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Fear of pain and defensive activation

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Abstract

Fear of pain and its relationship to dental fear was investigated by measuring autonomic reactions (skin conductance and heart rate) in individuals reporting high and low dental fear when in the presence of a cue that threatened the presentation of electric shock ("threat") or not ("safe"). Acoustic startle probes were also presented during both threat and safe periods, and the reflexive eye blink, the skin conductance response, and cardiac changes to the startle probe measured. All participants reacted with greater defensive reactivity, including potentiated startle blinks, heightened skin conductance, and cardiac deceleration in the context of threat, compared to safe, cues. Individuals reporting high dental fear were significantly more reactive during threat periods, compared to low fear individuals, showing larger blink reflexes and heightened electrodermal activity, as well as heightened autonomic responses to the startle probe itself. Individual differences in defensive reactivity persisted even after participants received a single mild shock halfway through the experiment. The data indicate that threat of shock elicits heightened defensive reactivity in those reporting high dental fear, consistent with the hypothesis that fear of potentially painful events may be a potent mediator of the anxiety involved in anticipated medical and dental treatment.

A large body of literature suggests that fear of pain is a key component in medical, especially dental, fears, finding it a better predictor of dental fear than claustrophobia, fear of social contact, or mutilation fear (McNeil and Berryman, 1989). Fear of pain is also a better predictor of dental fear than factors related to actual pain experience, including the number of painful dental experiences, ability to accept pain, or the desire for control (Liddell and Locker, 1997). Moreover, Arntz and colleagues (1990) found that, although ratings of experienced pain did not differ between low and high fear individuals, those reporting high dental fear overpredicted anticipated pain prior to treatment. Thus, anticipation of pain appears to play an important role in the anxiety associated with dental treatment.

In the current study, the relationship between fear of pain and dental fear was explored by determining whether individuals reporting high dental fear are more defensively reactive in a context in which pain is anticipated. In animals, fear has been investigated using aversive conditioning procedures in which an innocuous cue (e.g., light) is paired with painful footshock. When the animal is subsequently in the presence of the light, the fear state is probed by presenting a loud, sudden burst of noise, which elicits a reflexive startle response that is reliably potentiated in the context of the cue predicting shock (Davis et al., 1993). The startle response is similarly potentiated in humans (measured as the magnitude of the reflexive eyeblink) when a probe is presented in the context of a cue that predicts painful electric shock (Hamm et al., 1993). Moreover, in human participants, the startle reflex is also reliably

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potentiated when cues simply indicate the *threat* of shock (Grillon et al., 1991;1993; Bradley et al., 2005): in this case, anticipation of pain engages similar defensive responses as occur following actual exposure to a painful stimulus.

If fear of pain is a key component of dental fear, we expected that individuals reporting high dental fear would be more reactive to startle probes presented during threat of shock, compared to safety, or when compared to individuals reporting low dental fear. In the threat of shock paradigm, one light cues that an electric shock is possible (“threat”) whereas another light cues safety. Using this type of paradigm, Grillon et al.(1991) found that startle reflexes were larger when elicited during threat, compared to safe, periods, and that fear-potentiated startle persisted throughout an hour-long experiment, despite presentation of only a single shock. Using a similar design, Kopacz & Smith (1971) found that skin conductance also increases when anticipating shock. In the current study, autonomic and somatic measures of fear were measured during safe and threat periods, and in response to startle probes. Midway through the experiment, participants received a mild, painless shock. We expected that high fear participants would be more reactive to threat cues and that defensive reactions might persist following the presentation of a non-painful shock for those who are highly fearful of potentially painful events.

Method

Participants

Participants were 84 students recruited from General Psychology classes at the University of Florida, who received either course credit or were paid \$25.00 for participation. In an initial step, individuals reporting high fear of dental procedures were identified on the basis of three items relating to dental fear administered on a pre-screening questionnaire to students (typically over 1000) at the beginning of each semester. Participants scoring in the upper 3% of the distribution were contacted by phone and invited to participate in the study. Of the 32 participants who agreed to participate on the basis of phone contact, six individuals (4 men and 2 women) subsequently declined to participate after reporting to the laboratory and reading the consent form (which described the possibility of receiving an electric shock). At the laboratory, the complete Dental Fear Survey (Kleinknecht et al., 1973) was administered to each participant to further assess fearfulness and a cutoff of 60 used to identify high fear participants. Of 26 screened participants agreeing to participate, 3 scored lower than the cutoff at the laboratory and were omitted from the analysis ¹, resulting in 23 high fear participants (16 women).

The remaining 52 participants signed up for participation on a computer website (based solely on the date and time of the study) and were also administered the Dental Fear Survey at the laboratory. One declined to participate after reading the consent form, and two who scored greater than 60 on the Dental Fear Survey and were omitted from the analysis, resulting in 49 (30 women) low fear participants.

Of the final 72 participants, 72% identified themselves as Caucasian, 10% African-American, 14% Hispanic, 3% Asian, and 1% other.

Due to equipment error, data were missing for 2 participants (low fear males) in the analysis of the heart rate data.

¹When all of the participants, regardless of prior phone contact, who scored greater than 60 on the Dental Fear Survey were included in a high fear group (n=25), and all of those who scored less than 60 were included in a low fear group (n=52), all of the results were identical to those reported here.

Materials and Design

Participants were instructed that one light (red or blue; counterbalanced across participants) signaled that an electric shock could be delivered through an electrode placed on their arm whenever the light was present (“threat” condition), whereas no shock was possible when a different light (blue or red) was present (“safe” condition). Red and blue color slides were projected onto a wall across from the participant (an area approximately 32 inches wide by 18 inches high) using a Kodak Ektapro 9010 slide projector. Cue lights were illuminated for 20 s, with a 2 s inter-trial interval (ITI) in which no cue light was present. On 32 trials, only the cue light was presented during each 20 s period, including 16 red and 16 blue cues; on 32 trials, 3 pictures (one pleasant, one neutral, and one unpleasant) were additionally projected during the safe or threat period. The latter data are not included here. Cues were presented in blocks of 4, with 2 threat cues (one with pictures, one without) and 2 safe cues (one with pictures and one without) in each block of 4. Four orders were constructed that balanced the condition in each serial position across participants.

Startle probes were 98 dB, 50 ms bursts of white noise generated by a Coulbourn S81-02 noise generator and gated by a Coulbourn S82-24 audio-mixer amplifier. Startle probes were delivered through E-A-RTONE 3A air conduction insert earphones (Aearo Company, Indianapolis, IN). One startle probe was presented during each 20 s cue period at either 4.5, 10.5, or 16.5 s following onset of the cue light.

Experimental stimuli were controlled and presented by VPM software (Cook, 2001) on a Northgate IBM compatible CPU. VPM software was also used to collect and score all physiological measures.

Electric shock was delivered halfway through the experiment through a concentric Tursky electrode placed on the participant’s inner right wrist. Shock was generated with a Grass S8800 Stimulator with an attached SIU7 Stimulus Isolation Unit (Grass Instruments, Quincy, MA). Participants received one mild electric shock (2 milliamps, 500 ms duration), in the context of the threat cue.

Questionnaires

The Dental Fear Survey (Kleinknecht et al., 1973) consists of 20 items that assess dental fear on several dimensions including behavior (putting off or canceling appointments), physiology (e.g., tense muscles, increased respiration, etc), and feelings of anxiety (e.g., while sitting in the waiting room, feeling an injection into the gums, etc).

A subset of 48 participants (16 high dental fear) completed the Fear of Dental Pain questionnaire (van Wijk & Hoogstraten, 2003), which instructs individuals to rate the fear of experiencing pain associated with several dental events, ranging from having a toothache or having a tooth pulled to being drilled in the jawbone or having some of their gum burned away. The scale consists of 18 items (scored 1–5; total range 18–90).

The trait portion of State-Trait Anxiety Inventory (STAI-T, Spielberger, 1983) was used to assess possible differences in general anxiety between the two dental fear groups.

Physiological Response Measurement and Reduction

Skin conductance was measured using two large silver/silver chloride electrodes filled with 0.05-m NaCl paste that were placed adjacently over the hypothenar eminence of the left palm. A constant current (.5 v) was generated between the electrodes using a Coulbourn S71-22 coupler. Activity was acquired at 20 Hz, and half-second bins of mean skin conductance were calculated off line. For assessing reactions during the threat and safe periods, each half-second

was deviated from a 1 s baseline prior to cue onset and averaged across the 20 s trial, resulting in change scores that reflected increases (or decreases) from a pre-cue baseline. For assessing reactions to the startle probe, each half-second following probe presentation was deviated from the .5 s prior to probe presentation, resulting in change scores that reflected increases (or decreases) from a pre-startle baseline. The maximum change was then scored in a window from 1 to 4 s after probe onset as an index of reactivity to the startle probe.

Heart rate was collected using large silver/silver chloride electrodes placed on participants' forearms. Raw electrocardiogram activity was acquired using a Coulbourn S75-01 bioamplifier with a bandpass filter of 8–40 Hz. Interbeat intervals (R-wave spikes) were recorded using a Coulbourn S52-12 retriggerable one-shot and converted off line into heart rate in beats per minute (bpm) in half-second averages. For assessing reactions during the threat and safe periods, each half-second was deviated from a 1 s baseline prior to cue onset and averaged across the 20 s trial, resulting in change scores that reflected increases (or decreases) from a pre-cue baseline. For assessing reactions to the startle probe, each half-second following probe presentation was deviated from .5 s prior to probe presentation and the maximum change in a window from 2 to 8 s following probe onset was used as an index of reactivity to the startle probe.

The startle reflex was recorded using two small silver/silver chloride electrodes placed over the left orbicularis oculi muscle. Raw orbicularis oculi activity was sampled at 1000 Hz from 50 ms prior to probe onset to 250 ms after probe onset. Activity was filtered with a 90–250 Hz bandpass filter using a Coulbourn S75-01 bioamplifier, and the signal was integrated with a 120 ms time constant through a Coulbourn S76-01 contour-following integrator. Peak magnitude and onset latency were scored off line using VPM software (Cook, 2001). Trials with an onset of less than 20 ms were omitted from analysis.

Procedure

After obtaining informed consent, participants were seated in the testing room and sensors for physiological recording and shock were attached. They were then instructed that a shock could be delivered through the electrode on their wrist in the presence of one light, but not in the presence of another light. Participants were queried a number of times regarding the meaning of each cue light prior to beginning the experiment. After the experiment, all sensors were removed, and participants completed several questionnaires and used a 7-point Likert-type scale to rate the pleasantness–unpleasantness (anchored at 7 and 1, respectively) of their anticipation of shock during threat periods before and after shock exposure, as well as the experience of receiving the shock.

Participants were then debriefed and thanked for their participation. The entire procedure lasted approximately two hours.

Data Analysis

For each physiological measure, repeated measures ANOVA (SYSTAT) were conducted using dental fear (high, low) and gender (male, female) as between subject factors, and Cue (threat, safe) and Phase (before or after shock exposure) as repeated measures. There were no main effects or interactions involving gender, so the data were averaged over this variable in the analyses presented below.

Results

As expected, participants in the high dental fear group scored significantly higher on the Dental Fear Survey ($M=77.7$, $SE=2.2$) than the low fear group ($M=36.7$, $SE=1.5$), $F(1, 70) = 240$, p

< .0001. The high dental fear group also reported significantly higher fear of dental pain ($M=74.6$, $SE=2.3$) than the low dental fear group ($M=51.5$, $SE=2.1$) as assessed with the Fear of Dental Pain questionnaire, $F(1, 56) = 33.9$, $p<.0001$, and scored slightly higher on the STAI-T (43.4 vs 36.3), $F(1,68)=5.4$, $p<.05$.

Responses during safe and threat periods

Table 1 lists the mean skin conductance and heart rate responses during threat and safe periods as a function of high and low dental fear both before and after exposure to shock.

Skin conductance—Skin conductance activity was significantly modulated following the presentation of a light cue that signaled either threat or safety, Cue ($F(1,70) = 55.06$, $p<.001$), with heightened activity when under threat of shock, compared to safety, both before ($F(1,70) = 79.04$, $p<.001$) and after ($F(1,70)=10.89$, $p<.005$) shock exposure. Dental fear affected electrodermal reactivity as evidenced by a significant interaction between Dental Fear and Cue, $F(1,70)=12.32$, $p<.01$. As illustrated in Figure 1 (top), those reporting high dental fear responded with more activity in this sympathetically mediated system than low fear participants during threat periods, $F(1,70)=11.15$, $p<.005$, as well as with less activity during safe periods, $F(1,70)=4.99$, $p<.03$. When the scores on the Dental Fear Survey were treated as a continuous variable in an analysis predicting the difference in electrodermal reactions in the context of threat or safe cues, results confirmed greater reactivity as a function of dental fear, $F(1,70) = 17.83$, $p<.0001$.

These effects were somewhat modulated by shock exposure. Prior to shock exposure, both high and low fear participants reacted with greater skin conductance during threat, compared to safe, periods, ($F(1,22)=44.15$ and $F(1,49)=26.53$, $p < .001$), and high fear subjects showed heightened responses during threat, compared to low fear participants, $F(1,70)=8.50$, $p<.01$, as well as less activity during safe periods, $F(1,70)=8.10$, $p<.01$. Following shock exposure, however, only high fear participants continued to reliably respond with greater sympathetic reactivity during threat periods, compared to safe periods, $F(1,22)=8.55$, $p<.01$, and with significantly heightened responses specifically during threat periods, compared to low fear subjects, $F(1,70)=7.59$, $p<.01$ (see Table 1). Consistent with a hypothesis of greater defensive reactivity, high fear participants were also more reactive (mean= $1.13 \mu\text{Siemens}$) when actually receiving a shock, $F(1,70)=5.47$ $p<.05$, compared to low fear participants (mean= $.56 \mu\text{Siemens}$).

Heart rate—During threat of shock, heart rate initially decelerated during threat periods, as illustrated in Figure 1 and remained significantly below heart rate measured during safe periods, Cue $F(1,68)=8.94$, $p<.005$ (see Table 1). Neither fearfulness or shock exposure modulated these effects, interactions $F<1$. An interaction of Phase and Dental Fear, $F(1,68)=5.95$, $p<.05$, indicated a marginal effect in which high fear participants showed overall more deceleration following shock exposure, compared to before exposure, regardless of threat status, $F(1,68) = 4.51$, $p<.05$.

Reactions to the startle probe

Responses to the startle probe as a function of dental fear (high, low), cue (safe, threat) and phase (pre- or post-exposure) are listed in Table 2.

Blink reflex—Figure 2 (top) illustrates blink magnitude for startle probes presented during the threat and safe periods. Overall, startle blink magnitude was larger under the threat of shock, compared to safe periods, Cue $F(1, 70) = 86.74$, $p<.001$, both before ($F(1,70)=85.15$, $p<.001$) and after ($F(1,70)=30.29$, $p<.001$) exposure to shock. The blink reflex was potentiated during threat, compared to safe, periods for both high fear and low fear participants both before (F

(1,22)=31.28 and $F(1,48)=51.43$, $p's < .001$, respectively) and after shock exposure ($F(1,22)=11.16$ and $F(1,48)=14.5$, $p's < .005$, respectively; see Table 2).

An interaction of Dental Fear and Cue, $F(1,70) = 8.34$, $p < .05$, indicated that participants reporting high dental fear showed larger startle reflexes than low dental fear participant during threat periods, $F(1,70)=4.75$, but not during safe periods. This difference was found both before ($F(1,70)=4.29$, $p < .05$) and after ($F(1,70)=4.52$, $p < .05$) shock exposure. On the other hand, there were no differences in blink reflex magnitude between high and low fear participants during safe periods either before or after shock exposure. When Dental Fear Survey scores were used in an analysis that predicted the difference in startle magnitude in the context of threat or safe cues, results confirmed that startle was modulated as a function of dental fear, $F(1,70)=8.13$, $p < .01$.

The latency of the reflexive blink response was also generally faster when under threat of shock, compared to safety ($M=42.6$), Cue $F(1,70)=43.88$, $p < .001$, both before $F(1,70)=66.23$, $p < .001$, and after shock exposure, ($F(1,70)=5.68$ $p < .05$ (see Table 1). High fear participants showed faster blink reflexes to the startle probe during both threat and safe periods, compared to low fear participants, Dental Fear $F(1,70)=4.08$, $p < .05$ (see Table 2).

Skin conductance—Figure 2 (bottom left) illustrates the skin conductance response elicited by the startle probe. Overall, when presented in the context of shock threat, skin conductance to the startle probe was larger than when the probe was presented during safe periods, Cue $F(1,70)=35.10$, $p < .001$, for both high ($F(1,22)=16.4$, $p < .001$) and low fear participants ($F(1,48)=10.5$, $p < .005$). An interaction between Dental Fear and Cue, $F(1,70)=8.89$, $p < .001$, indicated that high fear participants responded with significantly larger skin conductance responses during threat periods than low fear participants, $F(1,70)=7.25$, $p < .01$, but not during safe periods, as illustrated in Figure 2. When Dental Fear Survey scores were used to predict the difference in electrodermal reactions to startle probes presented in the context of threat or safe cues, results confirmed that reactivity was related to dental fear, $F(1,70)=8.76$ $p < .005$.

Cardiac response—Figure 2 (bottom right) illustrates the cardiac response to the startle probe. The heart clearly accelerates following the presentation of a startling probe, and cardiac acceleration was significantly greater when the probe was presented in context of threat of shock, compared to safety, Cue $F(1,68)=10.54$, $p < .005$. An interaction of Dental Fear and Cue, $F(1,68)=7.47$, $p < .01$ indicated that the effect was primarily obtained for the high fear participants, who showed a significant difference in cardiac acceleration during threat and safe periods both before ($F(1,22)=9.15$, $p < .01$ and after ($F(1,22)=5.65$, $p < .05$) shock exposure, whereas low fear participants only showed a marginal effect prior to shock exposure, $F(1,46)=2.75$, $p = .10$ (see Table 2). High fear participants also showed a tendency to show greater cardiac acceleration during threat periods when compared to low fear participants, $F(1,68)=3.96$, $p = .05$. When Dental Fear Survey scores were used to predict the difference in cardiac reactions to the startle probe in the context of threat or safe cues, results confirmed greater acceleration in the context of threat cues as a function of dental fear, $F(1,68)=5.46$, $p < .05$.

Aversiveness ratings

Not surprisingly, anticipation of shock was rated as somewhat unpleasant by all participants (see Table 1). On the other hand, high fear participants rated anticipation of shock as more unpleasant ($M=2.62$) than did low fear participants ($M=3.48$), Dental Fear $F(1,65)=11.56$, $p < .001$. High fear participants rated threat of shock as significantly more unpleasant than low fear participants both before ($F(1,72)=8.55$, $p < .005$) and after shock exposure ($F(1,67)=7.27$, $p < .01$). see Table 1.

High and low fear participants also differed in their rating of the shock itself, Dental Fear $F(1,61)=5.59$, $p<.05$ with high fear participants rating it somewhat more unpleasant (mean=3.1) than low fear participants (mean= 4). On the other hand, both high and low fear participants rated their anticipation of shock *prior to* shock exposure as more unpleasant than actual exposure to the shock, Phase $F(1, 65)=13.45$, $p<.001$.

Discussion

When threatened with the possibility of receiving a potentially painful electric shock, the reflexive startle response was greatly potentiated and evoked with greater rapidity than when the same reflex was elicited in the context of a safe cue that signaled the presentation of electric shock was not possible. Moreover, skin conductance activity was also heightened during 'threat', compared to safe, periods. Taken together, these data indicate that human participants are quite reactive to cues that signal the threat of receiving a painful stimulus, even in the absence of actual exposure to a painful shock itself. Both startle potentiation and skin conductance elevation can be interpreted as evidence that threat of shock activates a defensive system, probably subcortically mediated, with projections to structures that have evolved to mediate reactions to threatening events (Lang et al., 1990; 1997). Animal research has suggested that the amygdala is a key component in this defensive system, projecting to structures that potentiate the defensive startle reflex (Davis et al., 1991) and prompting increases in sympathetic nervous system activity. Recent fMRI studies both in this laboratory (Costa et al., 2006) and others (Dalton et al., 2001; Phelps et al., 2006) corroborate the hypothesis that threat of shock induces measurable activity in the amygdala.

More importantly, the current study supports the view that fear of pain is a key component of dental fear. During anticipation of a painful stimulus, individuals reporting high dental fear exhibited larger and faster startle responses than low fear participants, as well as enhanced skin conductance activity specifically to cues that signaled threat of shock. Moreover, when under threat of shock, high fear participants showed greater autonomic responding, including heightened skin conductance and cardiac acceleration to the presentation of a non-painful, but aversive, acoustic startle probe. High dental fear participants also rated the anticipation of shock more unpleasant than low fear participants as well as the experience of receiving a single mild shock. Taken together, these data clearly indicate heightened defensive reactions in the context of shock threat for individuals reporting high dental fear. There were few differences in any measure between high and low fear participants when in the presence of safe cues, suggesting that a specific aversion to the possibility of future pain may play an important role in individuals reporting fear of dental, and probably other, medical procedures.

Prior to shock exposure, startle blink potentiation and heightened skin conductance activity during threat periods was highly reliable for both high and low fear individuals, indicating that anticipating an unexperienced and potentially painful event mobilizes defensive responses in all human participants. It is likely that participants imagined that the anticipated shock would be much more painful than could be ethically administered. In this sense, the mere threat of shock may be a more potent aversive stimulus than actual shock in the laboratory context. Supporting this, both high and low fear participants rated actual exposure to the (mild) shock as less aversive than anticipating the shock, particularly prior to shock exposure.

The magnitude of both the evoked blink reflex and skin conductance activity during threat periods decreased following shock exposure for all participants, and it is almost certainly the case that these decreases reflect, in part, habituation, as both measures typically habituate across a session (Bradley et al., 1993). If the actual shock were a more potent pain stimulus, one might expect sensitization to overcome the relatively strong effects of habituation (Davis, 1989; Greenwald et al., 1998; Rhudy & Meagher, 2000). On the other hand, despite the fact that the

actual shock experience was quite mild, following exposure to shock all participants continued to respond with potentiated startle blinks in the context of threat, compared to safe, cues. Moreover, high fear participants continued to show larger blink reflexes than low fear individuals, as well as heightened electrodermal activity specifically during threat periods. Thus, those reporting high dental fear show greater persistence of defensive responses in the context of a threat cue following exposure. In fact, following exposure to the mild shock, the reactions of high fear individuals looked quite similar to those of low fear individuals prior to shock exposure. One interpretation is that although exposure to the mild shock did decrease fear for high fear individuals, it was only reduced to the level experienced by low fear individuals prior to shock exposure.

In the context of threat cues, heart rate initially decelerated and then remained slower than during safe periods for all participants. Whereas heart rate acceleration is often taken as an index of fear, a number of studies have now indicated that cardiac deceleration occurs when processing threatening cues (e.g., Bradley et al., 2005; Lang et al., 1993). In a study that directly compared threat of shock and actual shock exposure, threat also resulted in a reliable cardiac slowing (Rhudy & Meagher, 2000). This fear bradycardia (Campbell et al., 1997) has been interpreted as indicating increased attention to a threatening stimulus (Lang et al., 1997), with cardiac deceleration promoting heightened sensory intake and orienting (Graham & Clifton, 1966). Given that threat of shock could induce a sympathetic increase in blood pressure, the observed deceleration might be secondary to a reflex reaction of the baroreceptors. However, studies using vagotomy or atropine to block parasympathetic activity have consistently implicated the parasympathetic system (e.g., Berntson et al., 1989, Campbell et al., 1999). Regardless of the specific mechanism, both high and low fear individuals reacted with similar cardiac deceleration in the context of threat cues, suggesting that the attention-getting properties of a threatening cue are similar in both low and high fear individuals.

In this study, more women than men were in the high fear sample, and evidence of gender differences in pain perception and sensitivity is widespread. Thus, women tend to report more dental fear than men (Kleinknecht et al., 1973; ter Horst & de Wit, 1993) and to show greater pain sensitivity, both in clinical pain settings (Unruh, 1996) and during experimentally induced pain (Dao & LeResche, 2000; Riley et al., 1998). In the current study, however, there was little evidence of differences mediated specifically by gender, which is consistent with previous studies which reported that fear of pain is a strong predictor of dental fear in both men and women (McNeil & Berryman, 1989; Liddell & Locker, 1997). Moreover, although the overall numbers were not large, high fear men were more likely than women to terminate participation upon reading the consent form (which mentioned electric shock) and were, at least anecdotally, somewhat more difficult to recruit via phone contact. Taken together, the data suggest that heightened reactivity during fear of pain is comparable in both men and women reporting high dental fear.

In summary, during anticipation of a potentially painful stimulus, both high and low dental fear individuals exhibited strong defensive reactions, including potentiated startle reflexes and heightened skin conductance activity. Moreover, the autonomic responses elicited by presentation of the startling probe, including electrodermal increases and cardiac acceleration, were heightened when probes were delivered during the threat of shock periods, indicating that people are generally more reactive to a sudden, aversive event when in the context of expecting another painful stimulus. In general, individuals reporting high dental fear were more reactive in all measures during threat periods, compare to low fear individuals, and showed more persistence of defensive reactivity following exposure to a mild shock. These data are consistent with literature suggesting that fear of pain is a key component of dental fear. This finding is striking given that the potentially painful stimulus employed in the current study was not related to dental or facial pain, nor was the actual shock, when received, highly aversive.

Taken together, the data suggest that fear of pain is sufficient to engage defensive reactions in human participants, and that it contributes to the anxiety associated with avoidance and aversion to medical or dental treatment.

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Figure 1.

Top: Skin conductance change following onset of cues signalling threat or safety is elevated throughout a 20 s threat, compared to safe, period for all participants. High dental fear participants show greater skin conductance activity in the context of threat cues compared to low fear participants. Bottom: Heart rate initially decelerates following exposure to a cue that threatens shock, compared to safety, for both high and low fear individuals.

Reactions to the Startle Probe

Figure 2.

Top: The magnitude of the reflexive blink response to an acoustic startle probe is potentiated when the startle probe is presented in the context of threat, compared to safe, cues, and participants reporting high dental fear react with larger startle blinks in the context of threat cues, compared to those reporting low dental fear. Bottom Left: The magnitude of skin conductance change to the presentation of an acoustic startle probe is larger in the context of threat, compared to safe, cues, and high fear participants react more strongly than low fear participants when probes are presented in the context of threat. Bottom Right: Cardiac acceleration following onset of the acoustic startle probe is larger when probes are presented in the context of threat, compared to safe, cues, and somewhat larger for high fear participants.

Table 1
Means (standard error) of autonomic changes during threat and safe periods before and after exposure to a mild shock, and threat aversiveness ratings for participants reporting high or low dental fear.

	High Fear	Pre-Exposure Low Fear	High Fear	Post-Exposure Low Fear	Mean
Skin Conductance (μ Siemens)					
Threat	.28 (.06)	.13 (.06)	.10 (.03)	-.02 (.02)	.09 (.01)
Safe	-.24 (.03)	-.08 (.03)	-.13 (.02)	-.04 (.02)	-.11 (.02)
Heart Rate (beats per minute)					
Threat	.09 (.58)	-.22 (.22)	-.53 (.34)	.24 (.30)	-.07 (.18)
Safe	.91 (.38)	.59 (.29)	.03 (.46)	.76 (.27)	.61 (.17)
Threat rating (1=unpleasant 7=pleasant)	2.2 (.2)	3.2 (.2)	2.9 (.3)	4.0 (.2)	3.2 (.14)

Table 2

Responses to acoustic startle probes delivered during threat and safe periods before and after exposure to a mild shock for individuals reporting high or low dental fear. Means and standard errors are listed for each measure.

	Pre-Exposure		Post-Exposure		Mean
	High Fear	Low Fear	High Fear	Low Fear	
Startle blink magnitude (μV)					
Threat	10.46 (1.22)	7.78 (.68)	7.65 (1.26)	4.97 (.63)	7.23 (.59)
Safe	7.59 (1.13)	6.00 (.66)	5.66 (.93)	4.20 (.55)	5.59 (.52)
Startle blink onset latency (ms)					
Threat	36.9 (1.1)	39.6 (0.8)	40.5 (1.4)	43.3 (1.0)	40.6 (.72)
Safe	40.0 (1.4)	42.9 (0.9)	41.1 (1.1)	45.2 (1.1)	42.9 (.79)
Skin conductance Change ($\mu\text{Siemens}$)					
Threat	.63 (.08)	.33 (.05)	.40 (.09)	.22 (.06)	.35 (.04)
Safe	.28 (.07)	.22 (.05)	.16 (.07)	.14 (.05)	.19 (.03)
Heart rate Change (bpm)					
Threat	2.97 (.58)	1.85 (.44)	2.31 (.45)	1.13 (.40)	1.87 (.28)
Safe	.91 (.44)	1.12 (.39)	.81 (.55)	1.55 (.39)	1.18 (.21)