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Abstract

Emotions can color people's attitudes toward unrelated objects in the environment. Existing evidence suggests that such emotional coloring is particularly strong when emotion-triggering information escapes conscious awareness. But is emotional reactivity stronger after nonconscious emotional provocation than after conscious emotional provocation, or does conscious processing specifically change the association between emotional reactivity and evaluations of unrelated objects? In this study, we independently indexed emotional reactivity and coloring as a function of emotional-stimulus awareness to disentangle these accounts. Specifically, we recorded skin-conductance responses to spiders and fearful faces, along with subsequent preferences for novel neutral faces during visually aware and unaware states. Fearful faces increased skin-conductance responses comparably in both stimulus-aware and stimulus-unaware conditions. Yet only when visual awareness was precluded did skin-conductance responses to fearful faces predict decreased likability of neutral faces. These findings suggest a regulatory role for conscious awareness in breaking otherwise automatic associations between physiological reactivity and evaluative emotional responses.

Keywords

emotions, consciousness, individual differences, subliminal perception

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Emotional events rapidly mobilize people's central and peripheral nervous systems toward adaptive action. Because affective changes inform decision making regarding the people and contexts one wants to approach or avoid, it is important that they do so accurately. Here, we report that conscious awareness changes the relationship between objectively measured emotional responses and subsequent appraisal of unrelated objects in the environment, which effectively rescues neutral stimuli from otherwise tainted first impressions.

Conscious awareness to a sensory stimulus refers to processing accompanied by subjective perceptual experience, about which one can report under normal circumstances (also called *conscious access*; Block, 2005; Dehaene & Changeux, 2011; Lau & Rosenthal, 2011). Biologically relevant emotional stimuli do not require

conscious awareness to mobilize early appraisal by central structures, such as the amygdala (Jiang & He, 2006), or to activate facial-expressive (Dimberg, Thunberg, & Elmehed, 2000) and autonomic nervous systems (Öhman & Soares, 1994). For example, studies have shown that the amygdala responds to facial expressions even when

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their visibility is prevented in experiments adopting backward masking (for a quantitative meta-analysis, see Brooks et al., 2012) or interocular suppression (Jiang & He, 2006; Pasley, Mayes, & Schultz, 2004; Williams, Morris, McGlone, Abbott, & Mattingley, 2004), coupled with rigorous procedures to verify stimulus unawareness (e.g., via two-alternative forced-choice, 2AFC, reporting paradigms; e.g., Jiang & He, 2006). With regard to the type of functional processing enabled in such reduced-awareness states, the amygdala can promote rapid mobilization of the organism via its downstream projections to neuro-modulator-releasing brainstem nuclei and the hypothalamic-pituitary-adrenal axis (reviewed in Ledoux, 2012).

Accordingly, the magnitude of skin-conductance responses (SCRs), a marker of sympathetic nervous system activity under the excitatory influence of the amygdala (Mangina & Beuzeron-Mangina, 1996), increases after the presentation of masked fear-relevant facial stimuli (e.g., Öhman & Soares, 1994; Olsson & Phelps, 2004). Taken together, relevant studies have suggested that conscious awareness of an affective stimulus is not a prerequisite for the stimulus to engender peripheral-physiological responses indicative of initial emotional reactivity and that the amygdala may support the central representations that drive such responses in states of reduced visual awareness. What then, if any, is the role of conscious awareness in the processing of emotional stimuli?

Researchers have suggested that conscious awareness of an emotional stimulus renders affective processing qualitatively different: In their “affect-as-information” theory, Schwarz and Clore (1983) proposed that affect caused by a nonidentified source is particularly prone to influence one’s evaluations of unrelated objects because humans are motivated to seek explanations for their affective states (Schwarz & Clore, 1983; Wyer & Carlston, 1979). If affect elicited by a stimulus outside of awareness, compared with an affect whose source is available and correctly identified, is more likely to be misattributed, then binding of affect to incidental stimuli should be stronger when conscious awareness of emotional stimuli is prevented. Accordingly, in the work of Murphy and Zajonc (1993), only when happy and angry faces were presented below the threshold for visual awareness did their affective content color preferences for subsequently presented, otherwise neutral Chinese ideographs (this result was replicated in Rotteveel, De Groot, Geurtskens, & Phaf, 2001).

Similarly, the finding that facial expressions of which one is unaware can color subsequent evaluations of neutral stimuli has been confirmed with additional awareness-manipulation techniques, including attentional crowding (Kouider, Berthet, & Faivre, 2011) and continuous flash suppression (CFS; Almeida, Pajtas, Mahon, Nakayama, & Caramazza, 2012; Anderson, Siegel, White,

& Barrett, 2012; but also see Faivre, Berthet, & Kouider, 2012). Moreover, greater affective coloring during subliminal, relative to supraliminal, processing of emotional information has been reported by researchers using valenced odors as the emotional stimuli (Li, Moallem, Paller, & Gottfried, 2007). In summary, the perceived “positivity” of a neutral stimulus can be modulated according to the affective content of a temporally preceding, nonperceived stimulus, with conscious awareness weakening such effects.

However, how conscious awareness influences affective coloring after an emotional provocation remains ambiguous: Does conscious awareness of emotional stimuli reduce the magnitude of emotional reactivity *per se*, thereby reducing the affective information that can bind to unrelated stimuli (as suggested by increased physiological reactivity to emotional stimuli presented to the subjectively blind visual field of individuals with affective blindsight; Tamietto et al., 2009)? Or does conscious awareness instead attenuate the relationship between emotional reactions and subsequent appraisals of the environment, whereby emotional responses preferentially color evaluations of unrelated stimuli in unaware states (as predicted by the affect-as-information theory; Schwarz & Clore, 1983)? If the latter is true, finding that the extent of affective coloring reflects the magnitude of the provoked emotional reactivity only when individuals are unaware of the emotional stimulus would constitute a strong demonstration of such a mechanism. In contrast, conscious awareness of the emotional stimulus should attenuate the association between emotional reactivity and affective coloring. Because studies to date have not examined how conscious awareness of an emotional stimulus affects emotional reactivity (e.g., via peripheral-physiological channels), subsequent coloring, and their association simultaneously, these alternative accounts remain unaddressed.

We sought to adjudicate between these accounts by simultaneously measuring physiological responses to neutral stimuli (flowers) and to two categories of emotional stimuli (fearful faces and spiders) presented in blocks (see Fig. 1 for a schematic representation of the experimental trial structure), as well as by collecting evaluative judgments of novel neutral faces. We manipulated conscious awareness in a within-subjects fashion by employing CFS (Tsuchiya & Koch, 2005), a powerful method that capitalizes on the phenomenon of binocular rivalry. In CFS, a continuously flashing colorful pattern is presented to one eye (usually at ~10 Hz), and a static low-contrast stimulus is presented to the other eye. In general, the static stimulus can remain reliably suppressed from visual awareness for relatively long durations (typically ~1,000 ms), which is a dramatic increase in visibility suppression compared with that enabled by backward masking (typically ~16–33 ms).

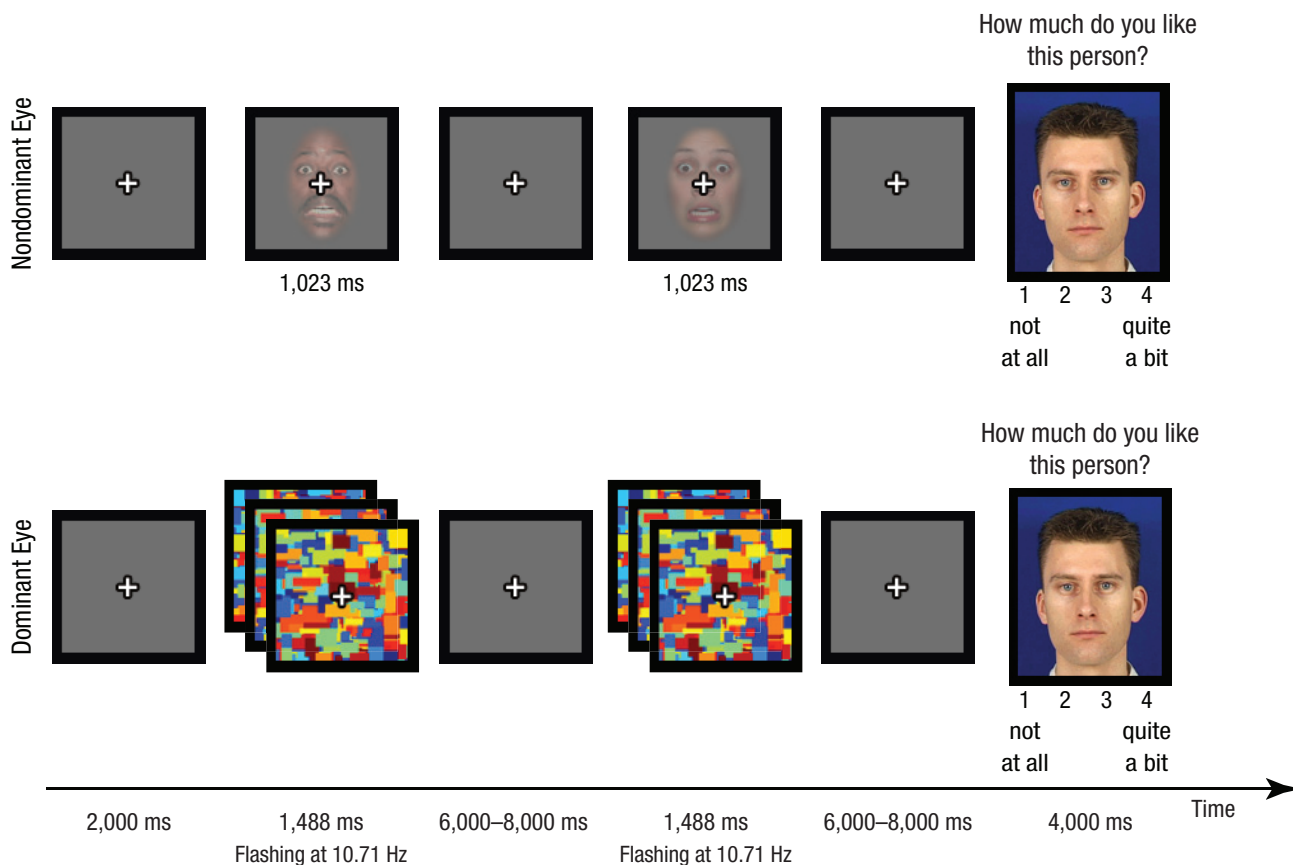


Fig. 1. Schematic representation of the experimental trial structure. Emotional (fearful faces or spiders) and neutral (flowers) stimuli were shown for approximately 1 s in a blocked fashion (fearful faces are shown here). Conscious awareness of these stimuli was manipulated within subjects. The figure shows stimuli presented to both eyes in a stimulus-unaware block: In stimulus-unaware blocks, the presentation of high-contrast, flashing Mondrian patterns to participants' dominant eye precluded visibility of stimuli shown to their nondominant eye. In stimulus-aware blocks, emotional or neutral stimuli were presented to both dominant and nondominant eyes.

Such an increase in stimulus-presentation time facilitates the measurement of affective changes via objective peripheral-physiological indices, such as SCRs. Accordingly, we quantified SCRs to the emotional stimuli, relative to neutral stimuli, to index emotional reactivity after the affective provocation.

To index affective coloring, we had individuals rate the likability of novel neutral faces shown during emotional and neutral blocks (e.g., Anderson et al., 2012; Li et al., 2007). To examine whether emotional responses per se were modulated by conscious awareness, we compared the extent of emotional reactivity between stimulus-aware and -unaware conditions after presentation of each category of emotional stimuli (fearful faces vs. flowers; spiders vs. flowers) as reflected by stimulus-locked changes in SCRs. Next, we adopted an individual-differences approach to examine an account compatible with the affect-as-information theory—namely, that conscious awareness changed the association between emotional reactivity after affective provocation (indexed by SCR

magnitude) and the extent of affective coloring (indexed by likability ratings of neutral faces). Specifically, from such an account, we predicted that larger SCRs to negative stimuli rendered nonconscious by CFS should be associated with decreased likability for subsequently presented neutral faces, an association that should be attenuated when the emotional stimuli are fully visible (and, thus, the source of affect is available for conscious processing).

Method

Participants

A total of 67 right-handed individuals from a pool of Introduction to Psychology students (43 females, 24 males) participated in this study. All volunteers provided written consent, and study procedures were approved by the University of Wisconsin–Madison Institutional Review Board.

Apparatus and stimuli

We used an adjustable mirror stereoscope mounted on a chin rest to present images displayed on an LCD monitor (75 Hz) at a 50-cm viewing distance. CFS stimuli consisted of 80 Mondrian-patterned images created by drawing rectangles of random colors at random locations in a $3.2^\circ \times 3.2^\circ$ square. The 24 affective-provocation images comprised 8 pictures of fearful faces (50% female, 50% male), 8 pictures of spiders, and 8 pictures of flowers subtending $3.2^\circ \times 3.2^\circ$ and matched on average luminance and root-mean-square contrast. To facilitate binocular fusion, we surrounded the stimuli with a $0.28^\circ \times 0.28^\circ$ black border. To assess affective coloring, we included as stimuli 24 pictures of neutral faces (50% female, 50% male) resized to $4.5^\circ \times 5.7^\circ$ rectangles surrounded by a $0.28^\circ \times 0.28^\circ$ border (for details on stimulus characteristics, including databases used for stimulus selection, see Stimuli in the Method section of the Supplemental Material available online).

Procedure

The first part of the experiment consisted of the emotion-processing task. In the second part of the experiment, a 2AFC stimulus-detection task was used to ensure the effectiveness of stimulus-visibility suppression via the CFS manipulation.

Emotion-processing task. Stimuli were presented stereoscopically in a 3 (stimulus category: fearful faces, spiders, flowers) \times 2 (awareness: aware, unaware) within-subjects design. To accentuate emotion-elicitation effects, we manipulated stimulus category and awareness in blocks. Block order and stimulus assignment to stimulus-aware (i.e., stimulus presented to both eyes) and stimulus-unaware (i.e., stimulus presented during CFS) conditions were counterbalanced across participants (see Condition Counterbalancing in the Method section of the Supplemental Material). Each neutral face used to examine affective coloring was presented only once and was randomly assigned to a stimulus category and awareness condition.

In stimulus-unaware blocks, we implemented CFS (Tsuchiya & Koch, 2005). For 1,488 ms, Mondrian-patterned images flashed to participants' dominant eye at 10.71 Hz, and a low-contrast (emotional or neutral) static stimulus was presented to their nondominant eye during the first 1,023 ms. Eye dominance was determined using the hole-in-the-card test (Durand & Gould, 1910). In stimulus-aware blocks, the low-contrast stimuli were presented for 1,023 ms to both dominant and nondominant eyes, and were thus fully visible.

Before the start of the experiment, we attached Ag-AgCl sensors on participants' left hand (detailed in Skin-Conductance Recordings and Processing in the

Method section of the Supplemental Material). Participants were asked to remain still and maintain central fixation throughout the experiment. Prior to the stimulus-unaware blocks, we told participants that another image might be presented simultaneously with the moving squares and asked them to indicate, with a button press, if they thought they saw an image in addition to the squares.

In each block, four unique stimuli were presented twice, as described earlier (see Fig. 1). Trials started with a 2,000-ms $0.5^\circ \times 0.5^\circ$ fixation cross, followed by the affective-provocation stimulus, which was in turn followed by a 6,000- to 8,000-ms (7,000-ms on average) intertrial interval (thereby allowing stimulus-evoked SCRs to unfold). In half of the trials, the intertrial interval was followed by a neutral-face-likability-rating task, in which individuals were asked to rate how much they liked a novel neutral face, which was presented for 4,000 ms along with the question, "How much do you like this person?" Responses were made with a button box, using 4-point scales from 1, *not at all*, to 4, *quite a bit*. Participants were instructed to report on their immediate impression of the faces based on their gut feeling. Responses were accepted within the 4,000-ms window only. Two individuals—1 across stimulus-aware and stimulus-unaware blocks and 1 during stimulus-aware blocks only—did not provide sufficient neutral-face-likability data (i.e., did not press a button within the 4,000-ms window).

To examine whether the affective provocation resulted in changes in subjective experience, at the end of each block, we asked participants to report on their mood ("How do you feel right now?"). Responses were made with a button box, using 4-point scales from 1, *very negative*, to 4, *very positive*.

2AFC task. Because it was critical to ensure that participants experienced robust suppression of stimulus visibility during CFS, in addition to requesting that participants press a button in the event of image breakthrough in the emotion-processing task, we examined the effectiveness of CFS after the emotion-processing task by testing stimulus-identification performance in a 2AFC procedure (cf. Jiang & He, 2006; for details, see 2AFC Task in the Method section of the Supplemental Material).

Statistical analysis

We verified that observers included in the analysis were unaware of stimuli in CFS blocks by using both 2AFC performance and subjective reports. In addition, we ensured that participants had detectable stimulus-evoked SCRs (i.e., greater than $0.02 \mu\text{S}$) in a minimum of 5% of trials (for details, see Skin-Conductance Recordings and Processing in the Method section of the Supplemental Material). Fifteen individuals (out of 67) performed significantly above chance level in the 2AFC

stimulus-identification task and were therefore excluded from all analyses reported here (for details, see Stimulus-Awareness Testing in the Results section of the Supplemental Material). Of the remaining 52 individuals, 6 did not show SCRs greater than $0.02 \mu\text{S}$ in at least 5% of the trials and were therefore considered nonresponders. Within the remaining sample of 46 participants, occasional trials in which observers indicated that they saw an image in addition to the colorful squares were excluded from the analysis of both SCRs and likability-ratings data (0.3% of trials).

We conducted a 2×3 multivariate analysis of variance (MANOVA) with awareness (unaware, aware) and stimulus category (fearful faces, spiders, flowers) on SCRs to verify the efficacy of the affective provocation and to examine whether emotional reactivity differed in magnitude as a function of conscious awareness. Likewise, we conducted 2×3 MANOVAs on neutral-face-likability ratings (see Impact of the Emotional Provocation on Average Likability Ratings of Novel Neutral Faces in the Results section of the Supplemental Material) and mood ratings to assess how awareness and stimulus category modulated affective coloring and the subjective experience of affect, respectively.

To examine whether conscious awareness modulated the association between emotional reactivity and affect coloring, we first computed pairwise correlations between changes in SCRs by emotion (e.g., fearful face – flower) in trials preceding neutral-face-likability ratings and the corresponding change in neutral-face-likability ratings (e.g., fearful face – flower) across individuals separately for stimulus-aware and -unaware conditions. We used Spearman's rank coefficients to estimate these associations, given the increased robustness of this method to mild outliers (observed in the stimulus-aware condition). Next, we tested for the difference between correlation coefficients obtained in stimulus-aware and -unaware conditions (i.e., stimulus aware – stimulus unaware). To that end, we used Zou's (2007) method, which yields a confidence interval for the difference of dependent correlation coefficients (statistical significance at $p < .05$ is indicated by the 95% confidence interval not including 0).

Results

Fearful faces increase sympathetic nervous system activation comparably across aware and unaware conditions

The affective provocation employed here successfully provoked emotional reactivity as indicated by a main effect of stimulus category on SCR magnitudes, $F(2, 44) = 6.46$, $p = .003$, $\eta_p^2 = .14$. Specifically, fearful faces and

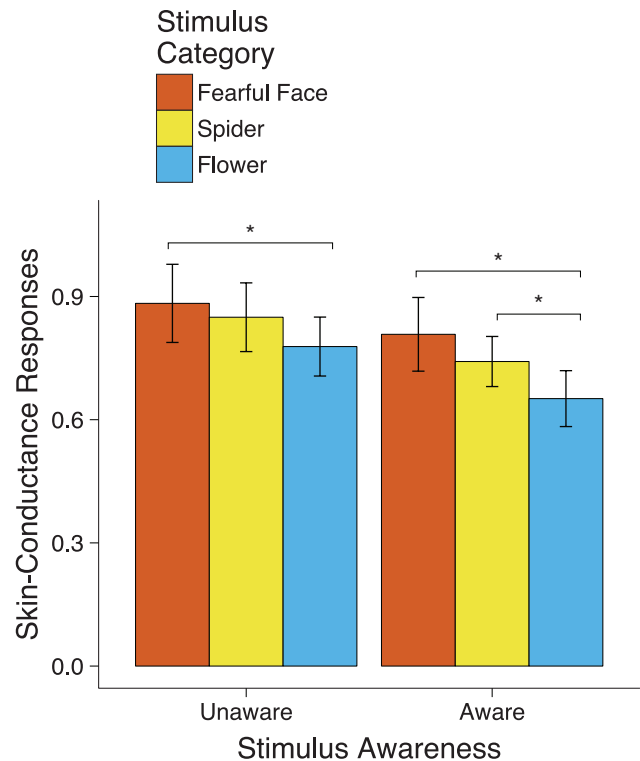


Fig. 2. Skin-conductance responses (in square root of microsiemens \times seconds) as a function of stimulus awareness and stimulus category. Asterisks indicate significant paired contrasts ($p < .05$). Error bars represent the within-subjects 95% confidence intervals for each condition, computed using Morey's (2008) method.

spiders elicited significantly stronger SCRs than did flowers (fearful faces vs. flowers: $p = .001$, $d = 0.56$; spiders vs. flowers: $p = .038$, $d = 0.34$). In addition, a main effect of awareness indicated that the magnitude of SCRs across stimuli was, on average, larger during the presentation of colorful Mondrian patterns, $F(1, 45) = 7.74$, $p = .008$, $\eta_p^2 = .11$.

Suggesting that sympathetic nervous system responding does not rely on conscious awareness in the face of biologically relevant stimuli, results showed that the Awareness \times Stimulus Category interaction did not approach significance, $F(2, 44) = 0.57$, $p = .56$, $\eta_p^2 = .007$. However, examination of the paired contrasts revealed that the similarity in reliability of emotional activation across stimulus-aware and -unaware conditions was found in response to fearful faces (relative to flowers) but not in response to spiders (relative to flowers; see Fig. 2 for SCR results showing increased sympathetic nervous system activation after the presentation of emotional stimuli). During stimulus-unaware presentations of stimuli, fearful faces produced significantly larger SCRs than did flowers, $p = .023$, $d = 0.32$. Likewise, when visible in the stimulus-aware condition, fearful faces elicited

significantly larger SCRs than did flowers, $p = .003$, $d = 0.53$. In contrast, when rendered invisible via CFS, spiders, relative to flowers, did not reliably increase SCRs, $p = .22$, $d = 0.19$. Only when spiders were visible did they elicit stronger SCRs than did flowers, $p = .04$, $d = 0.30$. In summary, fearful faces provoked reliable emotional reactivity as indexed by SCRs regardless of stimulus awareness, contrary to the possibility that conscious awareness decreases the magnitude of emotional responses per se.

Conscious awareness prevents the association between emotional reactivity and likability of novel neutral faces

Because fearful faces provoked robust physiological responses regardless of stimulus awareness, we analyzed the consequences of such emotional reactivity as it pertained to subsequent affective coloring. As predicted from an account whereby affect from a nonidentified source is prone to bind to other nonrelated objects (affect-as-information theory; Schwarz & Clore, 1983,

2003), only during stimulus unawareness did larger SCRs to fearful faces (relative to flowers) predict decreased likability of neutral faces that followed them, Spearman's $\rho = -.38$, $p = .01$ (see Fig. 3 for nonparametric correlation of neutral-face-likability ratings with SCRs). No such association was found during stimulus awareness, Spearman's $\rho = .09$, $p > .54$. Critically, awareness significantly attenuated the strength of the relationship between emotional reactivity and affective coloring, as indicated by the confidence interval (CI) on the difference between these two correlation coefficients, 95% CI = $[-.05, -.83]$, $p < .05$.

Controlling for mood

Participants' self-reported mood was not significantly modulated by stimulus category or awareness ($F_s < 1.38$, $p_s > .26$, $\eta_p^2_s > .06$). Importantly, the modulation of emotional reactivity and affective coloring by conscious awareness remained significant when we controlled for corresponding changes in mood: Changes in emotional reactivity continued not to predict neutral-face likability during aware processing when changes in mood were included in the regression model, $b = 0.16$,

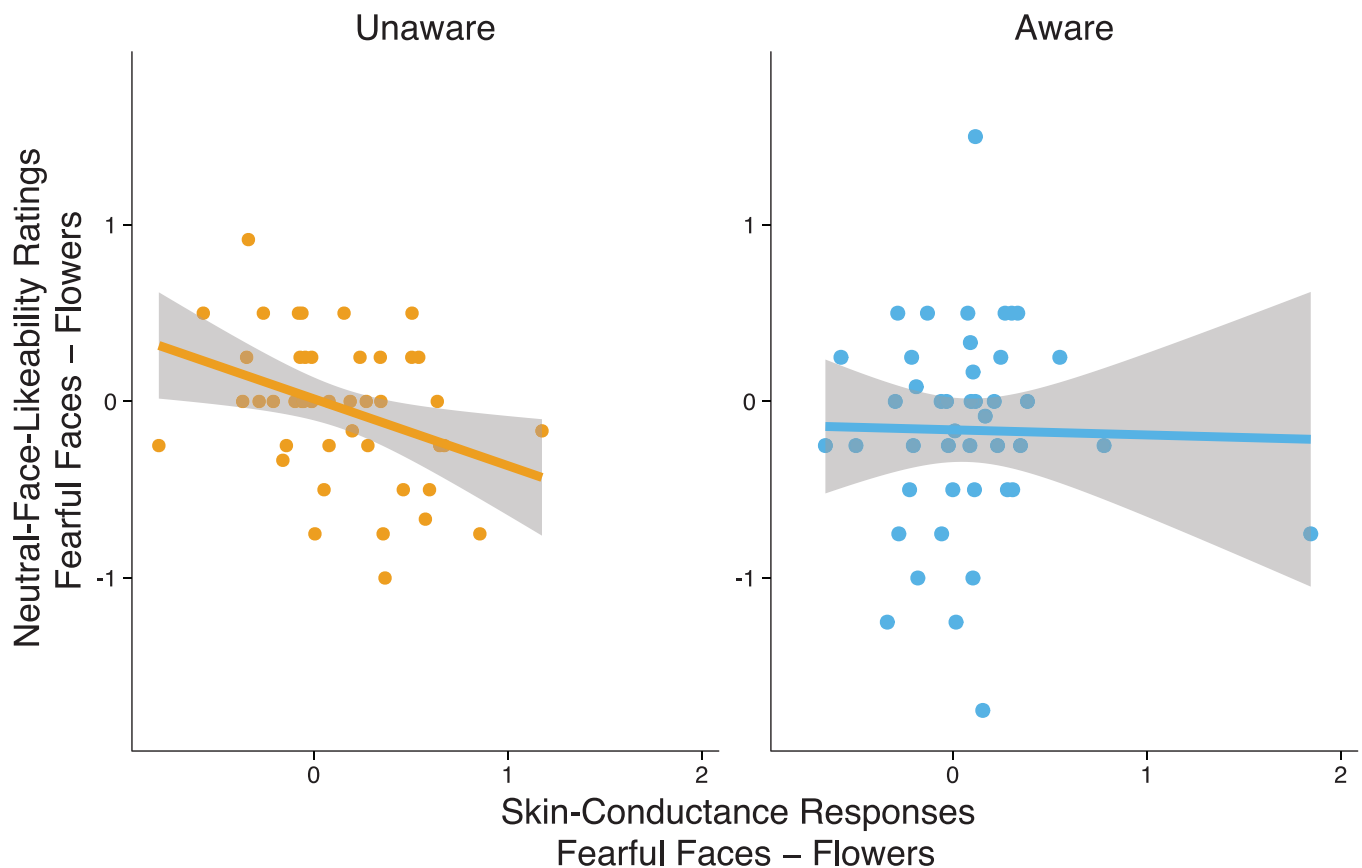


Fig. 3. Correlation between the extent of sympathetic nervous system activation (to fearful faces – flowers) as indexed by skin-conductance responses (in square root of microsiemens \times seconds) and changes in neutral-face-likability ratings (fearful faces – flowers). Results are shown separately for stimulus-unaware and stimulus-aware conditions.

$SE = 0.23$, $t = 0.72$, $p > .4$. During unaware processing, increases in SCRs continued to predict decreased likability of novel neutral faces, even after changes in mood were entered as a covariate in the model, $b = -0.48$, $SE = 0.2$, $t = -2.37$, $p = .022$. Therefore, when affect is used as information during unaware stimulus processing, it does not require affective changes themselves to reach conscious awareness and be subjectively experienced. Instead, our results are consistent with the idea that in the absence of stimulus awareness, emotional activation diffuses into preferences for incidental stimuli in the environment without it being translated into a reportable mood (akin to effects reported in Winkielman, Berridge, & Wilbarger, 2005).

Discussion

In this experiment, we examined how conscious awareness of emotional stimuli affects physiological and evaluative responses, as well as their association. In half of the trials, we manipulated visual awareness via a robust interocular-suppression technique, CFS. We measured SCRs to the emotional stimuli to index emotional reactivity, and likability ratings of novel neutral faces to index emotional coloring of evaluations. We found that even though fearful faces increased SCRs similarly across the stimulus-aware and -unaware conditions, only in the stimulus-unaware condition did SCR magnitudes predict subsequent decreases in likability of novel neutral faces. In contrast, when stimuli were presented binocularly and were consciously accessible, there was no relationship between peripheral-physiological responding to fearful faces and subsequent appraisal of neutral faces. Thus, this experiment highlights that even though conscious awareness does not reliably affect physiological responses to certain emotional stimuli, awareness can prevent emotional responses from diffusing to unrelated targets in the environment—such as a novel neutral face.

An emotional stimulus processed without conscious awareness, especially if biologically prepared, can modulate emotion-response systems, including sympathetic (Öhman & Soares, 1994) and facial-expressive (Dimberg et al., 2000) systems, via rapid valence and arousal computations in structures such as the amygdala, which can directly influence peripheral-physiological responses (Mangina & Beuzeron-Mangina, 1996). Accordingly, fearful faces modulate amygdalar activity in the absence of visual awareness across a variety of masking techniques (Jiang & He, 2006; Pasley et al., 2004; Whalen et al., 1998; Williams et al., 2004). In a recent study, a fear-relevant stimulus (an angry face previously paired with a shock) was reported to increase SCRs, an index of sympathetic nervous system activation, even when visually suppressed via CFS (Raio, Carmel, Carrasco, & Phelps, 2012). In the present study, we extended this finding by

showing reliable increases in SCRs to fearful faces rendered invisible via CFS, which were comparable in magnitude to SCRs observed when fearful faces were fully visible.

Furthermore, our results suggest that mobilization of the autonomic nervous system influences affective judgments of neutral stimuli when unchecked by conscious awareness. Indeed, if affect is used as information during source-of-affect unawareness (Schwarz & Clore, 1983, 2003), the extent of affective coloring should scale accordingly to the magnitude of the provoked affect, an idea that had not been previously tested. By independently indexing the magnitude of sympathetic nervous system activation by an affective stimulus, and the subsequent misattribution of affect toward neutral faces, we confirmed this prediction: Only during stimulus unawareness did the extent of affective coloring vary as a function of the magnitude of the previously provoked emotional response. Thus, this study underscores the relevance of central (especially amygdalar) responding to nonperceived facial expressions (e.g., Brooks et al., 2012; Jiang & He, 2006) by suggesting that, to the extent that such central processing is translated into peripheral-physiological changes, individuals may find themselves prejudiced against other, temporally adjacent external stimuli, a biasing that can be prevented via awareness of the source of emotion. Given the ubiquity of subtle facial behavior in the human environment, examining whether the effects reported here also manifest in naturalistic experimental contexts, such as in response to microexpressions, is an important direction for future research.

In our study, pictures of spiders did not modulate SCRs in the absence of visual awareness, whereas fearful faces did (see Fig. 2). It is possible that fearful faces are inherently more alarming and mobilizing than spiders (Öhman, 2009). Indeed, a recent report examining subjective and physiological responses to spiders revealed that heart-rate increases occasioned by spiders do depend on stimulus visibility (Peira, Öhman, & Anders, 2012). Conversely, it is also possible that other venomous animals, such as snakes, which are believed to have exerted central survival pressure on primates for an efficient perceptual decoding machinery, would modulate autonomic nervous system activity independently of visual awareness in humans (Öhman, 2009). Accordingly, relative to spiders, snakes drive visual attention in a more efficient manner (Soares, Esteves, Lundqvist, & Öhman, 2009). Thus, future research exploring the limits of unaware emotional-information processing should include stimuli for which humans have more “biologically prepared” fear than they do for spiders, such as snakes.

At least two important questions raised by this experiment warrant further research. First, given the important role of individual differences in determining the magnitude of affective-coloring effects, what are the neurobiological

features that distinguish individuals who are more prone to responding physiologically to nonperceived emotional stimuli from individuals whose autonomic nervous system is minimally affected during nonconscious processing? Second, given that physiological responding to emotional stimuli was associated with affective misattribution only during visually unaware states, what aspect of the affective computing circuitry explains the reduced affective coloring when emotional stimuli are consciously processed?

The search for the neural bases of conscious processing of visual information has consistently implicated the fronto-parietal network, including medial and dorsolateral regions of the prefrontal cortex (PFC; for a review, see Dehaene & Changeux, 2011). Given the well-described amygdala-inhibitory role of ventro-medial PFC (Kim et al., 2011), as well as the ventro-medial PFC participation in amygdalar downregulation in contexts in which dorsolateral PFC regions may initiate emotional regulation (such as in cognitive reappraisal; Delgado, Nearing, Ledoux, & Phelps, 2008), is it plausible that the mere engagement of dorsolateral and ventro-medial PFC structures, resulting from visual-information processing reaching the fronto-parietal network, could inhibit central-amygdalar activity, which in turn could prevent affective misattribution? Such a proposal is speculative and should be tested in future studies conducting functional-connectivity analysis of neuroimaging data coupled with assessments of physiological responding and affective coloring during aware and unaware emotional-processing states.

In conclusion, this study highlights the ability to respond to emotional facial signals even when one is not consciously aware of the signals and underscores an emotion-regulatory role for conscious awareness in decoupling physiological responses from evaluations of unrelated (and otherwise neutral) stimuli in the environment.

Author Contributions

R. C. Lapate and R. J. Davidson developed the study concept. R. C. Lapate, B. Rokers, and R. J. Davidson contributed to the study design. R. C. Lapate and T. Li performed the testing and collected the data. R. C. Lapate analyzed and interpreted the data under the supervision of R. J. Davidson and B. Rokers. R. C. Lapate drafted the manuscript. B. Rokers, T. Li, and R. J. Davidson critically revised the manuscript. All authors approved the final version of the manuscript for submission.

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Declaration of Conflicting Interests

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

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Supplemental Material

Additional supporting information may be found at <http://pss.sagepub.com/content/by/supplemental-data>

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