Emotion

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Sometimes risk involves taking actions that in and of themselves elicit emotion, often fearful emotions. Across two studies we test the hypothesis that preventing facial actions associated with fear and anxiety responses during a risky decision task leads to greater risk taking. We first demonstrate that while performing the balloon analogue risk task (Lejuez et al., 2002), individuals make grimaces associated with anxious anticipation. In Study 1 ($n = 120$), experimental condition participants had inflexible medical tape attached to their foreheads to disrupt movement of the brow, and they wore a mouth guard that interfered with actions involving the mouth. Tape was also applied to control participants' faces, but it did not disrupt facial action, and they did not wear a mouth guard. All participants performed the balloon analogue risk task, in which a greater number of balloon pumps signals more risk taking. Study 2 ($n = 202$) served as a replication and minor extension that added a second risk task also predicted to elicit anxious anticipation (i.e., a jack-in-the-box toy). As hypothesized, disrupting the activation of facial muscles led to more balloon pumps and lever turns. Our findings suggest that facial expressions modulate risk taking.

Keywords: emotion, facial expression, risk, decision-making

Risk is ubiquitous in daily life. People weigh the costs and benefits of important life decisions involving medical treatments, financial investments, leisure time activities, and even life partners. Some evidence suggests that emotional responses, measured by sympathetic nervous system activation, cardiovascular reactions, body posture, and self-report, are used by decision-makers as information about how much risk to take (cf. Castellano, Kessous, & Caridakis, 2008; Damasio, Everitt, & Bishop, 1996; Ekman, 2004). The present study investigates the role of facial expression in the regulation of risk taking.

Emotions in Decision-Making

There are several ways in which emotions affect decision-making (Lerner, Li, Valdesolo, & Kassam, 2015; Loewenstein, Weber, Hsee, & Welch, 2001; Schlosser, Fetchenhauer, & Dunning, 2016). The emotional consequences of choice options can be anticipated and the forecasted emotions sometimes guide decisions. For example, positive emotions predicted to result from moving to a particular country or city may cause people to make the move. However, because people are relatively poor affective forecasters, anticipated emotions may also lead to compromised decision-making (Kermer, Driver-Linn, Wilson, & Gilbert, 2006).

Emotions immediate to the decision context also affect choice. Emotions in context include background moods that the individual is feeling, as well as so-called action-related emotions, that are associated with the behaviors involved in the decision-making itself (Schlosser, Dunning, & Fetchenhauer, 2013; Schlosser et al., 2016). These latter emotions are pertinent to the context of risky decision-making. Deciding to jump off of a waterfall into a small pool of water for recreation involves taking risk (one might hit the edge or land poorly). But the act of jumping, independent of the successful entry into the water, is itself emotion-eliciting. Action-related emotions, such as the anxiety felt at the top of a cliff, are important in risky decisions because they may signal whether an individual should take a risk or be averse to a risk (Dunning, Fetchenhauer, & Schlosser, 2017). Fear and anxiety are frequently experienced in contexts that involve risk (Lerner & Keltner, 2001; Smith & Ellsworth, 1985). Because of their association with situational uncertainty appraisals, such emotions typically lead people to become more risk averse (Lerner & Keltner, 2001; Smith & Ellsworth, 1985).

Embodied Emotions in Risky Decisions

One account of the effects of action-related emotions in decision-making, the somatic marker hypothesis, holds that both conscious and nonconscious emotions associated with past behaviors are stored in sensorimotor systems of the brain (Bechara & Damasio, 2005; Damasio et al., 1996). Somatic markers regulate decision-making by providing cues about which objects and events are safe to approach versus should be avoided. In experiments involving

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the Iowa gambling task, emotional responses that signal positive outcomes promote drawing a card from a deck that is more likely to pay off with wins versus losses (Bechara, Damasio, Tranel, & Damasio, 1997). The disruption of the representation of emotional responses to outcomes, due to lesions in the ventromedial sector of the prefrontal cortex, has been found to compromise learning about gains and losses and consequently to lead to riskier decisions (Bechara et al., 1997; Bechara & Damasio, 2005). Recent evidence suggests that near-wins and near-losses in decision-making also involve the activation of facial musculature (Wu, van Dijk, & Clark, 2015). If negative emotions associated with risky outcomes can be useful in regulating risk taking, the disruption of facial expressions of emotion should also compromise decision-making.

Embodied Facial Expressions Inform Emotions

Indeed, sufficient evidence now exists to suggest that individuals' facial expressions feed back to affect their emotional experiences (e.g., Wood, Rychlowska, Korb, & Niedenthal, 2016). In particular, facial expressions appear to modulate emotional experience in an emotion-congruent manner (Davis, Senghas, & Ochsner, 2009; Niedenthal, 2007; Soussignan, 2002). Some of the most convincing demonstrations of the influences of facial expression on one's own emotional state come from investigations of facial mimicry. For example, findings of a recent study revealed that participants who were instructed to imitate facial expressions experienced higher arousal (as measured by pupillary dilation and skin conductance) when viewing angry faces than did participants who viewed the angry expressions without imitation (Lee et al., 2013). In another study, participants who were induced to smile during a cold pressor task reported less negative affect and had lower stress responses compared to participants who were not induced to smile (Kraft & Pressman, 2012).

Conversely, disrupting facial movement has been shown to reduce the intensity of experienced emotions (cf. Wood et al., 2016). When facial expression is prevented, for instance by injections of Botox to the brow, negative emotional experience is reduced as indicated by self-report (Davis, Senghas, Brandt, & Ochsner, 2010) and neuroimaging measures (Hennenlotter et al., 2009). Other related research suggests that manipulating the contraction of facial muscles on both the upper and lower parts of the face disrupts anxiety and fear processing (Ponari, Conson, D'Amico, Grossi, & Trojano, 2012).

Recent work by Rychlowska and colleagues (2014) is particularly relevant to the methods employed in the present research. Those researchers measured the muscle actions portrayed in facial expression stimuli using the Computer Expression Recognition Toolbox (i.e., CERT; Littlewort et al., 2011) software, and then recorded participants' facial muscles with electromyography (EMG) while they observed these facial expression stimuli. During observation, participants either wore a mouth guard to disrupt their smile activity or did not wear a mouth guard. When participants did not wear a mouth guard, there was a close correspondence between their facial action and that of the emotion expression stimuli they were observing, whereas when their facial action was disrupted participants did not show the same relationship. In other words, the mouth guard procedure prevented participants from producing accurate facial mimicry. Subsequent experiments showed that the disruption of facial mimicry using this method was associated with less accurate decoding of different types of smile expressions. Apparently, when feedback from matching facial muscles was disrupted, the internal affective experience used to recognize facial expressions was compromised.

Present Research

The link that has been established between facial expression and emotional responding is sufficient to suggest that feelings of fear and anxiety are useful in determining the extent of risk to be accepted in a decision task. Given that fear and anxiety provide information about whether to accept or reject risk, the disruption of facial expressions of those feelings should promote greater risk taking than would be present in the absence of such disruption. Thus, the goal of the present research was to test the hypothesis that disrupting facial expressions associated with fear and anxiety leads to increases in risk-taking behavior.

Pretest Demonstration

We first conducted a pretest investigation to assess whether negative facial expressions related to anxiety or fear occur spontaneously during a task involving wins and losses (i.e., the balloon analogue risk task [BART]; Lejuez et al., 2002), compared to on a task that probes the perceived likelihood of negative outcomes (DeSteno, Petty, Wegener, & Rucker, 2000, see Procedure for details). We selected the BART because we sought to study "action-related" emotions (cf. Dunning et al., 2017), whereby people experience emotions generated by actively engaging in a risky task that involves real consequences (i.e., you either win or lose real money). The BART is commonly used in the risky decision-making literature (cf. Lauriola, Panno, Levin, & Lejuez, 2014) to assess how people approach and avoid risky decisions that have real win versus loss consequences (Lejuez et al., 2002) and has been shown to predict real-world risk taking behaviors (cf. Lejuez, Aklin, Jones, et al., 2003; Lejuez, Aklin, Zvolensky, & Pedulla 2003). The BART has been found to have good test–retest reliability (White, Lejuez, & de Wit, 2008) and construct validity (Hopko et al., 2006), and has been used in neuroscience studies examining the neural correlates of risky decision-making (Fukunaga, Brown, & Bogg, 2012; Rao, Korczykowski, Pluta, Hoang, & Detre, 2008). A perceived likelihood judgment task was employed as a comparison task because it is well-established in the risky decision-making literature (cf. DeSteno et al., 2000), but does not involve real risky actions or consequences.

The facial expressions of six participants were recorded during both tasks using a laptop camera. Two coders blind to hypotheses rated visible facial expressions (Cohen's $\kappa = .66$, $p < .001$); discrepancies were resolved by a third coder also blind to hypotheses. No power analyses were performed prior to running this pretest and we were not anticipating significant results with a small sample. We were interested in whether the BART generally elicited facial expressions of emotion consistent with anxiety or fear directionally more than the likelihood judgment task. The coding revealed that participants made an average of 4.16 facial actions similar to those found in anxiety and fear expressions (e.g., brow raising and drawing together, and grimacing with the mouth) out of 30 trials (approximately 14% of trials, $SD = .72$) when performing the BART, and an average of .33 facial expressions associated with anxiety and fear out of 14 trials (approximately 2.3% of trials,

SD = .42) when engaging in the likelihood judgment task, $t(5) = 9.78$, $p < .001$, 95% confidence interval (CI) [2.82, 4.84], $d = 6.5$. During the BART, participants also made more brow movement and grimacing expressions ($M = 4.16$, $SD = .72$) than positive expressions (i.e., smiling, laughing; $M = 2.0$, $SD = 2.09$), $t(5) = -2.75$, $p = .04$, 95% CI [−4.19, −.14], $d = 1.4$. We had raters code observable facial expressions of emotion, rather than relying on participant self-reports of emotions in this pretest, because the BART (described in more detail below) is a dynamic task involving 30 trials of decision-making. Self-reports of emotions after each trial would interfere with the decision process, and self-reports of emotion following the task would likely only provide a summary of how participants felt at the end of the experiment. This initial demonstration provides evidence that individuals make visible facial expressions associated with anxiety and fear in a risky decision task.

Experiment 1

In the present study, we restricted the facial-muscular activity of half of our participants while they performed one risky decision task that elicited facial expressions consistent with the uncertainty-related emotions of anxiety and fear, and one task that did not. Compared to control participants, we expected those with restricted facial-muscular activity to make riskier decisions on the former, but not the latter task, because the signal to avoid the uncertainty inherent in the risk would be disrupted.

Method

Participants. One hundred twenty undergraduates (M_{age} = 19.23, 78 females) were recruited from an introductory psychology subject pool to participate in a 1-hr laboratory experiment. Eight participants ($n = 3$ experimental condition, $n = 5$ control condition) were excluded due to procedural errors or computer software malfunctions, leaving 112 participants for analysis. A sample size of 120 was determined prior to the beginning of data collection based on recent work on facial disruption (cf. Rychlowska et al., 2014) and on risk taking using the BART (cf. Kohno et al., 2015; Seaman, Stillman, Howard, & Howard, 2015), suggesting that a sample size of around 50 subjects per cell would be sufficient. A sensitivity analysis performed on the data of the first 47 subjects suggested that a smaller sample size was required, with strong between sample differences indicating that only a sample size of 42 was necessary to satisfy a power of .8 at $\alpha = .05$.

Procedure. Upon signing a consent form, participants were randomly assigned to either an experimental or control condition. Two procedures were followed to disrupt experimental participants' facial expressions of anxiety and fear, which involve both upper and lower parts of the face. To disrupt expressiveness of the upper part of the face, three varieties of stiff and inflexible medical tape were applied in layers across experimental participants' foreheads. The first layer of tape (1/2 in. wide) extended from the bridge of the nose to the hairline; the second layer of tape (2 in. wide) extended across the forehead from one temple to the other; and two pieces of the final layer of tape (1 in. wide each) were applied across the forehead, on top of the 2-in.-wide second layer of tape, to maximally hinder movement (see Figure 1).

To disrupt expressiveness of the lower part of the face, we relied on the previously discussed procedure that used CERT and EMG to test the effectiveness of protective sports mouth guards for this purpose (Rychlowska et al., 2014). Use of CERT and EMG is not possible in our study because the application of tape across the forehead in the experimental condition hinders our ability to record facial action using either of these techniques. Participants in our study prepared their own boil-and-bite mouth guards by first submerging the apparatus into boiling water for 7 s, then into their

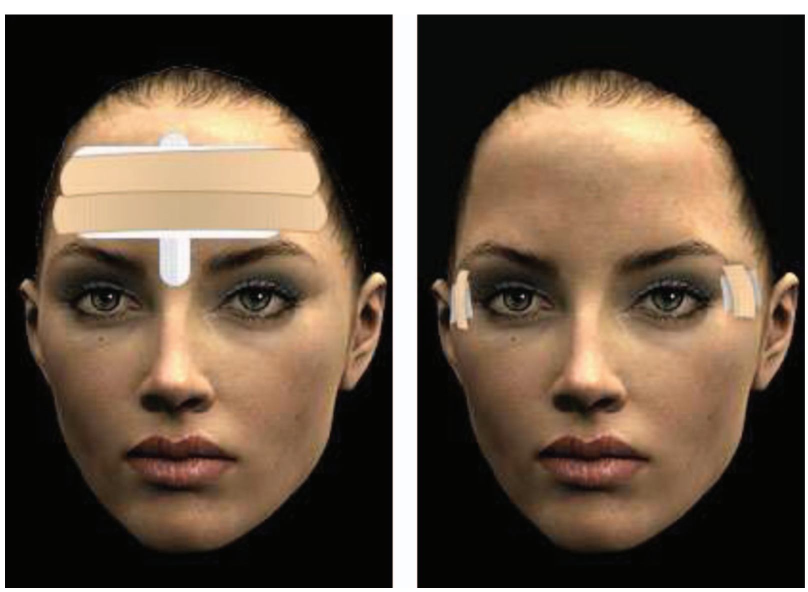

Figure 1. Depicts the face taping procedure in the experimental (left) and control (right) conditions. The face used here was generated from https://facegen.com/. The mock tape was applied using Adobe Photoshop software. See the online article for the color version of this figure.

mouth for 10 s, and finally in cold water for 20 s. Participants wore the mouth guard throughout the experiment.

In the control condition, participants also had tape applied to their temples, but in a position that would not disrupt movement of the corrugator muscle (see Figure 1). Control condition participants then prepared a boil-and-bite mouth guard, but were told to put the guard on a paper towel for later use and never wore it during the experiment.

Following the face-tape and mouth guard preparation, participants completed a computerized version of the BART (Lejuez et al., 2002). The BART was programed into E-Prime 2.0 Professional. Over 30 trials, participants pressed a button as many times as they chose to inflate a virtual blue balloon depicted on the computer screen. The pumps constituted points that were converted into real money (up to $2) based on performance. If the balloon popped on a given trial, participants lost points on that trial. Balloons popped at random intervals, such that participants did not learn a specific inflation rule. More balloon pumps on each trial indicated greater risk taking behavior.

After completing the BART, participants made 14 likelihood judgments that have been used before in work on emotion and risk perception (DeSteno et al., 2000). An example of a likelihood judgment includes, "Of the 20,000 violent criminals who will be put on trial this year in the United States, how many will be set free because of legal technicalities?" Likelihood judgments are often used as a measure of risk perception (Johnson & Tversky, 1983), and are influenced by both valence and specific emotions (Johnson & Tversky, 1983; Desteno et al., 2000). Although likelihood judgment tasks reveal risk perception, the individual making the judgment never actually takes a risk (in other words, the likelihood judgments do not elicit action-related emotions). The likelihood judgment task was included to test our prediction that the restriction of facial expressions would not affect decision tasks that do not contain risk behaviors and thus do not elicit action-related emotions. Participants then completed demographics and were debriefed. All measures, manipulations, and exclusions are reported in this study. All research reported here was approved by the University of Wisconsin—Madison Education and Social/Behavioral Science Institutional Review Board.

Results

Results of an independent samples *t* test confirmed our prediction that restricting the activation of facial muscles during the BART leads to riskier decisions, that is, a higher average number of pumps, adjusted for successful pumps only ($M = 38.96$, $SD = 14.13$), as compared to control participants who did not have disrupted facial muscle activation ($M = 33.27$, $SD = 11.68$), $t(110) = 2.32$, $p = .022$, 95% CI [.83, 10.56], $d = 0.44$ (Figure 2).

Moreover, performance on a decision task involving likelihood judgments of negative events, which did not elicit action-related emotions, was not significantly influenced by the disruption of facial expressions ($M = -.11$, $SD = .88$) compared to control ($M = .11$, $SD = 1.11$), $t(110) = -1.19$, $p = .24$, 95% CI [–.59, .15], $d = 0.2$. Likelihood estimates were averaged and then standardized. Participant gender also did not significantly influence the adjusted average for successful pumps, $F(1, 108) = .12$, $p = .73$, $\eta^2 = .001$, and did not significantly interact with the facial disruption condition $F(1, 108) = .72$, $p = .39$, $\eta^2 = .006$.

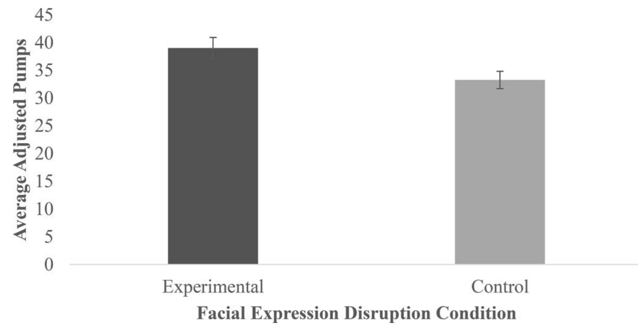

Figure 2. Depicts the average adjusted balloon pumps on successful trials by facial expression disruption condition. A greater number of balloon pumps indicates more risk taking. Error bars represent ±1 standard error of the mean.

Experiment 2

In Study 1, compared to control participants, we found that those with disrupted facial-muscular activity made riskier decisions on a task that elicits action-related emotions. The purpose of Study 2 was to replicate and extend our findings from Study 1 by readministering the BART with a larger sample and also adding a second action-related risk task (i.e., a jack-in-the-box toy procedure). We also directly tested the prediction that action-related risk tasks elicit more negative emotions with underlying uncertainty appraisals (i.e., fear and anxiety) than nonaction related tasks. We predicted the following:

> *Hypothesis 1:* As in Experiment 1, subjects with restricted facial-muscular activity would make riskier decisions on the tasks that elicit action-related emotion (the BART and jack-in-the-box task), but not on the non-action-related likelihood judgment task.

> *Hypothesis 2:* The action-related risk tasks, including the BART and a jack-in-the-box task, would elicit more negative emotions with underlying uncertainty appraisals (fear and anxiety) than would the non-action-related risk task (i.e., the likelihood judgment task).

Method

Participants. Two-hundred and two undergraduates ($M_{age} = 18.63$, 120 females) were recruited from an introductory psychology subject pool to participate in a 1-hr laboratory experiment. Twelve participants ($n = 5$ experimental condition, $n = 7$ control condition) were excluded due to procedural errors and malfunctions, leaving 190 participants for analysis. An original sample size of at least 82 subjects/condition was selected prior to the beginning of data collection based on an a priori power analysis conducted on the adjusted average pumps for successful trials data from Study 1. This analysis suggested we would need a total sample size of $n = 164$ to reach a power of at least .80. Some data loss in Study 2 also occurred due to E-Prime, video software, and jack-in-the-box malfunctions, as well as experimenter difficulty with the jack-in-the-box and taping procedures. The E-Prime malfunctions were likely due to use of a new lab space with a different set of computers.

Procedure. As in Study 1, participants were randomly assigned to either an experimental or control condition. Research assistants were blind to study hypotheses and read from a script to increase consistency across study sessions. Participants were videotaped so that lever turning during the jack-in-the-box task could later be counted by coders blind to hypotheses. The face taping and mouth guard procedures for the two conditions (e.g., facial expression disruption and control) were identical to those used in Study 1. Participants also completed the same computerized version of the BART as described in Study 1. The only procedural difference was that the pumps were converted into monetary values of up to $1 based on performance.

After completing the BART, participants were given a jack-in-the-box toy. Jack-in-the-box toys have been used in developmental research to study uncertainty-related emotions like surprise and fear (Condry & Condry, 1976; Izard, Huebner, Risser, & Dougherty, 1980; Reissland, Shepard, & Cowie, 2002). In our procedure, turning the lever corresponded to the receipt of real money (up to $1) based on performance (i.e., not popping the jack out of the box). The jack would typically pop out if the lever was turned between 10 and 15 times, but participants were told that it could pop out at any time. Participants were instructed that their task was to turn the lever forward between 1 and 20 times to receive points for each time they successfully turned the lever without the jack popping out of the box. If the jack popped out, however, participants were informed that they would lose all points, and therefore earnings, for this task. We included the jack-in-the-box task because it involves physically manipulating an object, and thus we predicted it would elicit stronger action-related emotions than the BART task. Following the jack-in-the-box task, participants completed the same likelihood judgments used in Study 1 (DeSteno et al., 2000).

Participants then rated the emotions they felt during each of the three risk tasks on a scale ranging from 1 to 5. These ratings were made at the end of the experiment, following the completion of all tasks. We asked participants to rate their emotions at the end of the study so that awareness of one's emotions would not interfere with natural emotional responses (cf. Schwarz & Clore, 1983). The emotions were divided into three categories: fear/anxiety (scared, nervous, jittery, afraid), other negative emotions (distressed, upset, guilty, hostile, irritable, ashamed), and positive emotions (interested, excited, strong, enthusiastic, proud, alert, inspired, determined, and attentive).

Participants finally completed demographics and were debriefed. All measures, manipulations, and exclusions are reported here. Study 2 was also preregistered before the beginning of data collection on the Open Science Framework (https://osf.io/t3fxs/register/565fb3678c5e4a66b5582f67) website.

Results

Emotions experienced during the risk tasks. We tested our prediction that action-related tasks elicit more fear and anxiety emotions than non-action-related tasks, and that these emotions would be stronger among the control (nondisrupted facial expression) participants. See Table 1 for the means and standard deviations of emotion types by task. A series of paired samples t tests confirmed our prediction that the BART, $t(189) = 9.46$, $p < .001$, 95% CI [.49, .75], $d = .78$, and the jack-in-the-box task, $t(189) = 13.86$, $p < .001$, 95% CI [.95, 1.27], $d = 1.21$, elicited significantly more anxiety and fear emotions than did the likelihood estimate task. The jack-in-the-box task also elicited stronger anxiety and fear emotions than did the BART task, $t(189) = -9.23$, $p < .001$, 95% CI [–.59, −.38], $d = .05$.

Table 1
Reflects the Raw Means (Standard Deviations) of Self-Reported Emotions Experienced During Each of the Three Risk Tasks by Condition Type

		Risk task		
Condition	Emotions	BART	Jack-in-the-box	Likelihood estimate
Disruption	Anxiety/fear	1.96 (.72)	2.42 (.93)	1.42 (.68)
	Other negative	1.48 (.43)	1.41 (.47)	1.43 (.53)
	Positive	2.68 (.68)	2.24 (.61)	1.95 (.62)
Control	Anxiety/fear	2.26 (.93)	2.79 (1.15)	1.56 (.81)
	Other negative	1.63 (.54)	1.52 (.60)	1.48 (.59)
	Positive	2.78 (.68)	2.35 (.76)	2.21 (.85)
Collapsed	Anxiety/fear	2.11 (.84)	2.60 (1.06)	1.49 (.75)
	Other/negative	1.55 (.48)	1.47 (.54)	1.45 (.56)
	Positive	2.73 (.68)	2.29 (.68)	2.07 (.75)

Note. BART = balloon analogue risk task.

We next investigated whether disrupting facial expressions weakens reports of experienced negative emotions. If disrupting facial expressions associated with fear and anxiety disrupts feedback from those emotions, then we would expect those people to also feel less emotional than participants without disrupted facial activity. Consistent with this reasoning, subjects in the disruption condition reported significantly lower anxiety and fear related emotions during the BART than those in the control condition, $t(188) = -2.50$, $p = .01$, 95% CI [–.54, −.06], $d = .36$. Similarly, subjects in the disruption condition also reported feeling significantly lower anxiety and fear during the jack-in-the-box task than those in the control condition, $t(188) = -2.45$, $p = .02$, 95% CI [–.67, −.07], $d = .34$. As predicted, there were no significant condition differences in anxiety related emotions elicited while making the likelihood estimates, $t(188) = -1.33$, $p = .18$, 95% CI [–.36, .07], $d = .18$. For the jack-in-the-box task, there were no condition differences for the "other" (nonanxiety or fear) negative emotions, $t(188) = -1.43$, $p = .15$, 95% CI [–.26, .04], or for the positive emotions, $t(188) = -1.09$, $p = .27$, 95% CI [–.31, .08]. Overall, the jack-in-the-box task also elicited overall greater anxiety/fear than positive emotions, $t(189) = 4.21$, $p < .001$, 95% CI [.17, .46], $d = .35$, and greater positive emotions than other negative emotions, $t(189) = 14.88$, $p < .001$, 95% CI [.72, .93], $d = 1.35$. On the BART task, there were significantly more "other" negative emotions experienced in the control condition than in the disruption condition, $t(188) = -2.17$, $p = .031$, 95% CI [–.29, −.01], $d = .68$. This suggests the BART elicited more mixed negative emotional reactions than the jack-in-the-box task. Overall, there were no significant differences in positive emotions experienced between the experimental and the control conditions during the BART, $t(188) = -1.01$, $p = .31$, 95% CI [–.29, .09], $d = .16$, but positive emotions were greater than both anxiety/fear, $t(189) = -10.27$, $p < .001$, 95% CI [–.73, −.49], $d = .81$ and other negative emotions, $t(189) = -23.43$, $p < .001$, 95% CI [−1.27, −1.07], $d = 1.99$. Participants also reported feeling significantly stronger anxiety/

fear emotions during the BART than other negative emotions, $t(189) = 10.83$, $p < .001$, 95% CI [.46, .66], $d = .81$.

The likelihood estimates did not elicit condition differences in negative emotions for either anxiety ($p = .18$, 95% CI [–.36, .07], $d = .18$) or the other negative emotions ($p = .48$, 95% CI [–.22, .10], $d = .08$), but did show condition differences for positive emotions, with more positive emotions reported in the control than in the disruption condition, $t(188) = -2.42$, $p = .02$, 95% CI [–.47, −.05], $d = .36$. However, because this relationship was not predicted a priori, it is not discussed further.

Disruption condition on risk tasks (replication and minor extension). Results of an independent samples *t* test replicated our finding from Study 1 that restricting the activation of facial muscles led to a pattern of riskier decisions on the two action-related risk tasks: the BART (i.e., adjusted average pumps on successful trials: $M = 35.02$, $SD = 12.09$) and the jack-in-the-box task (i.e., more lever turns; $M = 11.27$, $SD = 2.49$), as compared to control participants (BART adjusted average pumps on successful trials: $M = 33.35$, $SD = 12.94$), $t(175) = .88$, $p = .38$, 95% CI [−2.05, 5.38], $d = .13$ (Figure 3a) and the jack-in-the-box task: $M = 10.31$, $SD = 3.45$, $t(172) = 2.09$, $p = .038$, 95% CI [.05, 1.86], $d = .32$ (Figure 3b). It should be noted, however, that the BART results did not reach traditional levels of statistical significance. Moreover, standardized mean performance on the likelihood judgment task, which does not elicit action-related emotions, was not significantly influenced by the disruption of facial expressions ($M = -.012$, $SD = .96$) compared to the control ($M = .013$, $SD = 1.04$), $t(187) = -.17$, $p = .86$, 95% CI [–.31, .26], $d = .03$.

To be consistent with our analyses in Study 1, we also investigated the influence of gender and study version on risk task performance. Unlike Study 1, participant gender in Study 2 significantly influenced the adjusted average pumps on successful trials on the BART, with males pumping more than females in both the disruption (male: $M = 36.99$, $SD = 10.35$; female: $M = 33.86$, $SD = 12.96$) and the control condition (male: M = 36.46, $SD = 14.23$; female: $M = 31.07$, $SD = 11.52$), $F(1, 173) = 4.98$, $p = .027$, $\eta^2 = 0.03$. However, as in Study 1, gender did not significantly interact with facial disruption condition, $F(1, 173) = .35$, $p = .55$, $\eta^2 = .002$. Gender also did not significantly influence performance on either the jack-in-the-box ($p = .58$) or the likelihood judgment task ($p = .13$). The finding that males are more risk seeking than females is commonplace within the decision-making literature (cf. Byrnes, Miller, & Schafer, 1999) and because we did not have any a priori gender predictions, we do not further discuss these findings.

Comparison of the BART across studies. Given that the disruption condition did not significantly influence performance on the BART in Study 2, we combined the BART and likelihood estimate data in Study 1 and Study 2 and conducted a 2 (Condition: disruption, control) × 2 (Study: 1, 2) ANOVA predicting the average adjusted pumps on successful trials, and a second one predicting the average likelihood estimates. Combining the data across samples supported our prediction that restricting the activation of facial muscles during the BART led to riskier decisions, that is, more balloon pumps ($M = 36.34$, $SD = 13.14$), as compared to control participants who did not have disrupted facial muscle activation ($M = 33.52$, $SD = 12.32$), $F(1, 285) = 4.81$, $p = .029$, $\eta^2 = .012$. No differences emerged between the experimental ($M = -.04$, $SD = .95$) and control ($M = .027$, $SD = 1.05$) conditions for the likelihood estimates, $F(1, 297) = .64$, $p = .42$, $\eta^2 = .002$. Importantly, there was no significant main effect of study (1 vs. 2) or interaction between version and study for the number of BART pumps, $F(1, 285) = 1.56$, $p = .21$, $\eta^2 = .007$, or for the likelihood estimates, $F(1, 297) = 1.19$, $p = .28$, $\eta^2 = .004$. This analysis supports our prediction that risk tasks eliciting action-related emotions are disrupted by restricted facial expressions. Although assessing the adjusted average number of pumps on successful trials is typical in BART analyses (cf. Lejuez et al., 2002), we also examined the number of trials in which the balloon popped across conditions for both Study 1 and Study 2, and did not find significant differences between the control ($M = 9.36$, $SD = 3.43$) and experimental ($M = 9.92$, $SD = 3.37$) conditions, $F(1, 285) = 2.62$, $p = .11$, $d = .05$.

Discussion

The present findings across two studies demonstrate that restricting facial actions, and particularly brow and mouth actions associated with the anxiety or fear expression, leads to greater risk taking on two tasks in which action-related emotions are elicited. We conclude that facial expressions of emotions signal to the decision-maker that a risk should be avoided. When these facial responses are disrupted, however, the decision-maker feels freer to

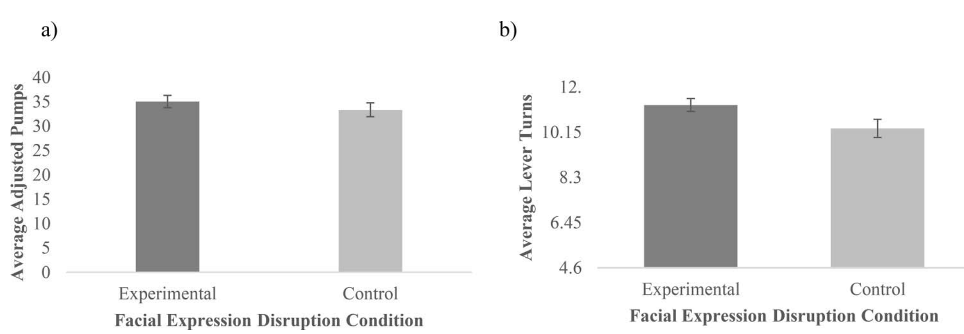

Figure 3. (a) The average adjusted balloon pumps on successful trials during the balloon analogue risk task by facial expression disruption condition. A greater number of balloon pumps indicates more risk taking. (b) The average number of lever turns on the jack-in-the-box task by facial expression disruption condition. A greater number of lever turns indicates more risk taking. Error bars represent ±1 standard error of the mean.

take the risk. Importantly, there was no effect on a decision task that did not require that the participant perform risk behaviors associated with action-related emotions.

We are also the first to demonstrate that the BART has the potential to elicit anxiety and fear responses, and that self-reports of these emotions are weaker when the activation of facial muscles is disrupted. Our research also demonstrates that risk tasks eliciting action related emotions are affected more by the disruption of the facial expression of emotions than risk tasks that do not involve actively taking a risk.

Our findings are consistent with behavioral and neural evidence that documents the importance of facial feedback in emotional processing (Niedenthal, Brauer, Halberstadt, & Innes-Kery, 2001; Ponari et al., 2012), and highlights the consequences of disrupting facial feedback in emotional information processing (cf. Davis et al., 2010; Hennenlotter et al., 2009; Rychlowska et al., 2014). It should be noted that our research suggests that disrupting facial actions associated with anxiety and fear increases risk taking on a risky decision task. Actions taken in other risky decision contexts may be associated with positive emotions such as exhilaration. In that case, disrupting facial expressions may lead to less risk taking because the concurrent actions are no longer rewarding. Therefore, the meaning of the suppression of facial expression for risk behavior depends upon the specific action-related emotions elicited by the task. Future research will thus need to examine how the disruption of emotional responses increases risk taking across different domains and involving different emotions, including positive emotions with underlying uncertainty appraisals (e.g., hope).

Recent evidence also suggests that activating safety-related concepts has similar outcomes on the BART. For example, wearing a bicycle helmet can lead to greater risk-taking behavior (Gamble & Walker, 2016). Although, in the present study, we cannot rule out the possibility that the mouth guard also activated a safety concept, extant research on facial expression disruption suggests that the wearing of a mouth guard does disrupt the activation of facial muscles (Rychlowska et al., 2014) and that actively suppressing the expression of one's anxiety also increases risk taking behavior on the BART (Parkinson, Phiri, & Simons, 2012). These findings suggest that multiple mechanisms may be at play. Further, in both our disruption and control conditions participants molded a mouth guard, which presumably could have activated safety-related concepts across both conditions. Future research should seek to determine whether the activation of safety concepts or the disruption of facial expressions of emotion is more important to risk taking behavior.

Further, some important limitations exist. For example, the current procedures were unable to precisely identify which action units were disrupted by the facial disruption procedures, and future work should aim to accomplish this with the use of EMG technology. Another important factor in risk behavior is the assessment of expected value, as well as rewards and costs. Although the tasks used in this study do not provide information on expected value, or explicit rewards and costs, future research should examine whether disrupting facial expressions of emotion changes the perception of factors like expected value, rewards and costs. Similarly, the present research is unable to disentangle whether participants' behavior was indicative of an increase in risk taking behavior, or if participants were just behaving in a less cautious manner, and future research could consider ways to distinguish between these different processes. The extent to which people popped the balloon also did not significantly vary by condition. For the BART task, this may have been because the balloon popped at random intervals. A similar pop-count analysis could have been conducted for the jack-in-the-box task in Study 2; however, given that each participant only completed one trial of the task, the jack remained in the box for the majority of participants (i.e., 71.3%). Thus, the pop count of the jack does not provide information that is as useful as the number of times the lever was turned. Future research would benefit from designing experiments to specifically test the conditions under which pop rate is influenced by disrupting facial expressions associated with risky decisions. Finally, personality measures linked to anxiety, including neuroticism, as well as to impulsivity, sensation seeking (Lauriola et al., 2014), and mindsets (Keller & Gollwitzer, 2017) could be assessed in future research to determine how the disruption of emotional responses influence these tendencies.

Another limitation was that the jack-in-the-box task, being a children's toy and not a controlled experimental task, sometimes malfunctioned during the experiment (e.g., the lever would stick, the box would not close properly, etc.). Such malfunctions led to the loss of some data during the experiment and to somewhat weaker results.

Despite these limitations, our results demonstrate the importance of peripheral processes, such as facial expressions, in decision-making. The present findings may be especially important when considering the decisions made by people suffering from health conditions that influence their ability to use facial expression of emotions (e.g., Bell's palsy). When individuals are unable to represent the meaning of an emotion during a risky decision task, our results suggest this may lead to greater risk taking behavior, which may or may not be beneficial depending upon the context. Future research should continue to examine this finding and isolate the specific facial expressions and actions that are particularly informative for risky decisions.

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