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In Bad Taste: Evidence for the Oral Origins of Moral Disgust

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In Bad Taste: Evidence for the Oral Origins of Moral Disgust

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In common parlance, moral transgressions "leave a bad taste in the mouth." This metaphor implies a link between moral disgust and more primitive forms of disgust related to toxicity and disease, yet convincing evidence for this relationship is still lacking. We tested directly the primitive oral origins of moral disgust by searching for similarity in the facial motor activity evoked by gustatory distaste (elicited by unpleasant tastes), basic disgust (elicited by photographs of contaminants), and moral disgust (elicited by unfair treatment in an economic game). We found that all three states evoked activation of the levator labii muscle region of the face, characteristic of an oral-nasal rejection response. These results suggest that immorality elicits the same disgust as disease vectors and bad tastes.

Although rationalist theories of moral psychology have long emphasized the role of conscious reasoning in morality (*1*, *2*), recent empirical (*3*–*5*) and theoretical (*6*, *7*) work suggests that emotion may also play a key role in moral judgment. These newer theories make the claim that moral cognition relies primarily on phylogenetically older affective systems, rather than on more recently evolved higher cognitive functions (*6*, *7*). For example, it has been proposed that the violation of moral norms might evoke a kind of moral revulsion or disgust in victims or onlookers (*8*–*10*). Disgust is a somewhat surprising candidate for a moral emotion, given its hypothesized origins in the very concrete, nonsocial, and straightforwardly adaptive functions of rejecting toxic or contaminated food and avoiding disease (*8*). In the moral domain, this rejection impulse might have been co-opted to promote withdrawal from transgressors, or even from the thought of committing a transgression. If the primitive motivational system of disgust is indeed activated by abstract moral transgressions, it would provide strong support for the idea that the human moral sense is built from evolutionarily ancient precursors.

The notion that moral transgressions might evoke the same disgust as potential toxins and disease agents has not gone unchallenged, however. Some have argued that just as a "thirst" for knowledge does not denote a desire to drink, moral "disgust" may reflect not the engagement of more primitive forms of disgust but merely the use of a compelling metaphor for socially offensive behavior (*11*, *12*). As well, prominent theories of disgust have proposed that although moral disgust may be related to contamination-based disgust (typically evoked by potential disease vectors), it is distinct from the most primitive forms of disgust related to the ingestion of potential toxins, having differentiated from the ancient oral distaste response rooted in chemical sensory rejection (*13*). Thus, the "bad taste" of moral disgust may serve as an abstract metaphor rather than reflect a concrete origin in oral distaste.

The evidence that does exist for the specific involvement of disgust in morality is also problematic. Moral transgressions elicit negative emotions (*9*), and induction of negative emotions such as disgust heightens sensitivity to moral transgressions (*5*). However, these studies do not specifically implicate disgust versus other negative emotions such as anger, nor do they demonstrate that moral "disgust" arises from oral disgust. As well, verbal reports of "disgust" in response to moral transgressions are suspect, because the word "disgusting" is used in colloquial English to describe angering or irritating situations (*14*). Thus, verbal self-report measures of subjective experience alone are not diagnostic of disgust. With respect to neural data, moral transgressions sometimes activate the insula (*10*, *15*), which has also been associated with oral disgust (*16*, *17*). However, many affective and cognitive functions besides disgust are associated with activation of the insula, including anger (*18*), anxiety (*19*), general viscerosensory awareness (*19*), and uncertainty (*20*).

The aim of the current series of studies was to provide a more powerful and direct test of the alleged involvement of disgust in morality, and hence of the notion that moral cognition calls on a phylogenetically older motivational system originating in the rejection of hazardous food. We tested the relationship among simple chemosensory distaste, basic forms of contamination-related disgust, and moral disgust by examining subjective experiential reports and objective facial motor activity associated with these states. Recent work supports Darwin's thesis (*21*) that the configuration of emotional facial expressions has evolved from a functional role in regulating sensory intake (*22*). These ancestral configurations may later have proven useful as social signals, assuming a new function without needing to change their basic form (*21*, *22*). Consequently, if moral disgust really is born from the same emotion involved in rejection of hazardous foods, then there should be continuity in facial actions between moral and oral disgust, despite the former being far removed from its purported origin in food rejection. Because moral disgust might result in subtle overt facial movements reflecting the residual engagement of a primitive oral disgust motor program, we recorded facial motor activity with electromyography (EMG), which enables greater sensitivity in detection relative to visual scoring techniques (*23*).

Our first goal was to collect objective measurements of the basic disgust expression with which to compare the moral disgust expression. The most

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primitive manifestation of disgust is thought to be distaste, a motivational response to the ingestion of unpleasant-tasting substances, many of which are harmful or toxic (*8*). However, little is known about spontaneous expressions elicited by distaste in adults and their underlying facial motor activity. Therefore, in the first experiment, we recorded facial EMG data while participants drank small samples of unpleasant-tasting bitter, salty, and sour liquids (*24*). A sweet solution of approximately equivalent subjective intensity to the unpleasant solutions was used as a control for nonspecific effects of gustatory stimulation; water was used as a neutral control.

We focused on measuring the activation of the levator labii muscle region of the face, which raises the upper lip and wrinkles the nose (*23*). These movements are thought to be characteristic of the facial expression of disgust (*25*, *26*) and may aid in the function of oral-nasal rejection of aversive chemosensory stimuli (*22*). Consistent with the proposed origin of disgust in distaste, drinking the unpleasant solutions resulted in activation of the levator labii region relative to drinking water or the sweet solution [repeated-measures analysis of variance (ANOVA): $F(2,52) = 8.07$, $P < 0.01$] (Fig. 1A). More specifically, levator labii region activity was greater for unpleasant solutions relative to the sweet solution [paired-samples *t* test: $t(26) = 2.89$, $P < 0.01$]. Levator labii region activity did not reflect a nonspecific response to intense tastes, as the pleasant sweet solution did not evoke significant activity relative to neutral water (paired-samples *t* test: $t < 1$). After each taste trial, participants rated the subjective valence of the preceding sample. These ratings of unpleasantness were highly correlated with the strength of levator labii region activity evoked (Fig. 1B, linear Pearson $r = 0.77$, $P < 0.001$; quadratic $r = 0.93$, $P < 0.001$).

To more accurately visualize the distaste response and the source of the activity in the levator labii region, we recorded on digital video an additional group of participants during ingestion of the solutions. A computerized facial appearance model was constructed to uncover the underlying action tendencies associated with the distaste response. The model represented facial expressions as vectors corresponding to variations from the average face common to face exemplars and then exaggerated these action tendencies by a factor of 2. Figure 1C (right panel) shows the model's depiction of a canonical distaste expression. Consistent with our finding of increased activity in the levator labii region, the upper lip raise and nose wrinkle are apparent, bearing striking similarity in facial actions to the putative disgust expression (*25*). Thus, tasting unpleasant liquids results in facial actions that are the precursors of more elaborated forms of disgust, and these actions may contribute to the adaptive sensory regulatory function of defending the senses against aversive and potentially harmful chemosensory stimuli (*22*).

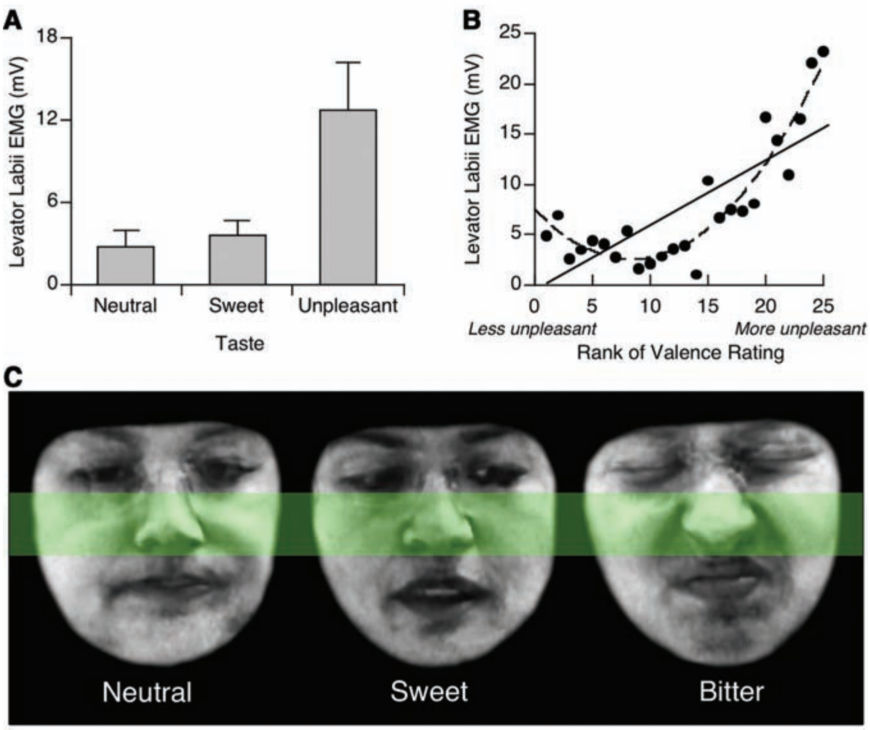

Fig. 1. (**A**) Mean levator labii region EMG response evoked by ingestion of neutral, sweet, and unpleasant liquids ($N = 27$). Error bars are +1 SEM [within-subjects (*31*)]. (**B**) Correlation between valence ratings and levator labii region EMG response. For each participant, valence ratings and the corresponding EMG responses for all trials were rank-ordered by decreasing valence. The EMG responses at each rank were then averaged across participants. Points on the plot show this average EMG response by rank; higher rank indicates greater unpleasantness. Linear (solid line) and quadratic (dashed line) fits are shown. (**C**) Appearance model–generated average facial expressions of the five most expressive individuals (from a total sample of 20) tasting neutral, sweet, and bitter solutions. The upper lip and nose areas are highlighted to show the action of the levator labii muscle (upper lip raise and nose wrinkle) across conditions.

We next moved beyond simple gustatory stimuli to examine the facial movements associated with more conceptual, but still relatively concrete, forms of disgust. We recorded EMG data from the levator labii region while participants viewed photographs of uncleanliness and contamination-related disgust stimuli, including feces, injuries, insects, etc. Sad photographs of equivalent negativity were used as a control for nonspecific effects of negative emotional arousal, and neutral photographs were also presented. All photographs were selected from the International Affective Picture System (*24*). Only the disgusting photographs resulted in increased activation of the levator labii region [repeated-measures ANOVA: $F(2,34) = 8.58$, $P < 0.001$] (Fig. 2A). Disgusting photographs resulted in significantly greater levator labii region activity than sad photographs [paired-samples *t* test: $t(17) = 3.71$, $P < 0.01$], whereas sad photographs did not differ from neutral photographs (paired-samples *t* test: $t < 1$). After viewing each photograph, participants rated their feelings of disgust and sadness. Subjective ratings of disgust were significantly correlated with activation of the levator labii region: The stronger the self-reported experience of disgust in response to a photograph, the more levator labii region activity was evoked (Fig. 2B; linear Pearson $r = 0.52$, $P < 0.001$). A more significant quadratic trend (Pearson $r = 0.80$, $P < 0.001$) suggests that the levator labii region may be most responsive to strong levels of disgust. In contrast to the disgust ratings, sadness ratings did not predict levator labii region activity (Fig. 2C; Pearson $r = 0.19$, $P = 0.15$). Because negative emotional arousal associated with increasing sadness did not correlate with activation of the levator labii region, facial motor activity in this area is not a general response to aversive experience (*25*, *26*). These results indicate that more abstract and complex—but still nonsocial or nonmoral—forms of disgust evoke facial motor activity that is very similar to that evoked by unpleasant tastes.

Having determined that both the primitive distaste response and more complex forms of disgust evoke levator labii region activity that is proportional to the degree of disgust or distaste experienced, we next examined whether the same pattern of results would hold for moral transgressions. Given that fairness is a cornerstone of human morality and sociality (*27*), we examined the facial motor activity associated with violations of the norm of fairness. We used the Ultimatum Game as a model of unfairness in social interactions. In our version of the Ultimatum Game, two players split \$10: The proposer suggests how the money should be split (an "offer"), which the responder can accept or reject. If the responder accepts, the money is split as proposed; if he or she rejects the offer, neither player receives anything. While undergoing EMG recording, participants played 20 rounds of the Ultimatum Game in the role of responder, one with each of 10 human proposers (confederates) and 10 with a computer partner. Participants treated offers from humans and computers almost equivalently, in terms of both behavior and emotional response (*24*), so the data presented below are collapsed across proposer identity. All offers were actually generated by a computer algorithm so as to control the number and size of offers made, which ranged from "fair" (proposing a $5:$5 split between proposer and responder) to very "unfair" (proposing a $9:$1 split). The EMG signal from the period when the proposer's offer was displayed was used to analyze facial activity associated with varying levels of unfairness.

In addition to measuring facial activity, we assessed subjective experience using a nonverbal self-report method that bypasses linguistic emotion labels, so as to avoid the common confusion between disgust and anger. At the end of each Ultimatum Game round, participants reported their experience by rating how well their feelings about the preceding offer were represented by photographs of seven different canonical emotional facial expressions [disgust, anger, contempt, fear, sadness, surprise, and happiness (*28*)]. To confirm that this self-report method separates disgust and its chemical sensory origins from other emotions, an independent group of observers matched the seven expressions to a variety of written emotion labels. The disgust expression was selected as the best match for disgust-relevant labels such as "tasting something bad" and "smelling something bad" in 85% of responses, whereas the anger expression was chosen in only 4% of responses [$\chi^2(1) = 35.4$, $P < 0.001$] and the contempt expression was never chosen. By contrast, the disgust expression was judged to portray anger-relevant labels such as "frustration" and being "pissed off" in only 12% of responses (table S1).

Participants accepted all fair ($5:$5) offers, with rejection rates increasing significantly as offers became increasingly unequal [fig. S1; repeated-measures ANOVA: $F(1,15) = 46.7$, $P < 0.001$], suggesting a motivation to punish unfair proposers even at personal financial cost. Of the seven emotions measured, four tracked the unfairness of offers: Disgust, anger, and sadness endorsement increased, whereas happiness endorsement decreased, as the offers became increasingly unfair [Fig. 3A; repeated-measures ANOVA, main effect of offer: $F(9,135) = 25.2$, $P < 0.001$]. Endorsement of contempt, surprise, and fear did not vary with the unfairness of offers [repeated-measures ANOVA, main effect of offer: $F(3,45) = 1.36$, $P = 0.27$; fig. S2]. In addition to reporting increasing disgust with increasing offer unfairness [focused contrast: $F(1,135) = 64.8$, $P < 0.001$], unfair offers evoked disgust to a greater degree than both anger [focused contrast: $F(1,135) = 25.0$, $P < 0.001$] and sadness [focused contrast: $F(1,135) = 25.0$, $P < 0.001$]. In other words, when participants received unfair offers, they judged their experience as most similar to tasting or smelling something bad.

To provide a visualization of participants' ratings of their internal feeling states, we used the emotion endorsements for $9:$1 offers to modify the expression photographs used in the self-report task. Using our facial appearance model, we weighted the vector representations of each expression such that the intensity of each expression matched its endorsement strength. Participants endorsed strong disgust, moderate anger, and mild sadness (Fig. 3C). Only disgust expressions showed levator labii activation (highlighted in green). Moreover, a comparison of the disgust expression to distaste and the six other emotion prototypes showed a significantly positive correlation only with distaste (Pearson $r = 0.58$, $P < 0.001$; fig. S3), which suggests that the emotion endorsed in response to unfair offers was most similar in appearance to that displayed by participants consuming unpleasant tastes in our earlier experiment.

Because the emotional response to unfairness was not characterized by disgust alone, we examined what the total self-reported emotional response to unfairness might look like. We created a blend of the disgust, anger, and sadness expressions that participants rated during the self-report task, weighted according to the strength of emotion endorsement for $9:$1 offers. The far right panel of Fig. 3C shows the resulting model of the facial response to unfairness, reflecting a complex blend of multiple emotions. We note that the presence of disgust is more subtle, likely because the presence of other emotions dilutes its appearance.

Confirming the subjective reports of disgust, levator labii region EMG was significantly affected by the type of offer presented [repeated-measures ANOVA: $F(3,45) = 3.51$, $P < 0.05$]. Specifically, the increase in self-reported disgust was paralleled by a parametric increase in levator labii region activity as offers became more unfair [Fig. 3B; linear contrast: $F(1,45) = 6.34$, $P < 0.05$]. Focused contrasts revealed that levator labii region activity was greater for $9:$1 offers (which were most often rejected; mean of 73% rejection) relative to $5:$5 and $7:$3 offers (which were most often accepted; mean of 10% rejection) [$F(1,45) = 9.32$, $P < 0.004$]. The decrease in levator labii region activity for $7:$3 offers relative to $5:$5 was not statistically reliable [focused contrast: $F(1,45) = 1.11$, $P = 0.29$].

The association between self-reported disgust and levator labii activity received further support from a significant correlation between disgust experience and the strength of levator labii region activity. Offers rated as more disgusting were associated with more activation of the levator labii region (Fig. 3D; Pearson $r = 0.61$, $P < 0.01$). Note that the period of EMG analysis preceded the viewing of facial expressions during self-report to ensure the independence of these measures. Although anger and sadness endorsement also increased with increasing unfairness, these ratings did not correlate with levator labii region activity (Fig. 3, E and F; anger, Pearson $r = 0.14$, $P > 0.5$; sadness, Pearson $r = 0.052$, $P > 0.8$). Contempt, another emotion that has been theoretically linked to immorality (*9*), also did not correlate with activation of the levator labii region (Pearson $r = 0.26$, $P > 0.2$). Levator labii region activity was thus specifically related to feelings of tasting or smelling something bad.

In sum, participants showed both subjective (self-report) and objective (facial motor) signs of disgust that were proportional to the degree of unfairness they experienced. These results bear a strong resemblance to the findings of the first two experiments, suggesting that moral transgressions trigger facial motor activity that is also evoked by distasteful and basic disgust stimuli, even though the "bad taste" left by immorality is abstract rather

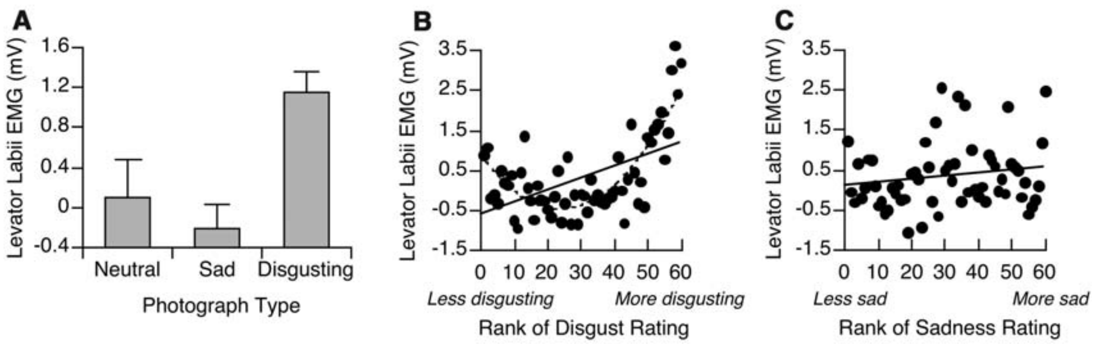

Fig. 2. (**A**) Mean levator labii region EMG response evoked by viewing neutral, sad, and disgusting photographs ($N = 18$). Error bars are +1 SEM [within-subjects (*31*)]. (**B**) Correlation between disgust ratings and levator labii region EMG response. Disgust ratings and the paired EMG responses for all photographs were rank-ordered for each participant in order of increasing disgust. The EMG responses at each rank were then averaged across participants. Points on the graph show this average EMG response by rank. Higher rank indicates a more disgusting photograph. Linear (solid line) and quadratic (dashed line) fits are shown. (**C**) Correlation between sadness ratings and levator labii region EMG response, showing linear fit. Correlation was calculated as in (B).

than literal. These data provide direct evidence for Darwin's notions regarding the primitive origins of facial expressions (*21*), as well as their exaptation into the social or moral domain (*22*).

Our results support the idea that moral transgressions evoke disgust as well as other negative emotions. However, the importance of these feelings is not yet clear: What effect do they have on decision-making, if any? One possibility is that negative emotions accompany unfairness but are irrelevant to the decision to reject unfair offers. However, contrary to this interpretation, we found that self-reported disgust was strongly correlated with the decision to reject unfair offers: The more disgust a participant reported, the more likely he or she was to reject a given unfair offer (Pearson r = 0.70, P < 0.05). In contrast to disgust, self-reports of anger were moderately correlated with rejection (Pearson r = 0.58, P = 0.078), whereas sadness was not significantly correlated with rejection (Pearson r = 0.34, P = 0.37). Thus, in addition to being experientially most salient, feelings of disgust were the strongest predictor of decision-making. Providing further support for an association between disgust and the behavioral response to offers, activation of the levator labii region was correlated with the tendency to reject unfair offers: Unfair offers that were associated with stronger levator labii region activity during offer presentation were more likely to be rejected (Pearson r = 0.71, P < 0.05). These results suggest that the spoiling of economically rational behavior—rejection of unfair offers (i.e., receiving no money versus some)—is strongly associated with subjective and objective measures of disgust. Although these correlations cannot establish a causal relationship between decision-making and emotionality, they do suggest that emotions evoked in response to unfairness—in particular disgust—are relevant to subsequent behavioral choices.

Taken together, our results provide direct evidence of the primitive oral origins of moral disgust. A facial motor action program evoked by aversive chemical sensory stimulation extends to other concrete forms of disgust related to cleanliness and contamination and is also triggered when the everyday moral code of fairness is violated. Furthermore, subjective feelings of tasting or smelling something bad were evoked in response to unfairness, and, in parallel with disgust-related facial motor activity, predicted increasing rejection of unfair offers. The disgust evoked by moral transgressions thus appears to be similar to that evoked by bad tastes and potential disease agents.

These results are consistent with the idea that in humans, the rejection impulse characteristic of distaste may have been co-opted and expanded to reject offensive stimuli in the social domain (*8*). Although some theories have proposed that moral disgust is reserved for transgressions that are conceptually related to notions of moral contamination or purity, with anger and contempt being the more likely response to violations of individual rights and community norms (*9*), our data suggest that moral disgust may in fact be triggered by a wider range of offenses. The role of disgust in active rejection and distancing could explain why

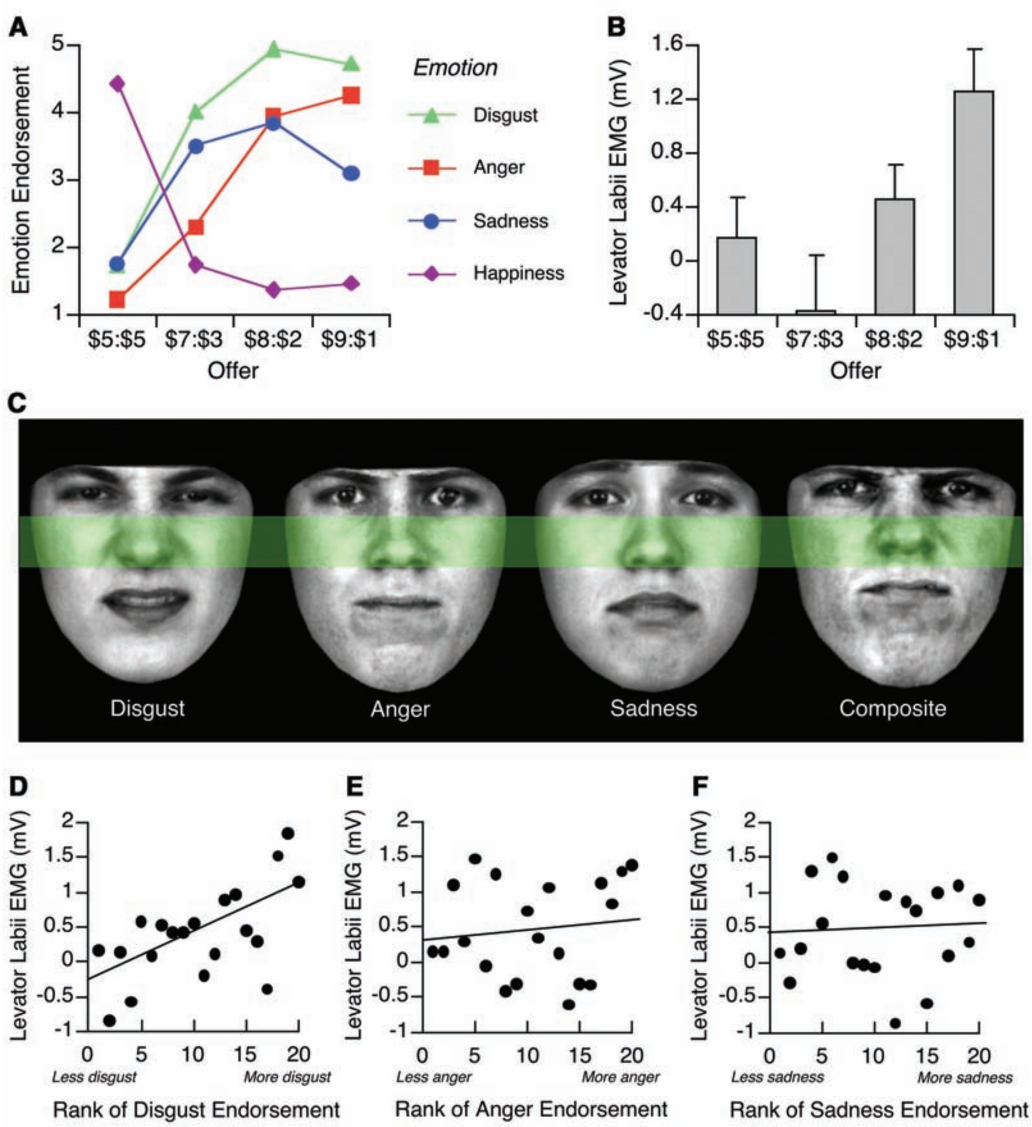

Fig. 3. (**A**) Mean self-reported emotion in response to different offers in the Ultimatum Game (N = 16). Only emotions that varied with offer type are shown. Higher numbers indicate greater endorsement. (**B**) Mean levator labii region EMG response evoked by the different offers. Error bars are +1 SEM [within-subjects (*31*)]. (**C**) Negative emotions endorsed for $9:$1 offers. Disgust, anger, and sadness expression photographs used in the self-report task were modified using a computer model of facial appearance by weighting the expression intensity by the strength of emotion endorsement; the far right panel shows a composite of these expressions. The upper lip and nose areas are highlighted, showing the action of the levator labii muscle (upper lip raise and nose wrinkle) in the disgust expression and composite. (**D**) Correlation between disgust ratings and levator labii region EMG response. For each participant, disgust ratings and the corresponding EMG responses for all trials were rank-ordered by increasing disgust. The EMG responses at each rank were then averaged across participants. Points on the plot show this average EMG response by rank. Higher rank indicates greater disgust endorsement. Linear fit is shown. (**E**) Correlation between anger ratings and levator labii region EMG response, calculated as in (D). (**F**) Correlation between sadness ratings and levator labii region EMG response, calculated as in (D).

immorality evokes this emotion in addition to others such as anger: Whereas anger is associated with approach motivation (*29*), disgust may motivate vigorous withdrawal (*8*). Thus, unfair offers may be received like a plate of spoiled food. This turning away or rejection of unfair actions may also extend to later avoidance of transgressors.

The ability to detect and avoid toxins appears to be very ancient: Sea anemones, which evolved about 500 million years ago, evert their gastrovascular cavities in response to being fed a bitter substance (*30*). That a system with the ancient and critical adaptive function of rejecting toxic foods should be brought to bear in the moral sphere speaks to the vital importance of regulating social behavior for human beings. Although the stimulus triggers for this rejection mechanism may have shifted far from their chemical sensory origins to the moral domain, the basic behavioral program of oral rejection appears to have been conserved. Thus, the metaphorical "bad taste" left by moral transgressions may genuinely have its origins in oral distaste.

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Supporting Online Material

www.sciencemag.org/cgi/content/full/323/5918/1222/DC1
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Blue or Red? Exploring the Effect of Color on Cognitive Task Performances

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Existing research reports inconsistent findings with regard to the effect of color on cognitive task performances. Some research suggests that blue or green leads to better performances than red; other studies record the opposite. Current work reconciles this discrepancy. We demonstrate that red (versus blue) color induces primarily an avoidance (versus approach) motivation (study 1, *n* = 69) and that red enhances performance on a detail-oriented task, whereas blue enhances performance on a creative task (studies 2 and 3, *n* = 208 and 118). Further, we replicate these results in the domains of product design (study 4, *n* = 42) and persuasive message evaluation (study 5, *n* = 161) and show that these effects occur outside of individuals' consciousness (study 6, *n* = 68). We also provide process evidence suggesting that the activation of alternative motivations mediates the effect of color on cognitive task performances.

Color is a fundamental aspect of human perception, and its effects on cognition and behavior have intrigued generations of researchers. Although a large amount of research has been done in this domain, the psychological processes through which color operates have not been explored fully. As a result, the field has observed certain conflicting results. One inconsistency, which is the focus of this report, concerns the effect of color on cognitive task performance. Most research examining this topic has focused on two of the three primary colors—red versus blue (or green). Some have proposed that red enhances cognitive task performance as compared with blue or green (*1*, *2*); others have shown exactly the opposite (*3*, *4*).

This report details our effort to understand the theory behind the psychological process through which color affects cognitive task performances. Based on our theorizing, we are able to reconcile the above-described inconsistency. We demonstrate that red and blue activate different motivations and consequently enhance performances on different types of cognitive tasks. In line with most of the extant research, we limit our research to the two primary colors, red and blue.

Color theorists believe that color influences cognition and behavior through learned associations (*3*). When people repeatedly encounter situations where different colors are accompanied by particular experiences and/or concepts, they form specific associations to colors. Red and blue have been shown to have different associations within the cognitive domain. Red is often associated with dangers and mistakes [e.g., errors that are circled with a red ink pen, stop signs, and warnings (*3*)]. Claims have been made linking the color red to the highest level of hazard and also the highest level of compliance (*5*, *6*). In contrast, blue is often associated with openness, peace, and tranquility [e.g., ocean and sky (*7*)]. A word association test confirmed that people indeed generate these different associations to red versus blue color in the cognitive task domain (*8*, *9*).

We propose that these different associations related to red versus blue color can induce alternative motivations. Specifically, red, because of its association with dangers and mistakes, should activate an avoidance motivation, which has been shown to make people more vigilant and risk-averse (*10*–*12*). Thus, red, compared with blue, should enhance performance on detail-oriented tasks (i.e., tasks that require focused, careful attention). In contrast, because blue is usually associated with openness, peace, and tranquility, it is likely to activate an approach motivation, because these associations signal a benign environment that encourages people to use innovative as opposed to "tried-and-true" problem-solving strategies (*13*). Indeed, an approach motivation has been shown to make people behave in a more

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