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The cognitive processing of somatic anxiety: Using functional measurement to understand and address the fear of pain

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Although anxiety has both dispositional and situational determinants, little is known about how individuals' anxiety-related sensitivities and their expectations about stressful events combine to determine anxiety. This research used Information Integration Theory and Functional Measurement to assess how participants' anxiety sensitivity and event expectancy are cognitively integrated to determine their anxiety about physical pain. Two studies were conducted—one with university students and one with anxiety clinic patients—in which participants were presented with multiple scenarios of a physically painful event, each representing a different degree of event probability, from which subjective expectancies were derived. Independent variables included anxiety sensitivity (low, moderate, high) and event expectancy (low, medium, high, no probability information). Participants were asked to indicate their anxiety (dependent measure) in each expectancy condition in this 3 X 4 mixed, quasi-experimental design. The results of both studies strongly suggest that anxiety sensitivity and event expectancy are integrated additively to produce somatic anxiety. Additional results and their implications for the treatment of anxiety-related disorders are also discussed.

Virtually everyone experiences anxiety, as well as the psychological, physical, and behavioral problems it can cause. Beyond the difficulties that anxiety causes for most people, there are millions for whom these effects are especially debilitating. Approximately 8% of Americans (roughly 32 million people) suffer from at least one anxiety disorder (Kessler, Chiu, Demler, & Walters, 2005), at a combined annual cost of more than $42 billion each year (Anxiety Disorders Association of America, 1999).

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Among the most prominent sources of anxiety is the anticipation of pain or other somatic discomfort. Like pain itself, the fear of pain is an important issue in psychological research, with significant implications for both mental and physical health. Pain anxiety can increase other forms of psychological and physical distress (Bradley, Silakowski, & Lang, 2007; Craig, 1994), cognitive impairment (McNally, 1996), and physical dysfunction (Strahl, Kleinknecht, & Dinnel, 2000), as well as actual physical pain (Turk, Robinson, & Burwinkle, 2004; Asmundson & Taylor, 1996). These effects are often independent of initial pain levels, and they can lead to even greater pain-related anxiety (Litt, 1996).

The fear of pain or discomfort can also lead people to avoid important health behaviors such as physical activity, healthcare treatment, and medical adherence (Asmundson, Norton, & Norton, 1999; Vlaeyen & Linton, 2000).[1] Pain anxiety can also have adverse, long-term effects on an individual's interactions with their family, friends, and romantic partners (Gruber, Fegg, Buchmann, Kolb, & Hiddemann, 2003; Smith, Gomm, & Dickens, 2003; Strahl et al., 2000).

As with all psychological responses, pain anxiety is influenced by characteristics of both the individual and the pain-related situation (or, more precisely, the individual's *perception* of this situation). It is clear that some individuals are more prone to pain anxiety than are others (e.g., Asmundson, Norton, & Veloso, 1999; Klepac, Dowling, & Hauge, 1982; Rapee & Medoro, 1994), and that many painful situations are anxiety-producing for most people (Van Balen & Verdurmen, 1999).

Measuring Dispositions and Perceptions. Pain and anxiety have been empirically associated with a number of dispositions, including optimism (Brenes, Rapp, Rejeski, & Miller, 2002), introversion (Trygg, Lundberg, Rosenlunch, Timpka, & Gerdle, 2002), neuroticism (Costa, Fleg, McCrae, & Lakatta, 1982), and hostility (Ondersma, Lumley, Corlis, Tojek, & Tolia, 1997). A particularly promising dispositional construct linked to both pain and anxiety is an individual's *sensitivity* to anxiety.

General anxiety sensitivity (AS; Reiss, 1991; Reiss, Peterson, Gursky, & McNally, 1986) is a significant predictor of pain anxiety (Asmundson et al., 1999; Asmundson & Taylor, 1996), independent of other factors such as trait anxiety and pain symptoms (Muris, Vlaeyen, & Meesters, 2001). The more specific concept of pain-anxiety sensitivity (PAS) was developed to

[1] Although "fear" is often distinguished from "anxiety" in terms of source specificity, the terms are used synonymously in the current context.

examine the fear of anxiety-related reactions to painful events (McCracken, Zayfert, & Gross, 1992). Not surprisingly, PAS is also significantly related to pain anxiety; in fact, it is a stronger predictor of pain anxiety than actual pain severity (Asmundson & Norton, 1995; Asmundson, Norton, & Veloso, 1999; Zvolensky, Goodie, McNeil, Sperry, & Sorrell, 2001).

Anxiety is also influenced by individuals' perceptions of potentially painful situations (Phillips & Endler, 1982), among the most important of which is one's expected likelihood of these events (Lovibond & Chan, 1990). Event-related expectancy not only predicts subsequent pain (Logan & Rose, 2005), but it is also one of the most consistent predictors of anxiety, whether manipulated or measured through self-report (Lovibond & Chan, 1990; Paterson & Neufeld, 1989). Prior exposure to a particular painful event is not required to create this expectancy, nor to generate pain anxiety (Fisher, Hauck, & Fenwick, 2006; Rhudy & Meagher, 2003), which can be even more aversive than the painful event itself (Arntz, Van Eck, & Heijmans, 1990). It is clear that anxiety sensitivity and pain expectancy can have significant (and simultaneous) effects. However, we know relatively little about how they are cognitively integrated to determine pain-related anxiety.

Combining Sensitivity and Expectancy. A number of studies have simultaneously examined sensitivity and expectancy across a number of fear-related responses, including claustrophobic behavior (Valentiner, Telch, Ilai, & Hehmsoth, 1993), fear and avoidance of snakes (Schoenberger, Kirsch & Rosengard, 1991), and panic attacks (Harrington, Schmidt & Telch, 1996). These studies hypothesize that sensitivity and expectancy are integrated multiplicatively, positing that greater sensitivity increases the psychological impact of event expectancy. This hypothesis was examined in these studies by testing the significance of the sensitivity-by-expectancy interaction term, with the expectation that greater sensitivity will strengthen the relationship between fear expectancies and the fear-related outcomes.

The results of this research—within and between studies—have been mixed. Some interaction effects were marginal (Schoenberger, Kirsch & Rosengard, 1991), while others were significant for avoidance behavior but not for self-reported anxiety (Valentiner et al., 1993), and still others were significant in the opposite direction (i.e., higher expectancy led to *less* panic among high-AS participants) (Harrington, Schmidt & Telch, 1996).

Cognitive Integration Rules. While these results do not consistently support the moderating effects predicted for sensitivity and expectancy, neither do they preclude a multiplicative integration rule. For although they are very useful for qualifying main effects, a significant interaction term alone does not necessarily indicate a multiplicative cognitive process. For example, it may simply reflect differential subjective weights within a factor (e.g., if moderate expectancy causes proportionately greater anxiety than low expectancy), even when a non-multiplicative model is operative (Moore & Gump, 1995).

Thus, while anxiety-related sensitivity and expectancies may *multiply* each others' effects on pain anxiety, there are at least two other ways in which sensitivity and expectancy may combine to determine people's anxiety-related responses. First, an *additive* rule may be operative, whereby expectancy information increases (or decreases) pain anxiety equally, regardless of participants' anxiety-related sensitivity. Alternatively, people may use an *averaging* process, whereby the same expectancy that decreases pain anxiety among highly sensitive individuals may actually increase it among those with lower anxiety sensitivity. It is also possible that the cognitive integration of sensitivity and expectancy differs across populations; for example, between the general population and those suffering from anxiety disorders. Of course, it is also possible that a readily discernable integration rule determining anxiety may simply not emerge.

Identifying the cognitive integration process for anxiety, including pain anxiety, has profound implications for both our understanding and treatment of the problems it often creates. For example, if those with anxiety disorders integrate sensitivity and expectancy differently than the general population, these differential integration rules may determine the development of these conditions.

As for treatment, if anxiety is a *multiple* of sensitivity and expectancy, reducing either component to near zero should dramatically decrease or even eliminate it. On the other hand, if sensitivity and expectancy are *added* to produce pain anxiety, treatments would need to reduce both components to be maximally effective. Finally, an *averaging* rule would indicate a need for therapy to generate expectancies that are lower than an individual's respective anxiety sensitivity (or vice-versa) to reduce their pain anxiety.

Information Integration Theory. Information Integration Theory (IIT; Anderson, 1981; Anderson, 1996) was developed to identify such cognitive integration rules, as well as observable outcomes that reflect

implicit responses to the information being integrated. Often associated exclusively with cognition, information integration analysis—known as *functional measurement*—can also be used to examine emotional responses and their behavioral counterparts (Klitzner & Anderson, 1977). In this context, cognition, emotion and behavior are all considered organic elements of the same overall response.

Information integration can also be used to investigate the role of dispositional characteristics in a variety of judgments (Kaplan, 1971a,b). Dispositions can be viewed as knowledge systems for dealing with one's environment, as they reflect relatively stable integrations of perception and experience. Recent research has identified how general anxiety sensitivity (AS) and event expectancy are cognitively integrated to produce anxiety among both normal adults and clinical anxiety patients (Chung et al., 2005; Moore et al., 2009). This research has consistently found that general anxiety sensitivity (AS) and event expectancy are integrated additively to determine anxiety (including pain anxiety) among both general and anxiety-clinic populations. Similar research, however, has yet to be conducted with more specific sensitivity to pain anxiety.

The Current Research. The current research was conducted to assess whether pain anxiety sensitivity (PAS) operates similarly to general AS in the development of pain anxiety. Because both are measures of sensitivity, they might be expected to be processed in the same way. On the other hand, more focused sensitivity may increase the impact of pain-related information on anxiety, perhaps by changing the nature of their integration. In addition, prior factor analyses have distinguished them as separate constructs (Taylor & Fedoroff, 1999), and different cognitive integration rules have previously been found within measurement categories, such as the integration of adjectives influencing person perceptions (Anderson, 1996).

Two studies were conducted to assess whether pain anxiety sensitivity and event expectancy are cognitively integrated to determine pain anxiety. These studies involved adults from both general and anxiety clinic populations, and were designed to address the following questions: First, how are pain anxiety sensitivity and event expectancy cognitively integrated to determine pain-related anxiety? Second, do clinical anxiety patients integrate PAS and event expectancy differently than those in the general population?

STUDY 1
METHOD

Participants. Participants were 76 George Washington University undergraduates who participated in partial fulfillment of psychology course requirements. Participants (47 females, 29 males, mean age = 19.39 years, SD = 1.10) included 46 Caucasians, 7 African Americans, 4 Hispanics, 13 Asians, and 6 participants from other ethnic backgrounds. No participants reported relevant prior or current pain experiences.

Procedure. Participants were brought into the laboratory in groups of up to six individuals. Upon being seated, they were informed that they would be participating in a study about their perceptions and reactions to potentially stressful situations. Participants were then presented with multiple situations, all of which were based on the following core scenario:

> *You are at a medical clinic awaiting a physical examination required by your health insurance carrier. Because of repeated delays, this is the last opportunity for you take the physical before your policy expires. This examination includes having your blood drawn to determine your red and white blood cell counts, as well as your iron and serum cholesterol levels. The blood is drawn by medical technicians, who usually take it from a vein at the base of the forearm, opposite the elbow. Almost all of the technicians associated with this clinic are highly skilled, experienced professionals. However, the newest technician has yet to master the technique of drawing blood. As a result, he typically misses the vein on the first attempt, requiring him to move the needle around inside the arm, and often necessitating repeated insertions. Having blood drawn in this manner is extremely painful, including a sharp pain when the needle punctures the skin, and even more intense pain as the needle is angled inside the arm in search of a vein. In addition to being extremely painful, this procedure often results in temporary nerve damage causing, for up to two weeks, a continuous burning sensation, much like having a burning match under your arm.*

Participants were asked to respond to each scenario as if they were in the situation described. After these responses (described later) were recorded, participants' pain anxiety sensitivity was assessed, and their demographic information was obtained. Upon completing the study, participants were debriefed and thanked for their participation.

Independent Variables. *Pain anxiety sensitivity* (PAS) was assessed using 14 items designed to measure of the fear of anxiety-related reactions to painful events (see Appendix). These items come from the 40-item Pain Anxiety Symptoms Scale (PASS; McCracken, Zayfert, et al., 1992), which has demonstrated comparably high internal consistency, with Cronbach alphas ranging from 0.74 to 0.94 (McCracken and Dhingra, 2002; McCracken & Gross, 1995). The PASS measures three aspects of pain anxiety, including anxiety symptoms, physiological reactions, and appraisal (i.e., sensitivity). The current PAS index used in this research is comprised of items from the latter category, with a Cronbach's alpha in the current study was 0.76.

The current PAS items asked participants to respond to statements about their psychological appraisal of pain (e.g., "When I'm in pain, I worry that it will never decrease") by indicating the extent to which each statement accurately portrayed their own experience, from 0 (*very little)* to 4 *(very much).* Item responses for each participant were then summed to create their overall PAS score. Although anxiety sensitivity and anxiety are highly-correlated and overlapping constructs, the distinction is important for both scientific and practical reasons. As a relatively stable and significant determinant of pain anxiety, PAS may be crucial to identify and assess—both individually and in combination with other factors—to effectively understand and treat this condition.

The mean PAS score across all participants in the current research was 29.20 (*SD* = 10.03, range = 10.00 to 56.00). Overall PAS scores were trichotomized to establish three ordinal levels of pain anxiety sensitivity. Participants with relatively low (*n* = 26), medium (*n* = 24), and high PAS (*n* = 26) comprised the three levels of the between-subject factor in the current research design. The mean PAS score for each group was, respectively, 18.92 (*SD* = 4.13), 28.46 (*SD* = 2.50), and 40.15 (*SD* = 6.62).

Objective Event Probability was manipulated within-subjects through the use of different event scenarios. Similar scenarios have been used effectively in previous studies of pain anxiety (Chung et al., 2005). Participants were first asked to respond to the core scenario alone (i.e., without a specified probability), after which they were presented with three separate probability descriptions for the painful event detailed in the core scenario. In pilot research using likelihoods from 1 to 100, probabilities above 10% produced near-maximum anxiety ratings, so that higher event probabilities yielded almost no variability. Given this ceiling effect, event probabilities of 1%, 2%, and 10% were used in this research.

In the lowest event probability condition (1%), participants were presented with the following description:

> *Almost all of the one hundred technicians associated with this clinic are highly skilled, experienced professionals. Because there is only one technician currently on duty, the odds of having your blood drawn by the new technician is one out of one hundred, or 1%.*

The intermediate expectancy condition (2%) consisted of the following statement:

> *Almost all of the fifty technicians associated with this clinic are highly skilled, experienced professionals. Because there is only one technician currently on duty, the odds of having your blood drawn by the new technician is one out of fifty, or 2%.*

In the highest event probability condition (10%), participants were presented with the following description:

> *Almost all of the ten technicians associated with this clinic are highly skilled, experienced professionals. Because there is only one technician currently on duty, the odds of having your blood drawn by the new technician is one out of ten, or 10%.*

Each probability condition was presented on a separate page, and the order of the presentation of the probability conditions was randomized for each participant. Participants were instructed to take as much time as they needed to respond to each situation, to consider the scenarios in the order they were presented, and not to return to previous responses.

Subjective event expectancy was measured to determine how well specified event probabilities were reflected in participants' subjective probability estimates. Participants were asked in each condition to indicate what they felt their particular chances would be—on a scale from 0 to 100%—of getting their blood drawn by the unskilled technician. The average subjective event expectancy across all probability conditions (including the no-probability information condition) was 22.49 (SD = 19.72, range = 0 to 75), and the means for low, medium, and high expectancy were 11.93 (SD = 11.93), 19.17 (SD = 30.13), and 22.88 (SD = 27.15), respectively. The mean expectancy for the no-information condition was 35.99 (SD = 33.35).

Expectancies across low-probability conditions were significantly lower than those in medium probability conditions ($t(75)=3.37$, $p < .001$), which were not significantly different than high-probability expectancies ($p > .31$). Subjective expectancies were significantly higher when participants

were given no probability information than in any of the other objective probability conditions (*ps* < .01).

Dependent Variable. Prospective anxiety was assessed after each scenario by having participants indicate how anxious they would feel at that moment in that situation, using an anxiety analog scale from 0 ("*not at all anxious")* to 50 ("*extremely anxious")*. Given the anticipatory nature of anxiety, it is often assessed in response to prospective stressful events (e.g., Artnz, Van de Hout, Van den Berg, & Meijboom, 1991; Cipher & Fernandez, 1997; Schoenberger, 1999). For example, anxiety analog scales have been successfully used in past research to capture subjective discomfort prior to, and immediately following actual or imagined exposure to fear-related stimuli (Nietzel & Bernstein, 1981; Scott & Cadden, 1996; Walk, 1956; Wolpe & Lazarus, 1966).

Data Analysis. After summary statistics were computed, analyses were conducted to test for a discernable cognitive integration rule. In accordance with functional measurement (FM) procedures, an initial factorial graph was created with participants' anxiety responses (0–50) on the ordinal, and their pain anxiety sensitivity (low, moderate, high) on the abscissa. The mean anxiety responses for the nine conditions containing both PAS and event expectancy information (low, medium, high) were then plotted on this graph.

Cognitive Integration Rules. If sensitivity *multiplies* the effect of expectancy on pain anxiety, the lines representing each of these expectancy levels should be closest when PAS is low, and increasingly divergent as PAS increases. If this pattern emerges, the statistical interaction term in a mixed-design Analysis of Variance (ANOVA) is then examined to confirm the significance of this divergence. As demonstrated by the *linear fan theorem* contained in IIT, these results would indicate 1) that participants' observed responses are a linear scale of their internal responses, and 2) that the operative cognitive integration rule is multiplicative (Anderson, 1981).

On the other hand, if pain anxiety is a *general additive* function of PAS and event expectancy, then the lines representing low, medium and high expectancy should form a series of parallel curves, with a corresponding non-significant statistical interaction term. As indicated by IIT's *parallelism theorem* (Anderson, 1981), such observed parallelism provides strong evidence for both response linearity and an adding-type model. However, because both adding and averaging models are

fundamentally additive, such initial parallelism alone cannot distinguish between them.

To determine which of these models is operative, a critical test is needed in which conditions reflecting PAS alone (i.e., those without probability information) are added to the factorial plot. The critical comparison is between this curve and the one combining anxiety sensitivity with medium event expectancy.

A straight *adding* rule—whereby the effect of pain anxiety sensitivity is simply added to each level of expectancy—predicts that these lines will not intersect. If medium expectancy is anxiety producing (relative to no probability information), adding it would raise anxiety responses to all three levels of sensitivity. If medium expectancy is anxiety-reducing, it would lower each of these responses. Either way, an adding integration rule requires that each line lie entirely on one side of the other.

By contrast, the *averaging* hypothesis predicts that these lines will cross. For if medium expectancy is averaged with low sensitivity, the resulting pain anxiety should be higher than that for low PAS alone (i.e., with no given expectancy information), whereas when medium expectancy is averaged with high sensitivity, pain anxiety should be lower.

RESULTS

Anxiety Ratings. Across all participants and expectancy conditions, the average pain anxiety rating was 26.37 (SD = 13.95) out of a possible 50. Mean anxiety ratings for participants with low, medium, and high PAS were 20.39 (SD = 13.57), 23.24 (SD = 13.28), and 35.23 (SD = 10.44), respectively. Overall, greater PAS was associated with higher pain anxiety ($F(2, 73) = 10.28$, $p < .001$). Although there was no significant difference between those with low and those with moderate PAS ($p = .46$), participants with high PAS were significantly more anxious than those with medium PAS ($F(1, 49) = 12.70$, $p = .001$).

Pain anxiety responses to low, medium, and high event expectancies were 18.74 (SD = 16.29), 22.64 (SD = 16.56), and 28.97 (SD = 15.55), respectively. The mean anxiety for the no probability information provided conditions was 35.12 (SD =13.87). Overall, greater event expectancy was associated with higher pain anxiety ($F(3,71) = 31.09$, $p < .001$). Medium expectancy created significantly more anxiety than low expectancy ($F(1,73) = 23.64$, $p < .001$), and significantly less than high expectancy ($F(1,73) = 33.17$, $p < .001$). No probability information generated significantly greater anxiety than the high expectancy condition ($F(1,73) = 27.3$, $p < .001$).

Multiplication Rule Test. The factorial plot, as shown in Figure 1, suggests a systematic integration of PAS and event expectancy. However, instead of a linear-fan pattern, which would indicate a multiplicative rule, the curves in the factorial plot appear to be parallel. This parallelism was confirmed by a nonsignificant sensitivity-by-expectancy interaction ($p >$ .36). Thus, a critical test was conducted to determine whether an adding or averaging rule was operative.

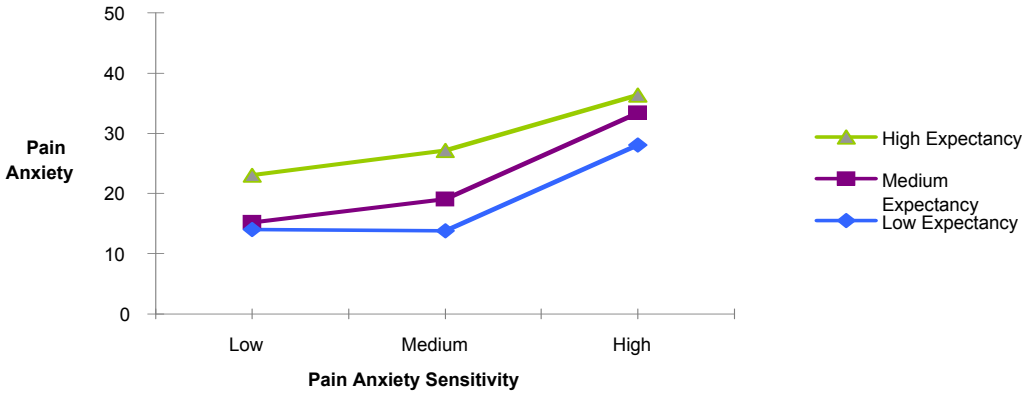

Figure 1. Factorial plot for anxiety as a function of pain anxiety sensitivity and event expectancy – Study 1.

Adding vs. Averaging. When the no-probability information curve was added to the factorial plot (see Figure 2), it led to higher pain anxiety than medium expectancy across all levels of PAS, indicating that the addition of medium expectancy (relative to no-probability information) lowered anxiety responses, and providing strong support for a straight adding model.

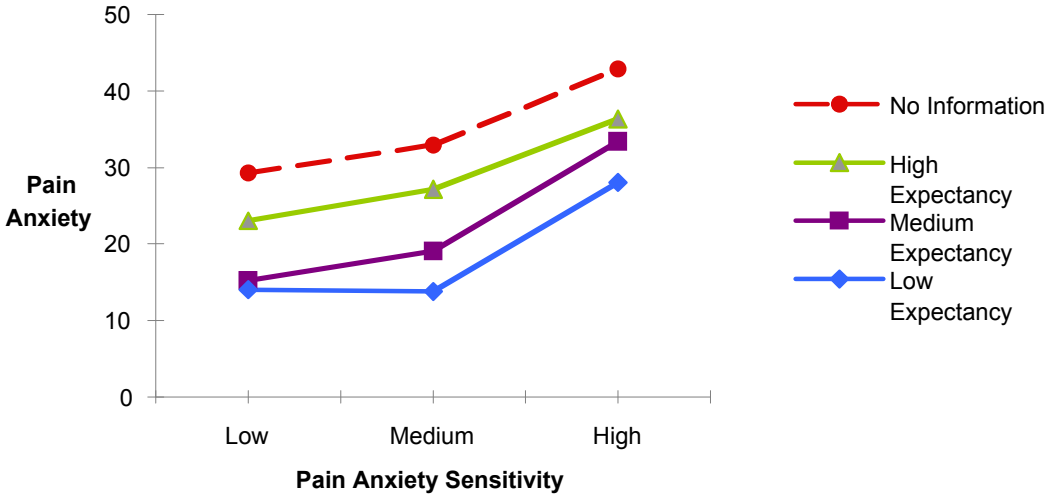

Figure 2. Critical test between adding and averaging models of pain anxiety

DISCUSSION

In this study, pain anxiety sensitivity and event expectancy were added—rather than multiplied or averaged—to produce anxiety in response to a physically painful event. These results suggest that sensitivity in this context increases pain anxiety directly, rather than by intensifying the impact of event expectancy. In addition, there was no difference in pain anxiety between low and moderate PAS levels, suggesting that relatively high pain anxiety sensitivity may be necessary to increase pain anxiety in the general population.

Higher event expectancy also led to greater anxiety, with each expectancy level generating significantly more anxiety than the level below it. Although participants' expectancies strongly reflected objective probabilities, these subjective expectancies were consistently higher than the actual event probabilities. This may help explain the ceiling effect for anxiety found in our pilot studies, as even low objective probabilities led to relatively high subjective expectancies.

These results support an additive model of pain anxiety among healthy, university undergraduates. However, it is yet unknown if such an integration generalizes to other populations, particularly those with anxiety

disorders. If the additive integration of PAS and event expectancy is consistent across both healthy and clinically anxious populations, it would support the generalizability of the integration rule for pain anxiety. To address this question, a second study was conducted to assess how PAS and event expectancy are integrated to determine pain anxiety among a sample of anxiety clinic patients.

STUDY 2
METHOD

Participants. Participants were 28 patients receiving treatment for one or more anxiety disorders at the Centers for Addiction and Mental Health in Toronto, Canada. These participants averaged 42.9 years of age (SD=13.4 years), and 64% were female. The majority (54%) of participants were Caucasian, 13% were Asian, and 43% were from other ethnic backgrounds. All participants exhibited severe anxiety symptoms, and received a complete psychiatric assessment as well as the Mini-International Neuropsychiatric Interview (MINI). The MINI is a short, structured, valid, and reliable diagnostic interview, developed by psychiatric clinicians in the United States and Europe, for DSM-IV and ICD-10 psychiatric disorders (Sheehan et al., 1998).

Table 1. Descriptive Statistics for Primary Diagnoses of Clinical Anxiety Patient

Primary Diagnosis*	Number	Percentage
Bipolar disorder	2	7.7
Generalized anxiety disorder	5	19.2
Manic-depressive disorder	3	11.5
Obsessive-compulsive disorder	4	15.4
Panic disorder	9	34.6
Post-traumatic stress disorder	1	3.8
Social phobia	2	7.7

*Total percentage does not equal 100 due to rounding.

Procedure. After the initial psychiatric consultation, prospective participants were approached by the consulting physician and asked if they would be interested in participating in a study of people's responses to various stressful situations. All patients who were asked agreed to participate in this research (patients with histories or current symptoms of psychosis were not approached for participation). After giving their informed consent, participants were led to a private room where they were presented with the study packet, which was administered individually (i.e., not in groups) in the same manner as in Study 1. Upon completing the study, participants were debriefed and thanked for their participation.

Variables. The mean PAS score across all participants was 30.15 (*SD* = 9.78, range = 9 to 45). Participants with low (*n* = 8), moderate (*n* = 10), and high PAS (*n* = 8) had mean PAS scores of 19.0 (*SD* = 6.02), 32.33 (*SD* = 2.78), and 40.25 (*SD* = 3.01), respectively.

Event Probability. Low, medium and high event probabilities were identical to those in Study 1 (1%, 2%, and 10%, respectively), and were also presented in random order (after the core scenario) to each participant.

Subjective Expectancy. As in Study 1, participants were asked to indicate how likely they thought it would be that they would get their blood drawn by the unskilled technician in each probability condition. In three cases, different objective event probabilities were associated with the same subjective expectancy ratings, while the remaining participant expectancy ratings corresponded to the order of the given event probabilities. The average subjective event expectancy across all probability conditions (including the no probability information condition) was 29.99 (*SD* = 23.05, range = 0 to 100). The means for low, medium, and high expectancy were 19.11 (*SD* = 25.07), 29.99 (*SD* = 23.05), and 38.57 (*SD* = 30.15), respectively. The mean expectancy for the no probability information condition was 40.00 (*SD* = 26.94).

There was a significant overall effect for subjective expectancy rating ($F = 12.05$, $p < .001$). Low subjective expectancy was marginally lower than medium expectancy ($p=.05$), which was significantly lower than high expectancy ($p < .001$). Subjective expectancy ratings for high expectancy was not significantly different than those for the no-information condition ($p>.94$).

Anxiety. As with the other study variables, anxiety in this study was assessed the same way as in Study 1.

RESULTS

Anxiety Ratings. The mean prospective pain anxiety rating across all participants and expectancy conditions was 31.90 (*SD* = 14.96) out of a possible 50. Mean anxiety ratings for participants with low, medium, and high PAS were 30.78 (*SD* = 9.98), 32.80 (*SD* = 11.03), and 31.47 (*SD* = 24.55), respectively. In this study, higher PAS was not associated with greater pain anxiety ($p = .964$).

Mean pain anxiety responses to low, medium, and high event expectancies were 24.46 (*SD* = 19.78), 25.32 (*SD* = 18.14), and 34.64 (*SD* = 16.55), respectively. The mean pain anxiety response to the no probability information condition was 43.21 (*SD* = 19.01). The low expectancy and medium expectancy conditions did not significantly differ in anxiety ($p > .56$), but medium expectancy created significantly less anxiety than high expectancy ($F(1,23) = 19.95$, $p < .001$). The no probability information condition generated significantly greater anxiety than the high expectancy condition ($F(1,23) = 4.99$, $p < .05$).

Multiplication Rule Test. As in Study 1, the factorial plot appears to exhibit parallelism (see Figure 3), which is again confirmed by non-significant sensitivity-by-expectancy interaction ($p > .76$). Thus, a critical test was again performed to determine whether an adding or averaging model was in operative.

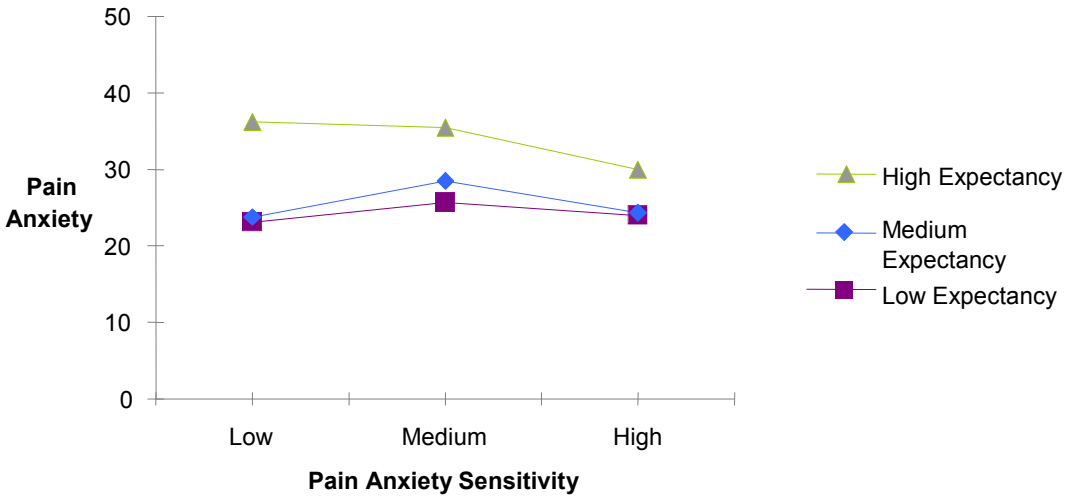

Figure 3. Factorial plot for pain anxiety as a function of pain anxiety sensitivity and event expectancy – Study 2.

Adding or Averaging? The results of the critical test again support an adding model. When the no probability information condition was added to the factorial plot and compared to the medium expectancy condition, as shown in Figure 4, the medium expectancy condition lowered anxiety across all levels of PAS, again strongly supporting a straight adding integration model.

DISCUSSION

In this study, PAS and event expectancy were integrated additively to produce anxiety in response to a potentially painful event. Consistent with Study 1, these results indicate that, for both clinical anxiety patients and non-anxious young adults, pain anxiety sensitivity did not influence the impact of event expectancy on individuals' anxiety about a painful event.

Unlike in Study 1, pain anxiety sensitivity in this study was not associated with participants' pain anxiety. This was likely due to much greater variability in anxiety among the undergraduates than among the anxiety clinic patients in this research. Specifically, while the clinic patients reported higher average anxiety than the college students (31.9 and

26.4, respectively), the range in anxiety among the clinical was less than one-seventh of that among the college sample (2.0 and 14.8, respectively). This further reflects the fact that while the clinical participants were more anxious on average than the undergraduates, many of the most anxious students reported as much anxiety as the most anxious clinical patients.

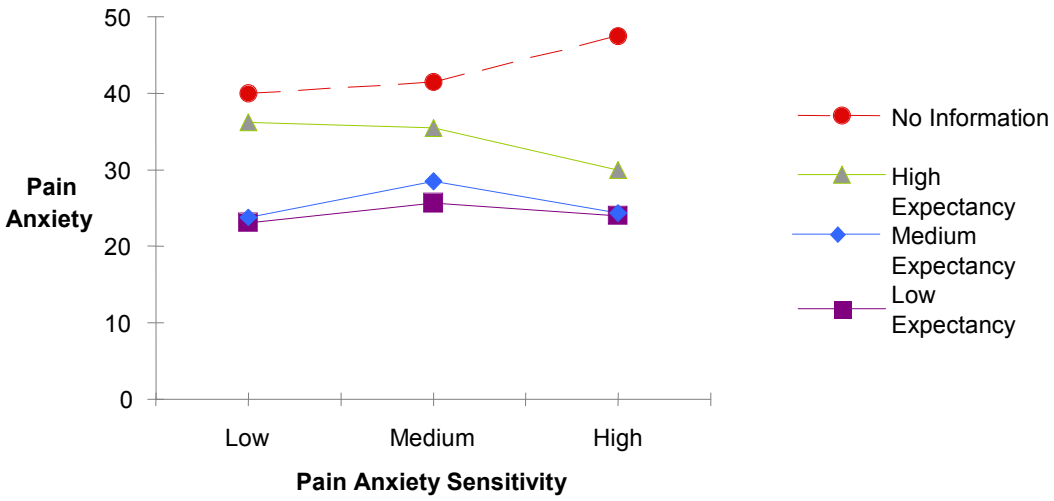

Figure 4. Critical test between adding and averaging models of pain anxiety – Study 2.

GENERAL DISCUSSION

The two current studies provide strong and consistent answers to the primary research questions: First, pain anxiety sensitivity and event expectancy were cognitively integrated in an additive fashion to determine participants' anxiety in response to a painful event. Second, this additive cognitive integration rule was used by both undergraduate and anxiety clinic populations.

These findings are also consistent with previous research demonstrating an additive integration rule for general anxiety sensitivity and event expectancy in determining anxiety related to pain (Chung et al., 2005) and social embarrassment (Moore et al., 2009). As in the present

study, this additive cognitive model was operative for both student and clinical samples.

Taken together, these results provide compelling evidence that anxiety sensitivity—rather than multiplying the effects of expectancy—is cognitively *added* to expectancy to determine anxiety in response to stressful situations. Thus, while anxiety sensitivity is strongly associated with panic attacks and other anxiety-related disorders, it does not appear to change the way information about event likelihood is perceived or processed. Instead, these findings suggest a threshold effect, in which people with greater AS also carry higher basal levels of anxiety. In turn, when faced with potentially stressful situations, these people—even though they experience anxiety increases comparable to those with lower AS—are more likely to reach threshold for anxiety-related problems.

Cognitive additivity may also explain why many people who know that the actual likelihood of harm from certain situations (e.g., air travel, injections, rollercoasters) is virtually zero, are nonetheless very anxious about engaging in these activities. Therapeutically, these results suggest the need for interventions to address both anxiety sensitivity and event expectancy (and perhaps other event-related perceptions) to maximize treatment effectiveness.

Interestingly, anxiety sensitivity was not associated with anxiety among anxiety clinic patients in the current research. While reflecting a ceiling effect for anxiety among clinical patients, this result also illustrates an important methodological difference between functional measurement and previous research designed principally to assess main effects and/or interaction terms. Because the primary interest in FM is the factorial pattern, the test of parallelism does not require statistically significant main effects, but merely separation (and parallelism) of the factorial curves (with parallelism confirmed by a non-significant interaction).

Although small main effects can make otherwise significant interactions harder to detect (and the test for parallelism less conservative), we are confident that the current results reflect actual parallelism for at least two reasons. First, previous research using the same methodology has consistently found the same pattern of additivity across populations and sources of anxiety. Second, just as small main effects reduce the statistical power of the parallelism test, so too is this power increased by larger samples sizes (as in Study 1) and within-subjects factors (which are included in all studies using this methodology).

Given that the interest in functional measurement is the factorial pattern as a whole, another way to assess an additive (or other) cognitive

integration rule vis-a-vis Type I error would be to compute the chance likelihood of observing the overall pattern (i.e., relative positions) of factorial means associated with that rule. This probability would be equal to the ratio of qualifying patterns (k) to the total number of possible patterns (N). In the case of parallelism with a particular order of factorial curves (low, medium, high) in the current 3 X 3 matrix, k is equal to 1 and N is equal to 9! (resulting in a p-value of 1/9!, or .000003), for if any one of the nine means in the current design is out of position relative to the others, this particular pattern will not be observed.[2] Thus, in terms of possible permutations of factorial means, observed parallelism is itself a statistically significant event.

A clear limitation of the current research involves the scenario-based nature of the design. Obviously, the embedding method in functional measurement (presenting scenarios with multiple probabilities) cannot mimic stressful events in their entirety. As Hommers & Anderson (1990) point out, "some loss of realism is inevitable even with the embedding method" (p. 130). On the other hand, because it is not a particular outcome level but rather the cognitive process that is being studied, observed models of integration are assumed to be generalizable to the situations described. "The integration rule," Hommers and Anderson note, "may thus be expected to have reasonable generality, even though the specific information being integrated may differ markedly across cases" (p.130). This generality is further supported by essential identical findings in similar previous research across age, populations, settings, and types of anxiety (Chung et al., 2005; Moore et al., 2009).

Because participants' pain histories were not assessed, we cannot necessarily apply the current findings to clinical pain patients or individuals suffering from chronic pain. However, given the pain/anxiety co-morbidity and process generality noted earlier, we would expect similar additive cognitive integration of sensitivity and expectancy among those suffering from chronic physical pain. Future research using functional measurement with this population could assess how personality and perception combine to determine not only anxiety, but also pain (and other related outcomes).

As with other forms of anxiety, pain anxiety has many significant, often devastating effects on the health and well-being of individuals, their families and others who know and/or depend on them. These effects also represent a tremendous drain on increasingly scarce personal and public resources. While it has long been known that anxiety is a function of both

[2] A more general expression of this ratio for parallelism would be q!/N, where q is the number of curves whose order is free to vary.

individuals and their situations, recent research—including the current findings—provide important insight into the nature of that function. Further, additive integration of sensitivity and expectancy argues for target treatment for individuals whose dysfunctional anxiety is due to high sensitivity alone (e.g., conditioning therapy), high expectancy alone (e.g., cognitive-framing therapy), or both (e.g., combination therapy).

Given their profound personal, social and economic costs, it is crucial that we continue to improve our understanding and treatment of anxiety-related conditions and their determinants. Learning how people process and respond to stressful information is an important part of this effort, for this knowledge will enable future research and interventions to more effectively address this pervasive and widespread healthcare challenge.

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