimuli are likely to be weak and transient. Moreover, their physiological manifestation may require on-line monitoring of one's affective state and awareness that this affective state bears on the task at hand. This speculation is consistent with findings from Study 1 in which participants selectively focused on negative responses did not show spontaneous smiles to easy-to-process stimuli, presumably because they did not trace their positive responses. Future research should systematically explore the issue of automaticity of the present effects (Bargh, 1996).

Finally, the present research has implications for understanding the mere-exposure effect. Our findings are consistent with suggestions that the effect may involve low-level changes in stimulus representation (Bonanno & Stillings, 1986; Bornstein & D'Agostino, 1994; Gordon & Holyoak, 1983; Jacoby et al., 1989; Klinger & Greenwald, 1994; Mandler et al., 1987; Seamon et al., 1983; Smith, 1998). At the same time, our studies show that such low-level changes can have genuine affective consequences. In fact, our EMG results parallel observations that repeatedly exposed neutral stimuli elicit stronger activity over the zygomaticus region without changing the activity over the corrugator region (Harmon-Jones & Allen, 2001). Similarly, findings suggest that subliminal presentation of mere-exposed stimuli enhances self-reports of positive mood (Monahan, Murphy, & Zajonc, 2000). In sum, the available data suggest that the mechanisms underlying the mere-exposure effect are closely tied to the positive affect system. Further, the available data can be interpreted as consistent with the statement that "preferences need no inferences" (Zajonc, 1980, 2000). After all, positive reactions to fluency are not based on descriptive features of a stimulus but rather on its processing dynamics. Further, as discussed previously, easy processing can mark very early stages of stimulus analysis before its identity has been detected.

There may be broader implications of our findings as well. In many situations, perceivers are required to focus primarily on the semantic content of a communication. The present work raises the possibility that the perceiver's internal processing dynamics may be a source of affective reactions that have nothing to do with the relevant content. If these reactions are misattributed to the features of the target, they may constitute a potential source of judgmental bias.

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