INTERACTIVE ROLE OF ANXIETY SENSITIVITY AND PAIN EXPECTANCY IN DENTAL ANXIETY

A Dissertation
Presented to
the Temple University Graduate Board

In Partial Fulfillment
of the Requirements for the Degree
DOCTOR OF PHILOSOPHY

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August 2017

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ABSTRACT

Dental anxiety is a major public health problem that leads to underutilization of dental care and poor oral health. Much research has demonstrated an association between the expectation of pain during dental treatment and dental anxiety; however, not all patients with high pain expectancy develop dental anxiety, suggesting that other factors may impact the degree to which pain expectancy increases dental anxiety. The present study examined whether anxiety sensitivity (AS; the fear of negative consequences of anxiety-related symptoms and sensations) increases the strength of the relationship between pain expectancy and dental anxiety. Participants were 104 adult patients of Temple University Kornberg School of Dentistry clinics. Baseline levels of AS and pain expectancy were assessed using self-report questionnaires. Baseline dental anxiety was assessed using self-report questionnaires and measures of psychological/physiological stress reactivity to films of dental procedures. Participants also underwent a pain expectancy induction, and all indices of dental anxiety were re-assessed following the pain expectancy induction. Linear regression analyses revealed that, in contrast to expectations, AS did not strengthen the relationship between self-reported or laboratory-induced pain expectancy and any indicators of dental anxiety. On the contrary, there was limited evidence that AS may weaken the pain expectancy-dental anxiety relationship. Consistent with previous studies, there was a strong pattern of findings supporting a direct association between pain expectancy and dental anxiety, but limited evidence of a direct association between AS and dental anxiety. AS may not be a strong risk candidate for dental anxiety, and future studies examining other theoretically-relevant vulnerability

factors are needed to elucidate pathways through which pain expectancy leads to greater dental anxiety.

This dissertation is dedicated to:

My parents, Betty and Harry, for having unending confidence in me
and supporting my education;

my sister, Julie, for inspiring me with her academic talents and dedication to her family;

my uncle, Harvey, for helping me find my place in the world of clinical psychology;

and my husband, Colin, for balancing me
and making my graduate school years a life changing experience.

Your love, support, and encouragement made this possible.

ACKNOWLEDGEMENTS

First, I would like to express immense gratitude to my advisor, Rick Heimberg. Rick, you put your heart and soul into mentoring your students, and I feel so lucky to have had you as my graduate school advisor. You taught me about the importance of conducting high quality, impactful research that has the potential to inform clinical practice and, ultimately, to make someone's life better. I'm so grateful for your guidance regarding my application for an F31 grant and for your generous use of personal funds to purchase the physiological monitoring equipment that was needed for my dissertation research. It is an understatement to say that this project would not have been possible without you.

I also want to thank Dr. Marisol Tellez for serving as a co-mentor on this project and lending me her expertise in dentistry and public health. Marisol, working with you has impressed upon me the importance of interdisciplinary collaboration. I must also extend my gratitude to Dr. Amid Ismail for allowing me to conduct my dissertation at the Temple University Kornberg School of Dentistry and providing me with many resources for this project.

I also wish to acknowledge Drs. Deborah Drabick, Tania Giovannetti, Michael McCloskey, and Shannon Myers Virtue for the time and energy they devoted as members of my dissertation committee. All of you made yourselves available to me to meet about research design, data analysis, or my career goals, and I cannot thank you enough for your guidance and support.

Conducting this project would not have been possible without the amazing group of Adult Anxiety Clinic of Temple's (AACT) undergraduate and post baccalaureate

research assistants. In particular, I would like to thank Connor Page for spearheading the effort on recruitment calls, Matt Goodman for running participants, Emily Hockenberry for becoming a whiz at scoring physiological data, and Liz Waldron for going above and beyond to make sure the study was run impeccably and smoothly. You all devoted a tremendous amount of time and effort to this study. I can't wait to see what's in store for your own careers, and I know you are all going to do great things.

There are many other friends, faculty members, and clinical supervisors that have made a tremendous impact on me and helped me become a better researcher and clinician. I feel so lucky to have graduate school cohort mates who are such supportive, interesting, and fun individuals, and being a part of our cohort has been one of my favorite parts of graduate school. My AACT lab mates have become like family to me and, in particular, I'm so grateful to Jonah Cohen for being the best office/cohort/lab mate I could have asked for.

I must also thank the National Institute of Dental and Craniofacial Research for providing me with a National Research Service Award, which funded not only this project, but also a large portion of my tuition and other professional activities over the past two years. Finally, I'd like to thank the dental patients who took the time to participate in this study. It was a true pleasure and wonderful learning experience to work with you all.

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CHAPTER 1

INTRODUCTION

Dental anxiety (i.e., anxiety related to dental treatment) is a major public health problem, as it leads to underutilization of dental care and poor oral health. Approximately 5-20% of individuals in the US have high dental anxiety, and 10-50% cancel preventive dental care appointments (e.g., teeth cleanings), delay treatment for a painful or dangerous dental condition (e.g., tooth infection), or avoid dental treatment altogether due to fears of dental procedures (Dionne, Gordon, McCullagh, & Phero, 1998; Milgrom, Fiset, Melnick, & Weinstein, 1988; Rizzardo, Borgherini, & Cappelletti, 1991; Sohn & Ismail, 2005). Individuals with high dental anxiety experience more oral health problems (e.g., more decayed teeth) than do less anxious patients due to avoidance of dental procedures (Berggren & Meynert, 1984). They also experience other types of impairment, such as diminished social/occupational functioning, poor quality of life, and increased risk of cardiovascular disease (Cohen, Fiske, & Newton, 2000; Petersen, 2009). The broader impairment related to dental anxiety often stems from earlier problems with oral health; for instance, individuals who engage in anxiety-related avoidance of dental treatment and have visibly decayed or disfigured teeth as a result often withdraw from social relationships due to embarrassment about their appearance (Moore, Brodsgaard, & Rosenberg, 2004).

Dental anxiety also contributes to increased personal and public healthcare costs. The prevalence of dental anxiety has remained stable over the past 50 years, despite advances in dental technology, and has perpetuated an overreliance on expensive sedation techniques to facilitate dental treatment (Boyle, Newton, & Milgrom, 2009; Smith &

Heaton, 2003). Many dentists offer nitrous oxide sedation to help anxious patients relax during dental treatment, and although the safety risks of this type of sedation are somewhat disputed, this practice significantly adds to the cost of dental care (Boyle et al., 2009; Imberger, Thorlund, Myles, & Moller, 2014). Dentally anxious individuals are also more likely to use emergency dental services because they often avoid addressing oral health problems until reaching the point of emergency, and this is another costly form of dental healthcare (Kanegane, Penha, Borsatti, & Rocha, 2003). Despite a long history of research on dental anxiety, its psychological risk factors remain unclear (Vassend, Røysamb, & Nielsen, 2011). Identifying malleable risk factors for dental anxiety will inform the development of interventions aimed at increasing anxious individuals' use of preventive dental care and decreasing the personal and public healthcare costs associated with dental anxiety.

Aversive Conditioning Model of Dental Anxiety

The aversive conditioning model of dental anxiety has received substantial attention and support (Armfield, 2010; Davey, 1989). This model proposes that dental anxiety is caused by negative dental experiences which often involve experiencing pain (de Jongh, Aartman, & Brand, 2003; de Jongh, Fransen, Oosterink-Wubbe, &Aartman, 2006; Kent, Rubin, Getz, & Humphris, 1996; Locker, Shapiro, & Liddell, 1996; Vassend, 1993). During negative dental experiences, patients learn to associate dental treatment-related stimuli (e.g., drilling) with aversive states (e.g., pain) and develop a conditioned fear response to dental treatment (Rachman, 1977). This conditioned dental fear can develop into a broadly generalized global dental anxiety over time (Vassend, 1993).

Role of Pain Expectancy in the Development of Dental Anxiety

A major limitation of the aversive conditioning model of dental anxiety is that it fails to explain why only a minority of individuals who have negative dental experiences go on to develop dental anxiety (Armfield, 2010; Oosterink, De Jongh, & Aartman, 2009). Negative dental experiences are less related to dental anxiety than are thoughts and feelings about dental treatment (e.g., perceptions of dental treatment as dangerous or painful), suggesting that cognitive-affective factors may underlie the development of conditioned dental anxiety (Armfield, 2010; Carillo-Diaz, Crego, Romero-Maroto, & Armfield, 2012). Expectation of experiencing pain is one of the most common concerns reported by patients with high dental anxiety, leading many researchers to theorize that pain expectancy may underlie conditioned dental anxiety (Lindsay & Jackson, 1993; Vassend, 1993; Woolgrove & Cumberbatch, 1986). Individuals with high expectations of experiencing pain during dental procedures often avoid dental treatment, which limits their chances of experiencing disconfirmation of their expectation that dental treatment will be painful and prevents opportunities for extinction of conditioned dental fear (Rachman & Arntz, 1991). Pain expectancy may also increase hypervigilance to painful stimuli during dental treatment, which may also exacerbate dental anxiety.

Associations between Pain Expectancy and Dental Anxiety

There is ample evidence that pain expectancy is associated with dental anxiety. Early studies revealed that dentally anxious individuals exhibit elevated expectations of experiencing dental treatment-related pain (Kent, 1984; Kent, 1985; Kleinknecht & Bernstein, 1978; Wardle, 1983). Further, when asked to provide ratings of expected and experienced pain during dental procedures, individuals with high dental anxiety tend to

expect more pain than they report experiencing during the dental procedures (Arntz et al., 1990; Lindsay & Jackson, 1993; Rachman & Arntz, 1991; Vassend, 1993). More recent findings from behavioral studies have corroborated that patients with high dental anxiety exhibit greater pain expectancy prior to undergoing dental procedures (Klages, Ulusoy, Kianifard, & Wehrbein, 2004; Muglali & Komerik, 2008). It has been argued that pain expectancy may be a manifestation of dental anxiety rather than a risk or maintenance factor; however, the shared variance between these two variables tends only to be moderate, suggesting that they are distinct, albeit related, constructs (Klages et al., 2004; Litt, 1996; Vassend, 1993). Additionally, many patients with low dental anxiety also report expectations of experiencing dental treatment-related pain, suggesting that, despite its association with dental anxiety, pain expectancy alone may not be a sufficient predictor of dental anxiety (de Jongh, 1995; Locker, 1999; Vassend, 1993).

If dental anxiety is caused or maintained by high pain expectancy, then reducing expectations of dental treatment-related pain should lead to subsequent reductions in dental anxiety. Arntz et al. (1990) examined this hypothesis by testing if dentally anxious individuals exhibited decreased pain expectancy and dental anxiety following a dental procedure during which they experienced less pain than they expected. In contrast to the tested hypothesis, highly anxious participants exhibited immediate reductions in pain expectancy, but their dental anxiety was unaffected. Furthermore, by follow-up, their pain expectancy had returned to its original level and their dental anxiety remained unchanged. This study demonstrates that although pain expectancy is related to increased dental anxiety, reducing pain expectancy does not lead to subsequent reductions in dental anxiety. Therefore, it is possible that other cognitive-affective characteristics play a role

in the pain expectancy-dental anxiety connection, and that these characteristics need to be targeted by interventions in order to successfully reduce dental anxiety.

Moderating Role of Anxiety Sensitivity

Anxiety sensitivity (AS), which is the tendency to fear symptoms of anxiety-related arousal (e.g., chest pain, stomach distress, racing thoughts) due to beliefs that such symptoms have negative consequences (e.g., believing that having pain in one's chest is a sign of a heart attack), is a promising moderator of the relationship between pain expectancy and dental anxiety (Reiss, 1986). AS is an established risk factor for most anxiety disorders and has been associated with many of the disorders that commonly co-occur with dental anxiety, such as panic disorder and social anxiety disorder (Bentley et al., 2013; Naragon-Gainey, 2010; Roy-Byrne, Milgrom, Khoon-Mei, Weinstein, & Katon, 1994; Schmidt, Zvolensky, Maner, 2006; Scott, Heimberg, & Jack, 2000). It is often a key change element in the treatment of pathological anxiety and has come to be regarded as a transdiagnostic risk factor for anxiety and related disorders (Boswell et al., 2013). Given AS's broad association with a range of anxiety disorders, it is a strong risk candidate for dental anxiety.

Although AS has not been thoroughly examined in the context of dental anxiety, there is growing evidence that AS is associated with both fear of pain and dental anxiety and may amplify the connection between these two constructs (Asmundson, Norton, & Norton, 1999; Asmundson & Taylor, 1996; Gonzalez, Zvolensky, Hogan, McLeish, & Weibust, 2011; Klages, Kianifard, Ulusoy, & Wehrbein, 2006; Liddell & Gosse, 1998; van Wijk, De Jongh, & Lindeboom, 2010). AS has been implicated in the maintenance of chronic pain conditions, as fearing the consequences of pain-related sensations increases

sensitivity to pain, which exacerbates chronic pain over time (Asmundson et al., 1999; Asmundson, Bovell, Carleton, & McWilliams, 2008; Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012; Zvolensky, Goodie, McNeil, Sperry, & Sorrell, 2001). AS may play a similar role in exacerbating dental anxiety by increasing sensitivity to and fear of pain-related sensations experienced during dental procedures. For instance, individuals with high AS may fear that experiencing pain during an anesthetic injection means that the dentist hit their nerve and caused long-term damage and may therefore be more hypervigilant to pain experienced during an injection. This increased sensitivity to and fear of dental treatment-related pain may make individuals with AS more susceptible to developing dental anxiety.

No published studies to date have examined the impact of AS on the relationship between pain expectancy and dental anxiety; however, these three constructs appear to be inter-related. Dentally anxious individuals who are high in AS have greater expectations of experiencing pain during dental treatment (Klages et al., 2004; Klages et al., 2006). Further, catastrophic thinking about pain, which, like AS, involves focusing on potential negative consequences of internal sensations, is associated with greater pain expectancy and dental anxiety (Crombez, Eccelston, Van den Broeck, Van Houdenhove, & Goubert, 2002; Lin, Niddam, Hsu, & Hsieh, 2013; Sullivan & Neish, 1998; Sullivan & Neish, 1999; Van Damme, Crombez, & Eccleston, 2002). These observed associations between AS, pain expectancy, and dental anxiety suggest that individuals with high AS may have a tendency to fear the potential negative consequences of pain and may therefore be at increased risk for developing dental anxiety due to having expectations of experiencing pain during dental treatment.

Clarifying the role of AS in the exacerbation of dental anxiety is especially important given that AS has been shown to be malleable using very brief psychological interventions that require limited specialized training to administer (e.g., single session computer-assisted interventions) and achieve reductions in AS that endure across follow-up periods (e.g., Keough & Schmidt, 2012). Thus, AS-focused treatments are not only highly efficacious, but they are also amenable to dissemination in dental healthcare settings where highly trained therapists are not readily available. Examining the moderating role of AS in the relationship between pain expectancy and dental anxiety will inform the utility of developing brief AS-focused treatments as dental anxiety prevention or intervention strategies, particularly for patients who report expectations of experiencing pain during dental procedures.

Psychophysiological Characteristics of Dental Anxiety

One of the major limitations of existing research on dental anxiety is an over-reliance on self-report measures. The Modified Dental Anxiety Scale (MDAS; Humphris, Morrison, & Lindsay, 1995), which is based on Corah's Dental Anxiety Scale (Corah et al., 1969), is one of the self-report measures that is most commonly used in studies on dental anxiety. The MDAS includes five items that assess anticipatory anxiety associated with an upcoming dental appointment, fear of dental cleaning and drilling, and fear of local anesthetic injection. Although the MDAS is psychometrically sound (Humphris et al., 1995), studies that incorporate multiple methods of assessing dental anxiety are needed to examine different aspects of dental anxiety (e.g., cognitive, emotional, physiological).

Assessing the psychophysiological characteristics of dental anxiety appears to be especially important, given that self-reported dental anxiety is associated with autonomic nervous system arousal (Johnsen et al., 2003; Lundgren, Berggren, & Carlsson, 2004). One study of 20 dental clinic patients with high dental anxiety demonstrated that while watching videos of scenes of dental treatment, patients exhibited increases in skin conductance levels (SCL), but decreases in a time-domain method of measuring heart rate variability termed the root mean square of successive differences (RMSSD; Johnsen et al., 2003). The authors attributed the corresponding, but opposite, changes in SCL and RMSSD to the fact that they measure parallel, but distinct, autonomic nervous system processes. They argued that the increases in SCL, which is a proxy for sympathetic arousal, were reflective of the anxious patients' immediate arousal in response to the dental films, whereas decreases in RMSSD (an index of the parasympathetic influence on the heart) occurred because the parasympathetic system decreases vagal tone in response to stress so the central nervous system has extra energy available to handle the stressor. This explanation is consistent with the interplay between sympathetic activation and parasympathetic (vagal) deactivation that is a hallmark of many types of anxiety (Kreibig, 2010). Still, the psychophysiological aspect of dental anxiety is under-researched and is an important direction for future studies.

The Present Study

The above review highlights several important findings in the literature on AS, pain expectancy, and dental anxiety: (1) thoughts and feelings about dental treatment are more related to dental anxiety than are negative dental experiences; (2) pain expectancy is associated with greater dental anxiety, but reducing expectations of pain does not lead

to subsequent reductions in dental anxiety; and (3) AS is associated with greater pain expectancy and dental anxiety. The present study aimed to extend these findings by examining AS as a moderator (i.e., amplifier) of the relationship between pain expectancy and dental anxiety. We had two main hypotheses. First, we predicted that AS would amplify the relationship between self-reported pain expectancy and baseline levels of dental anxiety (as indexed by self-report measures, emotional and physiological stress reactivity to films of dental procedures, and a clinician-administered diagnostic interview for specific phobia of dental procedures). Second, we predicted that AS would amplify the relationship between laboratory-induced pain expectancy and dental anxiety. Results in support of these hypotheses would suggest that developing brief, AS-focused psychological interventions that can be delivered to dental patients immediately before they undergo dental procedures might decrease anxious responding to dental procedures, reduce dental anxiety, and increase use of preventive dental care.

CHAPTER 2

METHODS

Participants

Participants were 104 adult patients of various dental clinics within Temple University's Kornberg School of Dentistry (TUKSoD). Participants were not selected on the basis of anxiety-related factors to provide variability in predictors (e.g., pain expectancy and AS) and outcome variables (e.g., dental anxiety). Inclusion criteria required that participants be between 18 and 65 years old and fluent in written and spoken English. Participants were excluded if they endorsed any of the following: (a) current or past serious medical condition (e.g., cardiopulmonary disease, seizure disorder); (b) current suicidal/homicidal ideation or intent; (c) current psychosis; (d) pregnancy; or (e) inability to give written, informed consent. These exclusion criteria were employed to reduce the risk of an adverse reaction to the brief administration of mild to moderate electric shock during the pain expectancy induction (see the description of the induction below for details).

TUKSoD serves a high percentage of low-income, minority individuals, the majority of whom reside in north Philadelphia. The racial/ethnic composition of participants in the current study was representative of the population of north Philadelphia (see Table 1; United States Census Bureau, 2010).

Table 1. *Demographic characteristics for the entire sample (N = 104)*

Age *M (SD)*	42.19 (13.04)
Sex *n* (%)	
Female	64 (62%)
Male	38 (37%)
Transgender	1 (1%)
Missing or not reported	1 (1%)
Race	
Black/African American	74 (71%)
White/Caucasian	18 (17%)
Asian/Pacific Islander	2 (2%)
Other	8 (8%)
Missing or not reported	2 (2%)
Ethnicity	
Hispanic	9 (9%)
Non-Hispanic	69 (66%)
Missing or not reported	26 (25%)
Marital Status	
Married	10 (10%)
In a relationship	21 (20%)
Single (never married)	50 (48%)
Widowed, divorced, or separated	23 (22%)
Religious Affiliation	
Christian	67 (64%)
Muslim	7 (7%)
Other	26 (25%)
Missing or not reported	4 (4%)
Highest Level of Education Completed	
Some high school	13 (13%)
Completed HS or GED	32 (31%)
Some college	32 (31%)
2-year degree	12 (12%)
4-year degree	9 (9%)
Some graduate	1 (1%)
Completed graduate	5 (5%)
Annual Family Income	
Less than $9,999	33 (32%)
$10,000-19,999	26 (25%)
$20,000-39,999	26 (25%)
More than $40,000	19 (18%)

Note. SD = standard deviation; HS = high school; GED = general educational development. Percentages do not always add to 100 because of rounding error.

Materials

Clinician-Administered Diagnostic Interviews.

Structured Clinical Interview for DSM-IV Axis I Disorders, Non-Patient Version (SCID-I/NP). The SCID-I/NP is a well-established clinician-administered diagnostic interview for psychiatric disorders (First, Spitzer, Gibbon, & Williams, 2002a). The SCID-I/NP has demonstrated good reliability on all assessed diagnoses (Zanarini et al., 2000) and good to excellent validity (Basco et al., 2000; Lobbestael, Leurgans, & Arntz, 2011). In the present study, the SCID-I/NP was used to index current (past year) Axis I diagnoses and to assess study exclusion criteria (current suicidal or homicidal ideation or intent or current psychosis). The non-patient version was used since participants were a community sample and not a sample seeking treatment for a psychiatric disorder. Interviewers (advanced graduate students and research assistants) received extensive training in administering the SCID-I/NP (for details on training procedures, see First, Spitzer, Gibbon, & Williams, 2002b).

Interviews were recorded and a randomly selected 20 interviews were independently coded for reliability assessment. Reliability coding raters were blind to the outcome of the original interview. The inter-rater reliability for primary diagnoses (categorized as none, any mood disorder, any anxiety disorder, or any substance use disorder) was fair (kappa = .64). Across primary and additional diagnoses, no instances of disagreement were noted between 15 of the sets of original and reliability ratings. There were disagreements between five of the sets of original and reliability ratings; in each of these cases, one evaluator assigned a primary or additional diagnosis of a depressive

disorder (e.g., Major Depressive Disorder, Adjustment Disorder with depressed mood), whereas the other assigned either no diagnosis or a diagnosis of a substance use disorder.

***Anxiety Disorders Interview Schedule for DSM-IV* (ADIS-IV).** The ADIS-IV (Brown et al., 1994) is a semi-structured interview designed to establish reliable diagnoses of the *DSM-IV* (APA, 1994) anxiety, mood, somatoform, and substance use disorders. In the present study, only the specific phobia module of the interview was administered to assess the presence or absence and severity of specific phobia of dental procedures. We used the specific phobia module of the ADIS-IV to assess dental phobia rather than the SCID-I/NP as the ADIS-IV includes more specific questions about the diagnostic criteria for specific phobia (e.g., severity of fear/avoidance of the phobic stimulus and degree of impairment). Interviewers were advanced graduate students or research assistants, trained to strict reliability standards (for details on training procedures, see Brown, Di Nardo, Lehman, & Campbell, 2001). Interviewers assessed participants' anxiety and avoidance of dental procedures, as well as their distress and impairment due to dental phobia symptoms and assigned a clinician's severity rating (CSR) for dental phobia that ranged from 0 (*none*) to 8 (*very severe*); a CSR of 4 or above indicates that the participant met criteria for dental phobia.

All interviews were audio-recorded for use in reliability coding. We examined agreement on presence of diagnosis and its severity (CSR) by conducing reliability coding on a randomly selected 20 interviews. Reliability coding raters were blind to the outcome of the original interview. Inter-rater reliability analyses were conducted using intraclass correlation coefficients (ICCs). Our interviewers demonstrated excellent

agreement ($r = .96$, $p < .001$; Brown et al., 2001), and all 20 sets of ratings were coded within 1 CSR point.

Self-Report Measures.

Positive Affect Negative Affect Schedule – Negative Affectivity Scale (PANAS-NA). The PANAS is a widely used indicator of the propensity to experience two global dimensions of affect: negative affect and positive affect (Watson, Clark, & Tellegen, 1988). The PANAS includes 20 adjectives, ten of which (e.g., irritable, scared, upset) comprise the PANAS-NA. Respondents rate how characteristic the adjectives are of them on a 5-point Likert-type scale ranging from 1 (*not at all characteristic of me*) to 5 (*extremely characteristic of me*). The PANAS-NA has demonstrated high internal consistency (αs = .85-.93), test-retest reliability, and convergent and discriminant validity with other measures of affect, mood, and personality (Watson, 2000). In the present study, the PANAS-NA average item score was entered as a covariate in all analyses to control for general negative affectivity ($\alpha = .87$).

Anxiety Sensitivity Index-3 (ASI-3). The ASI-3 is an 18-item questionnaire on which respondents rate the extent to which they are concerned about the potential negative consequences of anxiety-related symptoms and sensations on a 5-point Likert-type scale that ranges from 0 (*very little*) to 4 (*very much*; Taylor et al., 2007). The ASI-3 measures three lower-order factors of AS (physical, cognitive, and social concerns), and both subscale and total scores can be used (Taylor et al., 2007). Sample items include, “When I cannot keep my mind on a task, I worry that I might be going crazy” (cognitive concerns) and “When I notice my heart skipping a beat, I worry that there is something seriously wrong with me” (physical concerns). The ASI-3 has high internal consistency

(α = .95) and convergent validity with a wide range of established anxiety-related measures (Gonzalez et al., 2011; Taylor et al., 2007). In the present study, the ASI-3 average item score for the full scale was used to measure baseline levels of AS (α = .92).

Pain Expectancy Visual Analogue Scale (VAS). Participants were asked to indicate their expectations of how painful receiving five specific dental procedures (drilling and filling, anesthetic injection, scaling and polishing, tooth extraction, and root canal) would be on a VAS, a 10-centimeter horizontal line anchored by 0 (*not at all painful*) to 100 (*the worst possible pain*). VAS indices of pain expectancy have demonstrated convergent validity with other measures of pain experienced during dental procedures (Arntz et al., 1990; Kent, 1984). The Pain Expectancy VAS average item score was used to index baseline levels of self-reported pain expectancy.

Subjective Units of Distress Scale (SUDS). The SUDS has been widely used to assess anxiety experienced during laboratory tasks (Wolpe, 1973). Ratings are traditionally made on a scale that can range from zero (*no anxiety*) to 10 (*worst possible anxiety*); however we used a modified version of the SUDS that ranged from zero to eight (0 = *none*, 4 = *some*, 8 = *a lot*) because participants were instructed to type their SUDS ratings as quickly as possible using a computer keyboard and we believed that limiting ratings to single digits would facilitate this process. The SUDS was first administered to participants while they were watching an emotionally neutral film (a beach scene) as a measure of resting state anxiety and then while they were watching series of dental films (described below). Participants were instructed to rate their “peak SUDS” (i.e., the highest level of anxiety) that they experienced while watching each film clip within a series depicting a different dental procedure to assess their anxious responding to each

procedure. Psychological stress reactivity to the series of films of dental procedures was computed as the difference between the peak SUDS rating during the rest period and the average peak SUDS rating during the dental procedure film tasks.

Modified Dental Anxiety Scale (MDAS). The MDAS (Humphris et al., 1995) is a widely used 5-item questionnaire that assesses global dental anxiety. Sample items include, "If you went to your dentist for treatment tomorrow, how would you feel?" and "If you were about to have your tooth drilled, how would you feel?" Items are rated on a 5-point Likert-type scale ranging from 1 (*not anxious*) to 5 (*extremely anxious*). The total score ranges from 5 to 25; a score of 19 or above indicates high dental anxiety (Humphris et al., 1995; King & Humphris, 2010). The MDAS has demonstrated good internal consistency ($\alpha = .89$) and test-retest reliability ($r = .82$, interval unspecified; Humphris et al., 1995). In the present study, the MDAS average item scores at baseline ($\alpha = .86$) and the change in average item score from baseline to the end of the laboratory session ($\alpha = .85$) were examined as indices of self-reported dental anxiety.

Dental Fear Survey (DFS). The DFS is a 19-item questionnaire that assesses fear of specific dental procedures (e.g., drilling), avoidance of dental procedures, subjective physiological arousal (e.g., heart racing) related to dental treatment, and general anxiety related to dental treatment (Kleinknecht, Klepac, & Alexander, 1973). Items are rated on a 5-point Likert-type scale that has item-specific anchors. For instance, the item "Have you ever avoided calling for a dentist appointment?" is rated on a scale ranging from 1 (*never*) to 5 (*very often*), whereas the item "All things considered, how fearful of dentistry are you?" is rated on a scale ranging from 1 (*no fear*) to 5 (*extreme fear*). For all items, higher scores indicate greater dental anxiety. The DFS has demonstrated good

internal consistency (α = .93), test-retest reliability (r = .73), and split-half reliability (r = .96) (Kleinknecht et al., 1973; Schuurs & Hoogstraten, 1993). It has also demonstrated convergent validity with measures of trait anxiety, pain, and avoidance of dental procedures (Kleinknecht & Bernstein, 1978). In the present study, the DFS average item scores at baseline (α = .95) and the change in average item score from baseline to the end of the laboratory session (α = .94) were examined as indices of self-reported dental anxiety.

Psychophysiological Assessment.

Respiratory Sinus Arrhythmia (RSA) & Skin Conductance Level (SCL). Physiological stress reactivity to the films of dental procedures was assessed by measuring changes in two indices of autonomic nervous system functioning: RSA, which indexes parasympathetic activation, and SCL, which indexes sympathetic activation. RSA is a commonly investigated index of cardiac vagal control, and it is a measure of the variability in heart rate over the respiratory cycle (Beauchaine, 2001; Porges, 1995; Rottenberg, 2007; Rottenberg, Clift, Bolden, & Salomon, 2007). RSA and SCL were assessed with a BioPac BioHarness with AcqKnowledge software, a system that monitors, analyzes and records numerous physiological parameters, including heart rate, respiration rate, and skin conductance levels, which are necessary to calculate RSA and SCL. The BioHarness was attached to individuals via an adjustable chest strap, and disposable adhesive electrodes were placed on participants' collarbones, rib cages, and non-dominant hands to measure electrical activity generated by the heart and electrodermal activity. Resting RSA and SCL were calculated across a single 5-minute period of rest while participants viewed a pleasant film (a beach scene). Participants then

began the dental procedure film tasks (described below). Physiological stress reactivity was computed as the difference between average RSA/SCL during the rest period and average RSA/SCL during the dental procedure film tasks. Data were artifacted and detrended, followed by power spectral analysis and computation of variation in the interbeat intervals in the high-frequency range associated with respiration (0.15-0.40 Hz).

Dental Procedure Film Task

The Dental Procedure Film Task (DPFT) involved having participants watch a series of films of different dental procedures while having their psychological and physiological stress reactivity to the films measured. Each film series was about three minutes in duration. Participants were administered the DPFT three times: first to assess baseline stress reactivity to dental procedures (DPFT #1), second while undergoing the pain expectancy induction (DPFT #2; see description of the pain expectancy induction below), and third to assess post-pain expectancy induction dental procedure stress reactivity (DPFT #3). To minimize habituation to the films, two different series of dental films were used during administrations of the DPFT; "series A" included films of cavity drilling and filling, anesthetic injection, and tooth extraction, and "series B" included films of scaling and polishing (i.e., a regular cleaning), root canal, and tooth extraction. We counterbalanced the order of the film clips such that half of the participants watched series A during DPFT #1 and series B during DPFT #2 and #3, and half of the participants watched series B during DPFT #1 and series A during DPFT #2 and #3 (the individual films clips within each series were presented in a random order). Participants watched emotionally neutral film clips (nature scenes) between the administrations of the DPFT to minimize carry-over of anxious responding.

The DPFT was developed and validated for the purpose of the present study; however, numerous studies have validated the use of pictures and films as effective methods of exposure to phobic stimuli (Grühn & Scheibe, 2008; Ito, Cacioppo, & Lang, 1998; Keil et al., 2003; Lang & Bradley, 2007; Lang, Greenwald, Bradley, & Hamm, 1993; Moltó et al, 2013; Ragsdale, Mitchell, Cassisi, & Bedwell, 2013; Shapira et al., 2003; Smith, Low, Bradley, & Lang, 2006; Wangelin, Bradley, Kastner, & Lang, 2012). To test the ecological validity of the DPFT before using it in the present study, we conducted a preliminary DPFT validity study in which 39 undergraduates completed a measure of dental anxiety (the MDAS) and then watched films of the five dental procedures (in counterbalanced order) and provided SUDS ratings of their anxiety levels while watching the films. We expected that trait dental anxiety would be correlated with state anxiety experienced while watching these dental films. Validity testing also included a comparison of the two different series of films used during the DPFT to ensure that they were comparably anxiety-provoking.

Pain Expectancy Induction: The Shock Threat Paradigm

The shock threat paradigm is a classic method of pain expectancy induction that has been widely used and shown to be safe (Grillon, 2002; Grillon, Baas, Lissek, Smith, & Milstein; 2004; McCloskey, Berman, Echevarria, & Coccaro, 2009). It was chosen for use in the present study based on its established safety and ecological validity (Ohman & Mineka, 2001; Rhudy & Meagher, 2000). Prior to the pain expectancy induction, all participants underwent a pain threshold procedure to individually set the amount of shock that was used in the induction. Fingertip electrodes were attached to the index and middle fingers of participants' non-dominant hands. Participants were administered a series of

100 ms electric shocks, beginning with a 0.1 milliamp shock (a very low level most individuals cannot feel) and increasing at 0.1 milliamp intervals, and they were asked to report when the shock reached a level that was “very unpleasant.” The maximum level of shock administered was 2.5 milliamps.

Following the pain threshold procedure, participants began the pain expectancy induction. Participants were randomized to either the shock threat (n = 52) or safe condition (n = 52) of the pain expectancy induction when they were scheduled for the study. Participants randomized to the shock threat condition were told that they would be administered 1-5 electric shocks while they watched a second series of dental films (i.e., DPFT #2) and that the shocks would be up to twice as intense as the shock that they rated as “very unpleasant.” They wore the fingertip electrodes for the duration of DPFT #2 to maximize the believability of the shock threat; however, no further shocks were actually administered. At the conclusion of DPFT #2, they completed a pain expectancy induction check item (“How much did you expect to get shocked while watching the films?”) that ranged from zero (*not at all*) to eight (*a lot*) and then had their fingertip electrodes removed.

Participants randomized to the safe condition were told at the beginning of DPFT #2 that they were going to watch another series of films of dental procedures, but they would not receive any further shocks. They had their fingertip electrodes removed at this point as assurance that they would not receive further shocks.

Procedure

Screening. TUKSoD adult dental patients were telephone called and provided with a brief description of the study. Individuals who had attended any type of dental appointment at TUKSoD with any type of provider (e.g., dental student, licensed dentist) were contacted. Those who expressed interest were invited to complete a brief telephone screening survey after providing informed verbal consent. All study inclusion and exclusion criteria that did not require administration of the SCID-I/NP were assessed (e.g., age, serious medical conditions). Eligible patients were invited to participate in the laboratory visit, but were informed that the laboratory visit would begin with a more comprehensive assessment of study exclusion criteria, so they were not guaranteed an invitation to complete the entire study.

We called 1,518 patients of TUKSoD dental clinics about possible participation in the present study. Of these 1,518 patients, 581 were reached, and 255 indicated they were not interested in participating. The remaining 326 were screened for the initial inclusion criteria, and 315 of them were eligible and scheduled a study appointment. Of these 315 patients, 199 failed to appear for their study appointment, 4 attended the appointment but were screened out for endorsing current psychotic symptoms on the SCID-I/NP, and 8 attended the appointment but were unable to complete the study due to technical difficulties (e.g., computer crashing). The remaining 104 individuals completed the study.

Laboratory Session. The laboratory session began by obtaining written, informed consent. All procedures followed were in accordance with the ethical standards of the Temple University Institutional Review Board and with the Helsinki Declaration of 1975, as revised in 2013 (World Medical Association, 2013). Second, a graduate student

clinician or trained research assistant administered the SCID-I/NP and the specific phobia module of the ADIS-IV, and participants who endorsed current suicidal/homicidal ideation or intent or current psychosis were compensated for their time thus far and dismissed from the remainder of the study. Third, participants were administered a battery of self-report questionnaires assessing baseline dental anxiety (MDAS, DFS), AS (ASI-3), pain expectancy (Pain Expectancy VAS), and negative affectivity (PANAS-NA). Fourth, participants completed three administrations of the DPFT and the pain expectancy induction along with DPFT #2. Psychological and physiological stress reactivity to the films of dental procedures was measured before, during, and after the pain expectancy induction (i.e., SUDS ratings and RSA/SCL during DPFT #1, #2, and #3). Self-report questionnaires on dental anxiety (MDAS, DFS) were re-administered following the pain expectancy induction. After all assessments were completed, participants were debriefed and, at that point, we explained that the study involved deception regarding the shock threat condition of the pain expectancy induction. Any participants who exhibited emotional distress were provided with therapy referrals, if appropriate. Participants were compensated $10 per hour of their time.

Data Analytic Plan

Preliminary Analyses. Preliminary analyses were conducted using SPSS Version 21.0 (IBM Corp., 2012). Before beginning the present study, we conducted a preliminary study of the validity of the DPFT that included 39 undergraduates, and we calculated bivariate correlations between undergraduates’ trait dental anxiety (i.e., MDAS total score) and their state anxiety (i.e., SUDS ratings) during each of the five film clips of different dental procedures. We also conducted a paired-samples *t*-test comparing the

average state anxiety undergraduates experienced during the film clips that comprise DPFT "Series A" and "Series B" to ensure that the two series were equivalently anxiety-provoking. To check the efficacy of the pain expectancy induction, we examined descriptive characteristics (*M* and *SD*) for the pain expectancy induction check item to see how strongly participants randomized to the shock threat condition expected to be shocked during DPFT #2.

Prior to conducting analyses testing the main study hypotheses, data were inspected to ensure satisfaction of statistical assumptions (e.g., normality, collinearity). Proper adjustments (e.g., transformations of non-normally distributed variables) were made to the analytic plan in case of violation of any of these assumptions. Next, tests examining differences in the primary variables of interest (AS, pain expectancy, dental anxiety, dental phobia severity, dental procedure stress reactivity) as a function of demographic variables (age, sex, race, SES, education level) were conducted, and any demographic variables significantly associated with independent and dependent variables in the tested models were included as covariates when relevant. Associations between the primary variables of interest were also examined. Frequencies were calculated to explore the prevalence of dental phobia and other current Axis I psychiatric diagnoses in the current sample.

Main Analyses. The primary analyses testing our hypotheses were conducted using Mplus Version 7 (Muthén & Muthén, 1998-2012). Mplus uses Full Information Maximum Likelihood (FIML) estimation to address missing data. FIML uses all available data to estimate model parameters, but does not impute values, which allows maintenance of participants with missing data in model estimation (Enders, 2001).

Self-Reported Pain Expectancy. A series of linear regressions was conducted for which AS (ASI-3 average item score), self-reported pain expectancy (Pain Expectancy VAS average item score), and their two-way interaction term (AS x self-reported pain expectancy) were the independent variables. Indices of baseline dental anxiety/dental phobia were the dependent variables (e.g., baseline scores on MDAS/DFS, ADIS dental phobia CSR, psychological/physiological stress reactivity to DPFT #1). To minimize multicollinearilty, all independent variables were mean centered prior to analysis (Aiken & West, 1991). Negative affectivity (PANAS-NA average item score) was entered to control for its effect.

Pain Expectancy Induction Condition. A series of linear regressions was conducted for which AS (ASI-3 average item score), Pain expectancy induction condition (shock threat or safe), and their two-way interaction term (AS x Pain expectancy induction condition) were the independent variables. Post-pain expectancy induction indices of dental anxiety were the dependent variables (e.g., change in MDAS/DFS scores, psychological/physiological stress reactivity to DPFT #3). Negative affectivity was entered as a control variable.

Probing Significant Interactions. Significant interactions were examined both graphically and statistically. The forms of significant interactions were plotted by inserting values for the proposed moderator (AS) that fell at ±1 *SD* around the sample mean into the regression equation associated with the analysis (Cohen & Cohen, 1983, pp. 323, 419). *Post hoc* probing analyses were also conducted to examine the significance of the simple slopes for each significant interaction (Holmbeck, 2002). To conduct the probing analyses, two new conditional "high" and "low" AS variables were computed by

adding/subtracting 1 *SD* of AS to/from each participant's value on AS (Aiken & West, 1991, p.19). This approach examines the conditional effects of pain expectancy on dental anxiety at each level of AS. We then ran *post hoc* regressions using the conditional moderator variables to generate simple slopes for the high AS regression line (i.e., when AS was 1 *SD* above the mean) and the low AS regression line (i.e., when AS was 1 *SD* below the mean). The Johnson-Neyman technique (Johnson & Fay, 1950) was also used to probe for regions of significance in significant interactions using SPSS Version 21.0.

CHAPTER 3

RESULTS

Preliminary Analyses

DPFT Validity Testing. Bivariate correlations showed that trait dental anxiety as measured by the MDAS was significantly correlated with state anxiety experienced while watching the dental films that were presented during the DPFT, *r*'s > .49, *p*'s < .001, suggesting that the dental films were more anxiety-provoking for individuals with higher dental anxiety and supporting the validity of the DPFT. A paired samples *t*-test indicated that there was not a significant difference in the average amount of anxiety participants experienced while watching the dental films that comprised Series A (*M* = 4.00, *SD* = 2.72) and Series B (*M* = 4.01, *SD* = 2.96), *t* = -0.494, *p* = .624, suggesting that the two series were equivalently anxiety-provoking.

Pain Expectancy Induction Check. Descriptive statistics on the pain expectancy induction check item showed that, on average, participants in the shock threat condition moderately believed that they were going to be shocked while watching the second series of dental videos (*M* = 5.26, *SD* = 2.35, possible range = 0 – 8, with higher scores indicating greater shock expectancy).

Sample Characteristics and Covariates. Preliminary analyses revealed no violations of assumptions of normality on the majority of the variables of interest and no problems with multicollinearity. The only violations of normality were regarding the physiological indices of dental procedure stress reactivity (RSA and SCL), which were leptokurtotic (Kurtosis = 3.55 – 8.66); therefore, analyses including the physiological variables were conducted using both raw and log-transformed versions of the

physiological variables. Analyses of the raw and log transformed physiological variables generated largely the same results, so we have presented analyses of the raw data in the main paper and pointed out any discrepancies between analyses of the raw versus log-transformed physiological data. The complete set of analyses on the transformed physiological data is included in the supplemental analyses (Supplemental Tables 6 – 7).

Demographic characteristics and prevalence of psychiatric diagnoses are displayed in Tables 1 and 2. There was a high prevalence of the assessed Axis I disorders in the present sample, particularly major depressive disorder, cocaine abuse/dependence, alcohol abuse/dependence, social anxiety disorder, and specific phobia (both dental and non-dental subtypes; see Table 2). Approximately 11% of the sample met DSM-IV criteria for dental phobia. Dental anxiety, as measured by the MDAS, was reported as high (score of 19-25) by 14.4%, moderate (score of 13-18) by 32.7%, and low (score of 5-12) by 52.9% of the full sample. The only demographic variable that was associated with both independent and dependent variables of interest was sex, which was associated with pain expectancy, dental phobia severity, and MDAS and DFS scores (ts ≥ 1.98, ps $\leq .05$); therefore, sex was included as a covariate in analyses of these variables.

Bivariate correlations and descriptive statistics for the primary variables of interest are shown in Table 3. As expected, most of the variables were significantly correlated, with some noteworthy exceptions. AS was not correlated with dental phobia severity and two of the indices of dental procedure stress reactivity (SUDS rating and SCL), and the physiological indices of dental procedure stress reactivity (RSA and SCL) were not correlated with most of the other primary variables. Descriptive characteristics for the measured physiological parameters across study time points are available in the

Table 2. *Current Axis I psychiatric diagnoses for the entire sample (N = 104)*

	n (%)
Mood Disorders	
Major Depressive Disorder	31 (30%)
Depressive Disorder NOS	8 (8%)
Dysthymic Disorder	4 (4%)
Bipolar Disorder	3 (3%)
Adjustment Disorder	2 (2%)
Cyclothymic Disorder	1 (1%)
Any Mood Disorder	49 (47%)
Anxiety Disorders	
Social Anxiety Disorder	12 (12%)
Specific Phobia of Dental Procedures	11 (11%)
Specific Phobia (all other subtypes)	8 (8%)
Posttraumatic Stress Disorder	3 (3%)
Panic Disorder and/or Agoraphobia	2 (2%)
Generalized Anxiety Disorder	2 (2%)
Anxiety Disorder NOS	2 (2%)
Obsessive Compulsive Disorder	1 (1%)
Any Anxiety Disorder	32 (31%)
Substance Use Disorders	
Cocaine Abuse/Dependence	17 (16%)
Alcohol Abuse/Dependence	14 (13%)
Cannabis Abuse/Dependence	6 (6%)
Other Substance Abuse/Dependence	3 (3%)
Any Substance Use Disorder	28 (27%)
Any Axis I Disorder	68 (65%)

Note. Current (i.e., past year) mood, anxiety, and substance use disorders were assessed using the Structured Clinical Interview for DSM-IV Axis I Disorders, Non-Patient Version (SCID-I/NP). Mood and substance use disorders in sustained full remission are counted in the above percentage

Table 3. *Zero-order correlations and descriptive statistics for primary study variables for the entire sample (N = 104)*

Variable	1	2	3	4	5	6	7	8	9	*M (SD)*	Possible Range	*n* missing
1. Anxiety Sensitivity – ASI-3	1									0.84 (0.74)	0 – 4	0
2. Pain Expectancy VAS	**.21***	1								53.89 (22.87)	0 – 100	0
3. Negative Affect – PANAS-NA	**.30****	**.36****	1							1.42 (0.54)	1 – 5	0
4. Dental Anxiety – MDAS	**.23***	**.49****	**.45****	1						2.58 (1.00)	1 – 5	0
5. Dental Anxiety – DFS	**.44****	**.57****	**.44****	**.72****	1					2.38 (0.90)	1 – 5	1
6. Dental Phobia ADIS-IV CSR	.18	**.45****	**.36****	**.55****	**.54****	1				1.63 (1.65)	0 – 8	2
7. DPFT #1 – SUDS	.18	**.50****	.24*	**.48****	**.47****	**.42****	1			3.68 (2.60)	0 – 8	8
8. DPFT #1 – RSA	**.21***	-.10	.01	-.10	.00	-.01	**-.23***	1		76.11 (48.89)	N/A	4
9. DPFT #1 – SCL	-.06	**-.30****	-.03	-.19	-.12	-.09	-.10	.19	1	3.48 (4.30)	N/A	7

Note. Significant correlations presented in bold print. ASI-3 = Anxiety Sensitivity Index-3, VAS = Visual Analogue Scale, PANAS-NA = Positive Affect Negative Affect Schedule – Negative Affectivity Scale, MDAS = Modified Dental Anxiety Scale, DFS = Dental Fear Survey, ADIS-IV CSR = Anxiety Disorders Interview Schedule for DSM-IV Clinician Severity Rating, SUDS = Subjective Units of Distress Scale, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level. Average item scores were used for all self-report measures.

*$p < .05$, **$p < .01$.

supplemental analyses (Supplemental Table 1). RSA did not appear to change from baseline to the three administrations of the DPFT, whereas SCL rose from baseline to the DPFTs.

Main Analyses.

Self-Reported Pain Expectancy. Please refer to Tables 4 and 5 for a summary of the linear regression analyses examining the interactive effect of self-reported pain expectancy and AS on indicators of dental anxiety/dental phobia severity. In contrast to hypotheses, analyses did not reveal a significant interactive effect on dental anxiety as measured by the MDAS, dental phobia severity (ADIS-IV dental phobia CSR), state anxiety reactivity to the dental films (SUDS), or psychophysiological reactivity to the dental films (RSA and SCL).

There was a significant interactive effect of pain expectancy and AS on dental anxiety as measured by the DFS; however, the form of the interaction was in the opposite of the expected direction (see Figure 1). *Post hoc* probing analyses of the simple slopes revealed that pain expectancy was significantly related to dental anxiety as measured by the DFS among those low in AS ($B = .02$, $p < .001$), with high levels of pain expectancy being related to greater dental anxiety. However, the relationship between pain expectancy and dental anxiety (DFS score) was not statistically significant when AS was high ($B = .01$, $p = .094$). The Johnson-Neyman analysis revealed that the effect of pain expectancy on dental anxiety was significantly positive at or below an ASI-3 average item score of 1.44 (possible range of ASI-3 average item scores = 0 – 4, with higher scores indicating greater AS), but not significant above that.

Table 4. *Linear regression analyses predicting baseline dental anxiety/phobia severity*

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: Dental Anxiety (MDAS)					
Model ($F = 4.80, p < .001$)					**.36*** **
Sex	**.33**	**.16**	**.17***	**2.05**	
Negative Affect	**.53**	**.16**	**.29****	**3.21**	
Pain Expectancy	**.02**	**.00**	**.34*****	**3.92**	
AS	.05	.12	.04	0.44	
Pain Expectancy × AS	.01	.01	.09	1.08	
Outcome: Dental Anxiety (DFS)					
Model ($F = 6.98, p < .001$)					**.49*****
Sex	.17	.13	.09	1.29	
Negative Affect	**.38**	**.13**	**.22****	**2.82**	
Pain Expectancy	**.02**	**.00**	**.39*****	**4.94**	
AS	**.40**	**.10**	**.33*****	**4.21**	
Pain Expectancy × AS	**-.01**	**.00**	**-.17***	**-2.33**	
Outcome: Dental Phobia Severity (ADIS-IV CSR)					
Model ($F = 3.90, p < .001$)					**.29*****
Sex	**.64**	**.29**	**.19***	**2.24**	
Negative Affect	**.70**	**.29**	**.23***	**2.43**	
Pain Expectancy	**.02**	**.01**	**.31****	**3.26**	
AS	.14	.20	.06	0.67	
Pain Expectancy × AS	-.01	.01	-.11	-1.25	

Note. Significant effects presented in bold print. MDAS = Modified Dental Anxiety Scale, AS = Anxiety Sensitivity, DFS = Dental Fear Survey, ADIS-IV CSR = Anxiety Disorders Interview Schedule for DSM-IV Clinician Severity Rating.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 5. *Linear regression analyses predicting baseline dental procedure stress reactivity*

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: State Anxiety Reactivity to Dental Films (ΔSUDS during DPFT #1)					
Model ($F = 1.93$, $p = .054$)					.12
Negative Affect	-.59	.72	-.09	-0.83	
Pain Expectancy	**.05**	**.02**	**.31****	**3.01**	
AS	.51	.50	.10	1.02	
Pain Expectancy × AS	-.02	.02	-.10	-1.00	
Outcome: Parasympathetic Reactivity to Dental Films (ΔRSA during DPFT #1)					
Model ($F = 1.12$, $p = .263$)					.05
Negative Affect	-1.20	3.76	-.04	-0.32	
Pain Expectancy	-.08	.09	-.10	-0.95	
AS	**5.39**	**2.64**	**.21***	**2.05**	
Pain Expectancy × AS	-.02	.12	-.02	-0.17	
Outcome: Sympathetic Reactivity to Dental Films (ΔSCL during DPFT #1)					
Model ($F = 1.59$, $p = .112$)					.09
Negative Affect	.00	.28	.00	0.00	
Pain Expectancy	**-.02**	**.01**	**-.30****	**-2.82**	
AS	.12	.20	.06	0.61	
Pain Expectancy × AS	.00	.01	.02	0.16	

Note. Significant effects presented in bold print. SUDS = Subjective Units of Distress Scale, DPFT = Dental Procedure Film Task, AS = Anxiety Sensitivity, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.
*$p < .05$, **$p < .01$, ***$p < .001$.

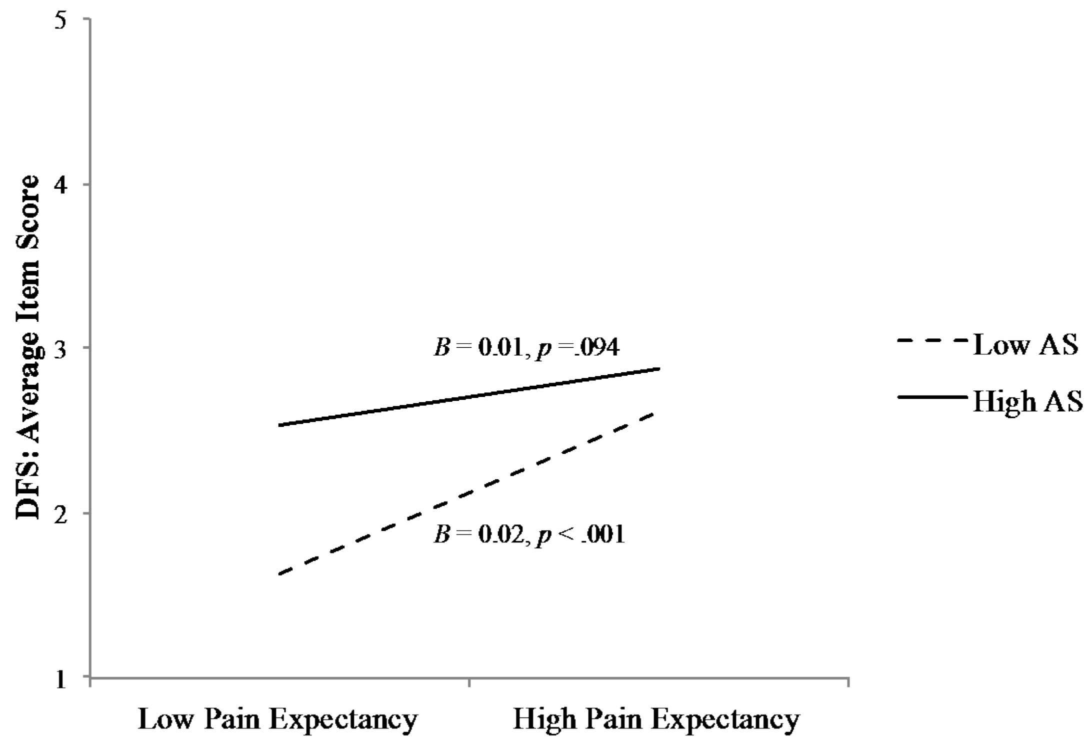

Figure 1. Interactive effect of self-reported pain expectancy (Pain Expectancy Visual Analogue Scale average item score) and anxiety sensitivity (AS; Anxiety Sensitivity Index-3 average item score) on dental anxiety severity (Dental Fear Survey [DFS] average item score), controlling for sex and negative affectivity. DFS average item scores had a possible range of 1 (*no fear*) to 5 (*extreme fear*). The relation between pain expectancy and dental anxiety was significant among adults with low AS (1 *SD* below the mean), but not among adults with high AS (1 *SD* above the mean).

We interpreted the main effects of pain expectancy and AS on dental anxiety/dental phobia severity within the regression analyses that did not yield significant interaction terms. There was a positive main effect of pain expectancy on greater levels of dental anxiety as measured by the MDAS, dental phobia severity, and state anxiety reactivity to the dental films. There was a negative main effect of pain expectancy on sympathetic nervous system reactivity to the dental films, such that greater levels of pain expectancy were associated with decreases in SCL during the dental films; however, this finding was not maintained in the analysis of the log-transformed SCL data (see Supplemental Table 6). Pain expectancy was not associated with parasympathetic reactivity to the dental films (i.e., changes in RSA).

There was a positive main effect of AS on parasympathetic reactivity to the dental films, such that greater levels of AS were associated with increases in RSA during the dental films; however, this finding was not maintained in the analysis of the log-transformed RSA data (see Supplemental Table 6). AS did not demonstrate a significant main effect on the remaining indicators of dental anxiety/dental phobia severity (MDAS, ADIS dental phobia CSR, SUDS during dental films, SCL during dental films).

Pain Expectancy Induction Condition. Please refer to Tables 6 and 7 for a summary of the linear regression analyses examining the interactive effect of the pain expectancy induction condition and AS on indicators of dental anxiety. In contrast to hypotheses, analyses did not reveal a significant interactive effect on any of the dental anxiety indicators (dental anxiety as measured by the MDAS or DFS, state anxiety reactivity to the third series of dental films, or psychophysiological reactivity to the dental films).

Table 6. *Linear regression analyses predicting post-pain expectancy induction dental anxiety*

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: Change in Dental Anxiety (MDAS)					
Model ($F = 1.46$, $p = .144$)					.07
Negative Affect	-.13	.14	-.10	-0.91	
Condition (shock threat, safe)	**.29**	**.14**	**.20***	**2.05**	
AS	.09	.10	.09	0.91	
Condition × AS	.25	.19	.13	1.30	
Outcome: Change in Dental Anxiety (DFS)					
Model ($F = 1.16$, $p = .247$)					.05
Negative Affect	.01	.18	.01	0.05	
Condition (shock threat, safe)	.29	.18	.16	1.64	
AS	-.17	.12	-.14	-1.38	
Condition × AS	-.11	.24	-.04	-0.44	

Note. Significant effects presented in bold print. MDAS = Modified Dental Anxiety Scale, AS = Anxiety Sensitivity, DFS = Dental Fear Survey.
*$p < .05$.

Table 7. *Linear regression analyses predicting post-pain expectancy induction dental procedure stress reactivity*

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: State Anxiety Reactivity to Dental Films (ΔSUDS during DPFT #3)					
Model (*F* = 1.26, *p* = .209)					.06
Negative Affect	.00	.72	.00	0.00	
Condition (shock threat, safe)	-.90	.75	-.12	-1.20	
AS	**1.01**	**.52**	**.20**◆	**1.95**	
Condition × AS	.18	1.01	.02	0.18	
Outcome: Parasympathetic Reactivity to Dental Films (ΔRSA during DPFT #3)					
Model (*F* = 1.26, *p* = .209)					.05
Negative Affect	7.81	4.30	.19	1.82	
Condition (shock threat, safe)	-2.30	4.47	-.05	-0.52	
AS	-2.32	3.11	-.08	-0.75	
Condition × AS	7.68	6.08	.13	1.26	
Outcome: Sympathetic Reactivity to Dental Films (ΔSCL during DPFT #3)					
Model (*F* = 0.93, *p* = .355)					.03
Negative Affect	-.47	.50	-.10	-0.94	
Condition (shock threat, safe)	.74	.52	.15	1.42	
AS	.20	.37	.06	0.54	
Condition × AS	-.14	.72	-.02	-0.20	

Note. Significant effects presented in bold print. SUDS = Subjective Units of Distress Scale, DPFT = Dental Procedure Film Task, AS = Anxiety Sensitivity, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.
◆*p* = .051

There was a significant main effect of the pain expectancy induction condition on dental anxiety as measured by the MDAS, such that participants randomized to the shock threat condition exhibited increases in MDAS average item scores (*M* = 0.05, *SD* = 0.84), whereas participants randomized to the safe condition exhibited decreased scores (*M* = -0.25, *SD* = 0.56). There was a nearly significant main effect ($p = .051$) of AS on state anxiety reactivity to the dental films, such that greater levels of AS were associated with increases in state anxiety while watching the films. There were no significant main effects of pain expectancy induction condition or AS on any of the remaining dental anxiety indicators.

Exploratory analyses on AS physical concerns subscale. Because study hypotheses regarding the moderating role of global AS in the pain expectancy-dental anxiety relationship were not supported, we conducted exploratory analyses examining the physical concerns facet of AS. We tested whether the AS physical concerns subscale, rather than the global measure that includes the other facets of AS (social and cognitive concerns), amplified the association between pain expectancy and the various indicators of dental anxiety (see Supplemental Tables 2 – 5). Exploratory analyses were generally consistent with the main analyses and did not provide evidence of a stronger moderating role of the AS physical concerns subscale. The only contradictions between the exploratory and main analyses were that the exploratory analyses did not generate the unexpected form of an interaction between self-reported pain expectancy and AS physical concerns on trait dental anxiety (DFS score) and the AS physical concerns subscale did not exhibit a main effect on any of the dental anxiety indicators.

CHAPTER 4

DISCUSSION

The present study examined whether AS moderates the association between pain expectancy and dental anxiety. Pain expectancy was examined in two ways. First, participants completed a questionnaire assessing how painful they expected dental procedures to be. Second, they completed a pain expectancy induction task and were randomly assigned to one of two conditions: they were either told that they would experience pain (i.e., electric shock) while watching videos of dental procedures or assured they would not experience pain while watching the dental videos. We expected that, across the two methods of measuring/inducing pain expectancy, AS would amplify the association between greater levels of pain expectancy and greater dental anxiety. In contrast to our hypotheses, we found no evidence that AS strengthens this association. On the contrary, we found limited evidence that AS may weaken the association between self-reported pain expectancy and trait dental anxiety.

The significant interaction between AS and pain expectancy was only observed in relation to one of the dental anxiety indicators (DFS score), was in the opposite of the hypothesized direction, and was not maintained in the exploratory analyses examining the AS physical concerns subscale. Therefore, this interaction should be interpreted with the utmost caution. As is observable in the graphical depiction of this interaction (Figure 1), individuals with high AS exhibited moderate levels of dental anxiety regardless of their degree of pain expectancy, whereas for individuals with low AS, expecting dental treatment to be painful was associated with increases from low to moderate levels of dental anxiety. One possible explanation for the unexpected form of this interactive effect

is that individuals with high AS tend to experience relatively strong dental anxiety regardless of their degree of pain expectancy. Having a tendency to fear anxiety-related arousal may lead individuals to fear dental procedures whether or not they expect them to be painful, because dental procedures may elicit a range of AS-related concerns, such as feared somatic sensations (e.g., racing heart and difficulty breathing; Carr, Lehrer, & Hochron, 1995; Domschke et al., 2010), anxiety about oral/physical health (Olatunji et al., 2009), and social anxiety regarding feared negative evaluation by the dentist or hygienist (Moore et al., 2004; Wheaton, Deacon, McGrath, Berman, & Abramowitz, 2012). On the other hand, individuals with low AS may tend to have low dental anxiety unless they believe that dental treatment will be highly painful. It is important to highlight that this is a speculative interpretation of the results from a single analysis on dental anxiety as measured by the DFS, and it is not generally supported across study analyses on various dental anxiety indicators. Since a pattern of findings exhibiting the same unexpected form of the AS-pain expectancy interaction did not emerge, it seems premature to assert that AS weakens the association between pain expectancy and dental anxiety. Future studies examining the inter-relations of AS, pain expectancy, and dental anxiety among clinical samples of individuals with high dental anxiety or dental phobia are an important next step, as the interactive effect of AS and pain expectancy might look different at low versus high ends of the dental anxiety spectrum.

The null effects of the AS-pain expectancy interaction terms across the range of assessed dental anxiety indicators suggests that AS may not be a strong moderator of the relationship between pain expectancy and dental anxiety. There are a number of reasons why this may be the case. Our initial thought was that the physical concerns component

of AS may be more relevant to pain expectancy and dental anxiety than the other AS facets (social and cognitive concerns), but our exploratory analyses examining the AS physical concerns subscale failed to generate significant interactive effects. It is possible that AS does not directly exacerbate dental anxiety in conjunction with pain expectancy, but does so indirectly by increasing vulnerability to fearing the specific sensations elicited by dental treatment (e.g., the scraping of dental tools, the pressure of the drill). There is growing evidence that AS exacerbates chronic medical conditions by promoting the development of condition-specific fears (e.g., fear of pain, fear of respiratory symptoms; Asmundson et al., 2000; Domschke et al., 2010; Thibodeau et al., 2013), and AS may play a similar role in causing/maintaining dental anxiety by promoting the development of dental treatment-specific fears. Measuring and statistically accounting for fear of the specific sensations experienced during dental treatment may reveal a pathway through which AS and pain expectancy interact to increase dental anxiety.

It is also possible that AS is not as strong a vulnerability factor for dental anxiety as it is for other forms of anxiety, such as panic disorder and social anxiety disorder (Bentley et al., 2013; Naragon-Gainey, 2010; Schmidt, Zvolensky, Maner, 2006; Scott et al., 2000). In comparison to pain expectancy, AS was not correlated with many of the dental anxiety indicators (see Table 3). When included in regression analyses with pain expectancy, AS only exhibited a direct association with two dental anxiety indicators (increases in SUDS ratings and RSA during the dental films), and these associations were not maintained in the exploratory analyses examining the AS physical concerns subscale or in the analysis of log-transformed RSA data. Although AS is an established transdiagnostic risk factor for anxiety disorders (Boswell et al., 2013), only a limited

number of studies have examined its association with dental anxiety, and findings have been mixed. Among studies investigating whether AS can help distinguish dental anxiety/phobia from other blood-injection-injury (BII) phobias, some results suggest that individuals with dental phobia and other BII phobias both exhibit greater AS relative to controls (Locker, Shapiro, & Liddell, 1997), whereas others indicate that AS is associated with greater levels of non-dental BII fears, but not with greater dental anxiety (as measured by the MDAS; Kilic, Ak, & Ak, 2014). Another study focused on examining the nuances of the AS-dental anxiety relationship among 160 patients about to undergo dental treatment (third molar removal) showed that AS was moderately associated with trait dental anxiety ($r = .42$, $p < .05$), but AS did not predict anticipated or expected anxiety during dental treatment above and beyond the effects of state anxiety and fear of dental pain (van Wijk, de Jongh, & Lindeboom, 2010). These findings, although somewhat disparate, generally suggest that individuals with high dental anxiety exhibit elevated AS, but that AS is not a strong predictor of dental anxiety in comparison to other vulnerability factors. The present findings are consistent with this conclusion and suggest that AS exhibits some degree of a direct association with dental anxiety but that it is not as potent of a dental anxiety vulnerability factor as pain expectancy. Future studies examining other vulnerability factors that are theoretically relevant to pain expectancy and dental anxiety, such as fear of pain (McNeil et al., 2011) and pain catastrophizing (Crombez et al., 2002; Van Damme et al., 2002), might identify stronger moderators of the pain expectancy-dental anxiety connection.

One of the main contributions of the present study is that it provides further evidence of the association between pain expectancy and dental anxiety. Self-reported

pain expectancy was associated with the majority of the examined dental anxiety indicators, including trait dental anxiety, increases in state anxiety while watching dental films, and clinician-assessed dental phobia severity. Self-reported pain expectancy was also, to some extent, associated with decreases in skin conductance while watching dental films (according the analysis of the raw SCL data, but not the log-transformed SCL data). The negative association between pain expectancy and SCL is surprising given that *increased* skin conductance is a typical indicator of anxious responding (Johnsen et al., 2003; Kreibig, 2010), but it could be indicative of an emotion regulation response among participants with high pain expectancy (Cisler, Olatunji, Feldner, & Forsyth, 2010). Further, expecting to experience pain while watching dental films (i.e., being in the "shock threat" condition of the pain expectancy induction task) was associated with increases in trait dental anxiety as measured by the MDAS. The demonstrated associations between pain expectancy and dental anxiety across both methods of examining pain expectancy and multiple methods of measuring dental anxiety represents a strong pattern of findings that is consistent with previous studies establishing a pain expectancy-dental anxiety connection (e.g., Kent, 1985; Klages et al., 2004; Muglali & Komerik, 2008). Prior studies have shown that individuals who report a general expectation that dental treatment is highly painful (Kent, 1984; Kent, 1985; Kleinknecht & Bernstein, 1978; Wardle, 1983) or who endorse high pain expectancy ratings just before undergoing an actual dental procedure (Klages et al., 2004; Muglali & Komerik, 2008) exhibit elevated dental anxiety on self-report measures. The present study extends these findings by replicating them across multiple methods of dental anxiety assessment,

thus demonstrating that the pain expectancy-dental anxiety relationship generalizes beyond self-report measures.

The connection between pain expectancy and greater dental anxiety was much more evident in the analyses including the self-report measure of dental treatment-specific pain expectancy than in those including the pain expectancy induction condition. Participants randomized to the “shock threat” condition of the pain expectancy induction reported, on average, a moderate expectation of being shocked during the shock threat period, yet they did not exhibit greater psychophysiological stress reactivity to the dental films shown during that period than participants randomized to the “safe” condition. We measured participants’ expectation of being shocked toward the end of the shock threat period rather than beforehand so as not to reveal the deception, and it is possible that participants may have exhibited a greater expectation of being shocked had we administered the manipulation check item at the beginning of the shock threat period. Still, the fact that participants in the shock threat condition did not exhibit greater anxious responding to the dental videos shown during the shock threat period leads us to question whether the pain expectancy induction task functioned as intended. The task was designed as a laboratory simulation of the *in vivo* experience of expecting to experience pain during dental treatment, but it may have lacked ecological validity. Expecting to experience electric shock may be type of pain or discomfort expectancy that is phenomenologically distinct from the type of pain expectancy that is elicited by the threat of dental treatment. Studies using electric shock often include ratings of the degree of pain and the degree of discomfort experienced during shocks to capture varied physical responses that individuals may have (e.g., Stewart, Finn, & Pihl, 1995). We did not

include such ratings in our study, so we cannot assume that participants randomized to the shock threat condition expected to experience pain rather than general discomfort. Even if the shock threat condition successfully induced pain expectancy, it may not have generated the kinds of AS-related concerns that could be may be elicited by dental treatment-related pain expectancy (e.g., "this is going to hurt, which will mean there is something very wrong me"). Future studies using more ecologically valid means of inducing dental treatment-related pain expectancy, such as having patients who are about to undergo dental procedures provide ratings of pain expectancy (Klages et al., 2004, 2006) may be more successful at identifying associations between AS, pain expectancy, and dental anxiety.

There are noteworthy limitations of the present study that should be kept in mind when interpreting the findings. Nearly all participants were residents of north Philadelphia, which is an urban area, and when interviewed about their trauma exposure during the SCID-IV assessment, the majority of participants reported experiencing or witnessing urban violence (e.g., muggings, shootings). The strong presence of urban violence exposure may in part, explain the high prevalence of Axis I psychopathology in this sample. As exposure to violence is associated with a host of psychological and physiological outcomes (Marshall et al., 2001; Pineles et al., 2013), it is unclear if the present findings can be generalized to non-violence exposed samples. Further, the present sample was not selected on the basis of dental anxiety or AS, and the prevalence of dental phobia was lower in this sample (11%) than in other unselected samples of TUKSoD patients (e.g., 20% in Tellez et al., 2015). Therefore, the present findings also may not generalize to clinical samples of individuals with high dental anxiety or dental phobia. It

is crucial that future studies on dental anxiety include diverse samples of individuals from different types of communities and with varying psychiatric presentations to generate a well-rounded body of research on risk and protective factors for dental anxiety.

The major strength of the present study is the multi-method assessment of dental anxiety, which allowed us to look for patterns of findings across the different types of dental anxiety indicators. Much of the existing research on dental anxiety relies on self-report measures, which is a significant limitation given that psychophysiological stress reactivity to dental treatment is an important component of dental anxiety that can impact treatment delivery (Liau et al., 2008). This is one of the first studies, to our knowledge, that has incorporated self-report, clinician-administered, and psychophysiological measures into the investigation of cognitive-affective risk factors for dental anxiety. Examining pain expectancy in two ways was also a useful strategy, as it revealed that dental treatment-specific pain expectancy is likely not adequately simulated using shock threat. Future studies examining pain expectancy related to dental/medical treatment should attempt to induce pain expectancy using the threat of dental/medical procedures rather than an analogue stimulus.

In conclusion, findings from the present study suggest that AS may not be a strong risk candidate for dental anxiety, whereas pain expectancy does appear to confer risk for dental anxiety. Previous studies have shown that it is difficult to create long-lasting reductions in pain expectancy regarding dental treatment (Arntz et al., 1990), so it is important that future studies aim to identify theoretically malleable moderators and mediators of the pain expectancy-dental anxiety connection. Although we did not find

strong evidence that AS plays a role in the development of dental anxiety, future studies that examine AS along with other risk candidates for dental anxiety may reveal unidentified pathways through which AS causes or maintains dental anxiety.

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APPENDIX A

SUPPLEMENTAL ANALYSES

Power Analysis

Prior to beginning the present study, we conducted a power analysis using G*Power 3.2 to determine our target sample size. We examined the power to detect an interaction effect of AS and pain expectancy on top of the effects of each of the predictors and the covariate within a linear regression model, based on a power of .80 and $\alpha = .05$. The sample size needed to detect a large interaction effect size ($f^2 = .35$) was 25, a moderate effect size ($f^2 = .15$) was 55, and a small effect size ($f^2 = .02$) was 395. The best estimates from the existing literature on associations between the proposed risk factors and dental anxiety suggest a moderate interaction effect size (Klages et al., 2004, Klages et al., 2006; Sullivan & Neish, 1998; van Wijk et al., 2010). A conservative estimate that the effect size is somewhat less than moderate ($f^2 = .10$) suggests a sample size of 81 was needed. Therefore, the present sample of 104 individuals provided adequate power.

Descriptive Statistics for Psychophysiological Variables

Supplemental Table 1. *Descriptive statistics for psychophysiological variables*

	Baseline (beaches video)	DPFT #1	DPFT #2		DPFT #3	
			Shock Threat	Safe	Shock Threat	Safe
RSA: *M*	75.72	76.31	73.28	75.60	72.59	73.77
(*SD*)	(50.68)	(48.69)	(41.63)	(54.18)	(37.83)	(53.24)
SCL: *M*	3.03	3.45*	6.19*	5.02*	4.94*	4.10*
(*SD*)	(3.66)	(4.29)	(6.11)	(4.99)	(6.00)	(4.20)

Note. DPFT = Dental Procedure Film Task, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.
*$p < .01$ change from baseline

Main Analyses with the Anxiety Sensitivity Index-3 Physical Concerns Subscale in Place of the Total Scale Score

Supplemental Table 2.
Linear regression analyses predicting baseline dental anxiety/phobia severity

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: Dental Anxiety (MDAS)					
Model (*F* = 4.91, *p* <.001)					**.37*****
Sex	**.32**	**.16**	**.16***	**1.97**	
Negative Affect	**.56**	**.16**	**.30*****	**3.58**	
Pain Expectancy	**.02**	**.00**	**.34*****	**3.98**	
AS-p	-.03	.10	-.02	-0.29	
Pain Expectancy × AS-p	.01	.01	.14	1.72	
Outcome: Dental Anxiety (DFS)					
Model (*F* = 6.29, *p* <.001)					**.46*****
Sex	.18	.14	.10	1.30	
Negative Affect	**.40**	**.13**	**.24****	**3.00**	
Pain Expectancy	**.02**	**.00**	**.41*****	**5.16**	
AS-p	**.30**	**.09**	**.26****	**3.36**	
Pain Expectancy × AS-p	-.01	.00	-.11	-1.50	
Outcome: Dental Phobia Severity (ADIS Dental Phobia CSR)					
Model (*F* = 3.83, *p* <.001)					**.71*****
Sex	**.67**	**.29**	**.20***	**2.35**	
Negative Affect	**.68**	**.28**	**.22***	**2.43**	
Pain Expectancy	**.02**	**.01**	**.32****	**3.47**	
AS-p	.04	.18	.02	0.24	
Pain Expectancy × AS-p	-.01	.01	-.08	-1.00	

Note. Significant effects presented in bold print. MDAS = Modified Dental Anxiety Scale, AS-p = Anxiety Sensitivity physical concerns subscale, DFS = Dental Fear Survey, ADIS-IV CSR = Anxiety Disorders Interview Schedule for DSM-IV Clinician Severity Rating.
*p < .05, **p < .01, ***p < .001.

Supplemental Table 3.
Linear regression analyses predicting baseline dental procedure stress reactivity

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: State Anxiety Reactivity to Dental Films (ΔSUDS during DPFT #1)					
Model ($F = 1.89$, $p = .059$)					.11
Negative Affect	-.65	.70	-.10	-0.94	
Pain Expectancy	**.05**	**.02**	**.32****	**3.15**	
AS-p	.51	.44	.11	1.16	
Pain Expectancy × AS-p	-.01	.02	.06	-0.63	
Outcome: Parasympathetic Reactivity to Dental Films (ΔRSA during DPFT #1)					
Model ($F = 0.89$, $p = .372$)					.03
Negative Affect	-.31	3.65	-.01	-0.08	
Pain Expectancy	-.08	.09	-.09	-0.89	
AS-p	3.75	2.37	.16	1.58	
Pain Expectancy × AS-p	-.01	.11	-.01	-0.08	
Outcome: Sympathetic Reactivity to Dental Films (ΔSCL during DPFT #1)					
Model ($F = 1.59$, $p = .113$)					
Negative Affect	.02	.27	.01	0.09	
Pain Expectancy	**-.02**	**.01**	**-.30****	**-2.85**	
AS-p	.07	.18	.04	0.37	
Pain Expectancy × AS-p	.00	.01	.04	0.43	

Note. Significant effects presented in bold print. SUDS = Subjective Units of Distress Scale, DPFT = Dental Procedure Film Task, AS-p = Anxiety Sensitivity physical concerns subscale, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.
*$p < .05$, **$p < .01$.

Supplemental Table 4.
Linear regression analyses predicting post-pain expectancy induction dental anxiety

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: Change in Dental Anxiety (MDAS)					
Model (*F* = 1.60, *p* = .109)					.08
Negative Affect	-.13	.14	-.10	-0.95	
Condition (shock threat, safe)	**.29**	**.14**	**.20***	**2.09**	
AS-p	-.03	.12	-.03	-0.26	
Condition × AS-p	.27	.17	.20	1.60	
Outcome: Change in Dental Anxiety (DFS)					
Model (*F* = 1.16, *p* = .256)					.05
Negative Affect	-.02	.17	-.01	-0.08	
Condition (shock threat, safe)	.29	.18	.16	1.63	
AS-p	-.11	.15	-.10	-0.70	
Condition × AS-p	-.10	.22	-.06	-0.44	

Note. Significant effects presented in bold print. MDAS = Modified Dental Anxiety Scale, AS-p = Anxiety Sensitivity physical concerns subscale, DFS = Dental Fear Survey.
**p* < .05.

Supplemental Table 5.

Linear regression analyses predicting post-pain expectancy induction dental procedure stress reactivity

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: State Anxiety Reactivity to Dental Films (ΔSUDS during DPFT #3)					
Model (F = 1.24, p = .215)					.06
Negative Affect	.14	.70	.02	0.20	
Condition (shock threat, safe)	-.93	.75	-.13	-1.25	
AS-p	.90	.62	.19	1.45	
Condition × AS-p	.04	.91	-.01	-0.05	
Outcome: Parasympathetic Reactivity to Dental Films (ΔRSA during DPFT #3)					
Model (F = 1.23, p = .221)					.05
Negative Affect	7.19	4.17	.18	1.72	
Condition (shock threat, safe)	-2.27	4.45	-.05	-0.51	
AS-p	-6.15	3.66	-.22	-1.68	
Condition × AS-p	7.51	5.40	.18	1.39	
Outcome: Sympathetic Reactivity to Dental Films (ΔSCL during DPFT #3)					
Model (F = 0.89, p = .373)					.03
Negative Affect	-.42	.49	-.09	-0.86	
Condition (shock threat, safe)	.74	.52	.15	1.40	
AS-p	.15	.43	.05	0.36	
Condition × AS-p	-.07	.64	-.02	-0.11	

Note. SUDS = Subjective Units of Distress Scale, DPFT = Dental Procedure Film Task, AS-p = Anxiety Sensitivity physical concerns subscale, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.

Main Analyses on Log-Transformed Versions of the Physiological Indices of Dental Procedure Stress Reactivity

Supplemental Table 6.
Linear regression analyses predicting baseline log-transformed physiological indicators of dental procedure stress reactivity

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: Parasympathetic Reactivity to Dental Films (ΔRSA during DPFT #1)					
Model ($F = 0.59$, $p = .556$)					.01
Negative Affect	.00	.02	-.01	-0.11	
Pain Expectancy	.00	.00	-.08	-0.78	
AS	.02	.02	.10	0.93	
Pain Expectancy × AS	.00	.00	-.01	-0.08	
Outcome: Sympathetic Reactivity to Dental Films (ΔSCL during DPFT #1)					
Model ($F = 0.87$, $p = .382$)					.03
Negative Affect	.00	.03	.00	-0.01	
Pain Expectancy	.00	.00	-.17	-1.57	
AS	.01	.02	.07	0.67	
Pain Expectancy × AS	.00	.00	-.04	-0.40	

Note. AS = Anxiety Sensitivity, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.

Supplemental Table 7.
Linear regression analyses predicting post-pain expectancy induction log-transformed physiological indicators of dental procedure stress reactivity

Predictor	*B*	*SE B*	β	*t*	R^2
Outcome: Parasympathetic Reactivity to Dental Films (ΔRSA during DPFT #3)					
Model (F = .94, p = .346)					.03
Negative Affect	.03	.03	.14	1.22	
Condition (shock threat, safe)	.00	.00	.08	0.75	
AS	-.01	.02	-.08	-0.78	
Condition × AS	.00	.00	-.06	-0.55	
Outcome: Sympathetic Reactivity to Dental Films (ΔSCL during DPFT #3)					
Model (F = 0.58, p = .560)					.01
Negative Affect	-.01	.05	-.02	-0.17	
Condition (shock threat, safe)	.00	.00	-.10	-0.91	
AS	.02	.04	.05	0.50	
Condition × AS	.00	.00	.03	0.30	

Note. AS = Anxiety Sensitivity, RSA = Respiratory Sinus Arrhythmia, SCL = Skin Conductance Level.