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Development of the Pain Responses Scale: A measure informed by the BIS-BAS model of pain

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Abstract

Background: The behavioural inhibition system and activation system (BIS-BAS) model of pain focusses on two clusters of responses to pain—escape/avoidance (BIS) and approach (BAS) behaviours. While the BIS-BAS model emphasizes *active* responses to pain, *deactivation* responses such as despondence and relaxation are also common. This study sought to develop self-report scales assessing cognitive, behavioural intentions and affective responses to pain consistent with this extended BIS-BAS framework. We also sought to develop short-forms of the emerging scales.

Methods: Confirmatory factor analysis was performed to derive scales from a large item pool administered to a community sample with heterogeneous chronic pain ($N = 476$).

Results: The items resulted in 16 scales assessing Thoughts, Affective responses, Behavioural Intentions and Valence-Associated Thoughts, which loaded on to the four theorized types of pain responses—Escape, Approach, Despondence and Relaxation—with the four emerging short-form scales assessing these overarching factors. The internal consistency reliabilities of the long-forms generally ranged from good to excellent ($\alpha s \geq 0.83$), with the exception of the Relaxation-Behavioural Intentions scale ($\alpha = 0.64$). The four short-forms demonstrated at least adequate internal consistency reliability ($\alpha s \geq 0.79$). An initial test of the construct validity of the scales in relation to pain-related outcomes is also reported.

Conclusions: We anticipate that the Pain Responses Scale (PRS) developed from this research will be useful for assessing mechanisms targeted by many psychosocial pain treatments and will provide a nuanced understanding of the shared versus specific nature of these mechanisms.

Significance: The Pain Responses Scale emerging from this research assesses four theorized, overarching responses to pain: Escape, Approach, Giving Up and Relaxation. This measure will afford the capacity to test a reconceptualized BIS-BAS model of pain and inform treatments that are adapted based on this framework.

1 | INTRODUCTION

Informed by Gray's Behavioural Inhibition System and Behavioural Activation System (BIS-BAS) model of anxiety (Gray, 1982, 1987, 1990), we have recently proposed a BIS-BAS model of pain which hypothesized that BIS- and BAS-related mechanism clusters underlie a person's tendency to engage in avoid/escape and approach behaviours, respectively, in response to pain (Jensen et al., 2016). The BIS and BAS (represented by system-related cognitions, emotions and behavioural intentions [i.e., precursors to the behaviour]) are engaged when an individual actively *does* something (i.e., avoid or approach) in response to pain. However, because daily activity is interspersed with periods of inactivity, a model that focusses only on active responses is incomplete.

Research has shown the affect domains included in the BIS-BAS model of pain lie along two orthogonal continuums as part of a circumplex based on their valence (negative-positive) and degree of (de)activation (activation-deactivation) (Posner et al., 2005; Russell, 1980). Integrating this framework with a BIS-BAS affective, belief and behavioural perspective results in a model (Figure 1) with four domain clusters: (1) a negative valence-activation domain characterized by *escape/avoidance*-oriented thoughts, behavioural intentions and affective responses (BIS); (2) a positive valence-activation domain characterized by *approach* responses (BAS); (3) a negative valence-deactivation domain characterized by *despondent* responses; and (4) a positive valence-deactivation domain characterized by *relaxing* responses.

To evaluate the utility of this revised BIS-BAS conceptualization of pain, it is necessary to have validated scales of its theoretical domains. Such an integrated and theoretically derived measure is important, given the wealth of research that supports each of the four domains as playing a role in characteristic emotional, cognitive and behavioural responses to sensory pain cues and the environment context. Building on the prior development of scales assessing two of the quadrants (negative valence responses to pain—active BIS, and positive valence responses to pain—active BAS; Jensen et al., 2017), the current study aimed to develop a Pain Responses Scale (PRS) that contains items assessing thoughts, behavioural intentions and affective pain responses consistent with each of the four quadrants. After writing items informed by this model and using data from a community sample with heterogeneous chronic pain, we performed factor analyses to identify the items that best reflected each quadrant. We also sought to develop a short form of the measure for researchers and clinicians who may require briefer measures.

We hypothesized that items assessing the thoughts, behavioural intentions and affective responses within each quadrant would cluster together (i.e., four overarching factors would emerge). Moreover, we hypothesized that the scales made up of the items in the long form would evidence at least adequate internal consistency (Cronbach's alphas ≥0.70). Finally, if the scales were valid, we anticipated that the scales assessing negative valence would be positively associated with pain-related domains (i.e., pain intensity and interference) and the scales assessing positive valence would show the opposite patterns, with the negative valence scales evidencing larger absolute associations than the positive valence scales.

2 | METHODS

2.1 | Study design

The data for this study came from a cross-sectional survey administered to individuals, who were recruited from a database that is maintained by the University of Washington, with medical conditions frequently

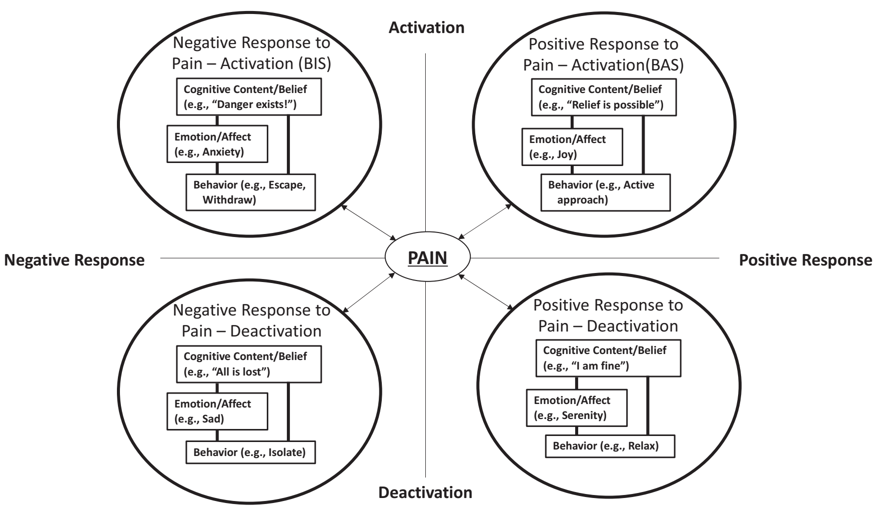

FIGURE 1 The BIS-BAS informed model of responses to pain

comorbid with chronic pain Although two papers have been written using the data collected from this survey (de la Vega et al., 2019; Ramírez-Maestre et al., 2020), none of these other papers used PRS items, and the questions addressed by those other papers were unrelated to the issues addressed in this paper. Prior to the beginning of the study, the Institutional Review Board of the University of Washington reviewed the protocols and considered the study of 'minimal' risk and exempt from a full board review. Data were collected anonymously between October 2016 and June 2017.

2.2 | Item pool development

Our initial measure development included items that we proposed assessed BIS- and BAS-related mechanism domains (Jensen et al., 2017). However, the findings examining the associations among those initial items only partially supported the model. In support of the model, items assessing distinct BIS-related domains were identified, including items that assessed negative valence (hypothesized to be BIS-related) cognitions about pain and behavioural intentions. However, items assessing affect did not load together on a single BIS emotion factor but loaded on two distinct factors—anxiety and depressive affect. Moreover, the items hypothesized to assess BIS- and BAS-related cognitions (helplessness, hopelessness and optimism) did not load onto a single and distinct cognitive factor, as hypothesized. Thus, in the current iteration, we sought to retain the items that emerged as useful in this initial attempt, as well as build a large new item pool with content developed to assess cognitive, behavioural intention and affective responses to pain that were informed by theory and consistent with the four quadrants of the model depicted in Figure 1.

Prior to developing the new potential items, we began by writing a paragraph description of each of the four domain clusters (i.e., Escape/Avoidance, Approach, Despondent and Relaxing responses), as well as a description of each of the associated thoughts, behavioural intentions (i.e., as theoretically it is behavioural intentions/motivations that underlie behaviour, and we were interested in assessing this underlying aspect, as opposed to the observable output of, for example, pain behaviour) and affective responses within each of those domain clusters. See the supplementary materials for a copy of these initial domain descriptions. Each author then proposed items that corresponded to these aspects within each domain. We then selected non-overlapping items, and further refined the item content via regular communication to avoid complex sentence structure, double negatives, passive voice and ambiguity.

The initial Escape/Avoidance item pool included 26 items, the Approach item pool contained 20 potential items, the Despondent pool had 19 items and the Relaxation pool included 21 items. At least four items for each associated cognitive, behavioural intention and affective response were developed within each domain. As with our initial attempt at a BIS-BAS informed measure, the response format for each of the items was modelled after the Pain Catastrophising Scale (Sullivan et al., 1995), which is widely used in pain research and asks participants to indicate the frequency with which they experience each response '…when in pain'. For each item, participants were asked to indicate the frequency that they respond in a way described by the items on 5-point scales ranging from 0 ('*I never feel this way*') to 4 ('*I feel this way all the time*').

2.3 | Measures

2.3.1 | Demographic and pain characteristics

A brief demographic questionnaire assessed race/ethnicity, age, sex and employment status. Participants were asked to provide information pertaining to their chronic pain diagnosis (utilised for determining inclusion/exclusion), and to report their pain type and pain location.

2.3.2 | Criterion variables

Average pain intensity over the last week was rated on an 11-point numerical rating scale (NRS). A great deal of research supports the validity of the 0–10 NRS for assessing pain intensity (Daut et al., 1983; Dworkin et al., 2005; Jensen & Karoly, 2001). The PROMIS 6-item short-form scale was used to assess pain interference (Cella et al., 2010). The items that are rated on a 5-point Likert scale with higher scores indicate higher levels of pain interference. The PROMIS Pain Interference scale was developed using item-response theory and has demonstrated good construct validity and reliability (Cella et al., 2010).

2.4 | Participants and procedures

Participants were recruited from a database of individuals with medical conditions frequently comorbid with chronic pain, which is maintained by the University of Washington. All participants in the dataset had a medical diagnosis, and some participants had multiple diagnoses. The most common were back pain (44%), multiple sclerosis (38%), osteoarthritis (21%), spinal cord injury (20%) and amputation (14%). The specific inclusion criteria for participants from this dataset to be included in this current study were: (1) having access to an internet-enabled device (e.g., computer, smartphone) with internet connection and (2) self-reporting that they have chronic pain (i.e., a constant or recurrent bothersome pain during the last 3-months that was experienced on at least half of the days during this period).

The study data were collected and managed using REDCap (Research Electronic Data Capture), which is a secure web platform, hosted at the University of Washington. Emails with a brief explanation of the study purposes, a general description of the contents of the survey questions and a link to the online survey were sent to 2871 potential participants. After reading the explanation, 899 of these expressed an interest in participating and were then presented with some screening questions (to check they met the chronic pain criterion). Two hundred and twelve did not meet the inclusion criteria (i.e., did not have chronic pain). The remaining 687, those who were eligible for the study, were shown an informed consent statement that they could sign digitally. After signing their consent, they were then presented with the survey questions. A total of 533 individuals participated in the research, but some participants did not complete the PRS items or left large numbers of items unanswered. Those individuals were excluded by requiring that at least 80 of the 86 items have a response. When this criterion was applied, 476 cases were retained for analyses. Participation was voluntary, and the participants were not required to answer any question they did not want to answer. The online nature of this research meant that participants could complete the survey from the location of their choosing. Participants were not compensated for their time.

2.5 | Statistical analyses

Mplus 8.0 (Muthén & Muthén, 2017) and SPSS version 26 were used in data analyses. Confirmatory factor analysis (CFA) procedures, using Mplus, were applied to item data to construct 16 scales, which were evaluated by CFAs. Weighted least squares mean and variance adjusted (WLSMV) estimation was used with the ordered categorical item data. Robust maximum likelihood (MLR) was applied to data from the scales, which were formed from two or more items. SPSS version 26 was used for a few routine statistical procedures, including calculation of internal consistency reliabilities (i.e., α coefficients).

Fit indices for the CFAs were judged on the basis of guidelines from Brown (2006) and Hu and Bentler (1998). Based on the latter research, models tested with MLR were considered to fit the data well when the comparative fit index (CFI) was 0.95 or higher, the RMSEA was 0.06 or lower, and the standardized root mean square residual (SRMR) was 0.08 or lower. Following the recommendations of Brown (2006), fit was considered acceptable when CFI was 0.90 or above and RMSEA was 0.08 or lower. The same criteria were used for the models evaluated with WLSMV estimation, except that the weighted root mean square residual (WRMR) replaced the SRMR. A WRMR of 1.00 or less generally implies adequate fit for a model with ordered categorical indicators (DiStefano et al., 2018).

Data for the 86 items were limited to no more than six missing values per case. Missing data for item CFAs were managed by pairwise deletion, which is the default in Mplus with the WLSMV estimator when there are no covariates. There were no missing values for scale data, because scale scores were computed as means of nonmissing items.

3 | RESULTS

For purposes of deriving and cross-validating CFA models, data from the 476 participants were randomly divided into a derivation sample ($N = 241$) and a validation sample ($N = 235$). The former sample consisted of 141 women and 88 men (16 cases with sex not reported) with a mean age of 58.3 years (SD = 12.1 years; 21 individuals did not report age). The latter sample had 144 women and 75 men (sex not reported for 16 cases) with a mean age of 60.1 years (SD = 11.1 years; age not reported for 17 cases).

The initial analyses were conducted on the derivation sample ($N = 241$) and consisted of separate CFAs of 45 negative items and 41 positive items. Models were modified in accordance with Mplus modification indices and tested in the validation sample ($N = 235$). Based on the final models, items were chosen for negative valence and positive valence scales, and CFAs were used to examine the combined factor structure of scales for negative and positive valence items.

3.1 | Factor structure of negative valence items

The hypothesized covariance structure for the 45 negative valence items was examined in the derivation sample ($N = 241$). CFA specified eight correlated factors with each item loading only on one factor, and no correlated errors were hypothesized. The fit of this model was fair (CFI = 0.977, RMSEA = 0.064, WRMR = 1.131). The model was also significantly at variance with the data, χ^2 (917, $N = 241$) = 1827.46, $p < 0.001$.

These results for the hypothesized model indicated misspecifications. Mplus modification statistics identified seven items that should have substantial and significant ($p < 0.001$) cross-loadings, and two pairs of items that had large and significant ($p < 0.001$) residual covariances (correlated errors). In addition, exploratory analyses showed that the covariances of seven items designated for a single factor were better explained by two factors having four and three items. These modifications substantially improved model fit (CFI = 0.989, RMSEA = 0.045, WRMR = 0.815), but the model-implied covariance matrix deviated significantly from the actual covariance matrix, χ^2 (900, $N = 241$) = 1347.21, $p < 0.001$.

When the modified model was cross-validated in the second sample ($N = 235$), model fit was not noticeably attenuated, and all model modifications were confirmed (i.e., improved fit significantly). Although the goodness-of-fit index was significant, χ^2 (900, $N = 235$) = 1253.96, $p < 0.001$, fit indices (CFI = 0.993, RMSEA = 0.041, WRMR = 0.809) indicated a very good fit.

3.2 | Factor structure of positive valence items

As with the negative valence items, CFA was applied to item data to evaluate the hypothesized factor structure of the 41 positive valence items. In the derivation sample ($N = 241$), eight oblique factors were specified (no correlated errors), and each item loaded on only one factor. The chi-square goodness-of-fit index indicated a significant difference between predicted and obtained covariance matrices, χ^2 (751, $N = 241$) = 2181.17, $p < 0.001$, and fit indices revealed a less than adequate fit (CFI = 0.956, RMSEA = 0.089, WRMR = 1.540). The model was modified by eliminating two items that were redundant with other items and adding four cross-loadings and six correlated error terms for item pairs. These changes resulted in a model for 39 items that fit the data adequately (CFI = 0.982, RMSEA = 0.061, WRMR = 0.949), although the goodness-of-fit statistic was significant, χ^2 (664, $N = 241$) = 1259.30, $p < 0.001$.

In cross-validation ($N = 235$), there was not evidence of shrinkage. The fit of the model (CFI = 0.987, RMSEA = 0.067, WRMR = 0.947) was substantially the same as in the derivation sample, although the chi-square was somewhat larger despite the slightly smaller sample, χ^2 (664, $N = 235$) = 1358.78, $p < 0.001$. The correlated errors and cross-loadings that were added during model modification were replicated with the exception of one cross-loading.

3.3 | Construction of positive and negative valence scales

When applied to data from the full sample ($N = 476$), model fit was at least adequate. Fit indices for the negative valence items indicated a close fit (CFI = 0.990, RMSEA = 0.044, WRMR = 0.951), although the chi-square goodness-of-fit test was significant, χ^2 (900, $N = 476$) = 1742.24, $p < 0.001$. The modified model for the positive valence items fit well (CFI = 0.983, RMSEA = 0.065, WRMR = 1.157), but was significantly at variance with the data, χ^2 (664, $N = 476$) = 1358.78, $p < 0.001$.

Based on item content and the results of these analyses, items were selected to comprise eight scales for negative valence items and eight scales for positive valence items. Items for the ninth negative valence-item factor with only three items were eliminated. The eight negative valence scales had four items each, whereas seven of the positive valence-item scales had four items and one scale had two items.

Tables 1 and 2 show factors and standardized factor loadings obtained by applying CFA to the data from the complete sample ($N = 476$) for the reduced number of items (32 negative valence Despondent and Escape items, and 30 positive valence Approach and Relaxation items). CFA of negative valence items indicated a very good fit (CFI = 0.988, RMSEA = 0.055, WRMR = 0.760), but the degree of misfit was statistically significant, χ^2 (430, $N = 476$) = 739.73, $p < 0.001$. The fit for the positive valence-item model was fair (CFI = 0.987, RMSEA = 0.070, WRMR = 1.045), and the chi-square fit statistic was significant, χ^2 (373, $N = 476$) = 1234.16, $p < 0.001$.

As given in Table 1, loadings for the negative valence Despondent and Escape items were generally quite high. Factor names, given in Table 1, were based on theory. Specifically, the thoughts, affective responses, behavioural intentions, and valance-associated thoughts scales that are part of the Despondent factor are those that we theorized to be linked with inactivity or a reduction in behaviour associated with both negative affect *and* a marked decrease in behavioural motivation. Whereas the thoughts, affective responses, behavioural intentions and valance-associated thoughts scales that are part of the Escape factor are those theorized to be linked with negative affect *and* withdrawal behaviours driven by a desire to escape pain.

TABLE 1 Standardized factor loadings for confirmatory factor analysis of items that assess Despondent and Escape responses to pain ($N = 476$)

Item	Factors							
	Despondent Thoughts	Despondent Affect	Despondent Behavioural Intentions	Despondent Valence-Associated Thoughts	Escape Thoughts	Escape Affect	Escape Behavioural Intentions	Escape Valence-Associated Thoughts
I think that there is just no use to do anything.	0.61							
I believe that I am not able to manage the pain.	0.72							
I feel that the pain is controlling me.	0.82							
I think that the pain will just go on.	0.79							
I feel sad.		0.94						
I feel downhearted.		0.96						
I feel depressed.		0.95						
I feel blue.		0.96						
It is hard to feel motivated to do anything.			0.91					
I don't feel like doing anything.			0.89					
I feel uninspired to go anywhere.			0.86					
It is hard for me to get started with anything.			0.92					
I feel helpless.				0.92				
I feel hopeless.				0.98				
I feel defeated.				0.98				
I feel discouraged.				0.69				
I think that the pain is harmful.					0.86			
I think the pain is a threat.					0.88			
I expect the worst.					0.93			
I think about all of the bad things that can happen.					0.88			
I become nervous.						0.89		
I feel anxious.						0.90		
I feel fear.						0.98		
I feel worried.						0.91		
I want to hit the pause button.					0.39		0.46	

TABLE 1 (Continued)

Item	Factors: Despondent Thoughts	Despondent Affect	Despondent Behavioural Intentions	Despondent Valence-Associated Thoughts	Escape Thoughts	Escape Affect	Escape Behavioural Intentions	Escape Valence-Associated Thoughts
I feel an urge to stop what I am doing.							0.92	
I want to stop whatever I am doing until I feel better.							0.93	
I feel like taking a break from what I am doing.							0.82	
I feel a sense of dread.								0.67
I feel a sense of impending doom.								0.95
I feel uneasy.								0.94
I feel apprehensive.								0.93

Note: Each item has the phrase 'When in pain' at the beginning. All factor loadings are significant at $p \leq 0.001$. Correlated errors were specified for two item pairs. Factor loadings less than 0.30 are not listed for clarity of presentation.

Factor loadings for positive valence Approach and Relaxation items in Table 2 were typically very high. Factor names were determined by theory. Specifically, the thoughts, affective responses, behavioural intentions and valance-associated thoughts scales that are part of the Approach factor are those we theorized to be linked with positive affect *and* approach behaviours driven by a desire to achieve valued goals, despite pain. The thoughts, affective responses, behavioural intentions and valance-associated thoughts scales that are part of the Relaxation factor are those we theorized to be linked with positive affect *and* a marked decrease in behavioural motivation.

3.4 | Factor structure of negative and positive valence scales

The factor analyses in Tables 1 and 2 demonstrated that it is reasonable to construct 15 brief scales corresponding to each factor with four high loading items, and a 16th scale was formed from the two items loading on this additional factor. A factor model for the 16 scales that were comprised of the 32 negative valence Despondent and Escape items and 30 positive valence Approach and Relaxation items was tested with the 241 participants in the derivation sample. The model consisted of four Despondent-related scales and four Escape-related scales plus four Approach-related scales and four Relaxation-related scales. The fit of this model was less than fully satisfactory (CFI = 0.935, RMSEA = 0.084, SRMR = 0.050), and the model-generated covariance matrix departed significantly from the obtained covariance matrix, χ^2 (98, N = 241) = 264.91, $p < 0.001$. Based on an Mplus modification index, a residual minor factor with two items was added to the model[1]. The Satorra-Bentler chi-square difference test for the MLR estimator demonstrated a highly significant improvement in model fit, χ^2 (1, N = 241) = 65.41, $p < 0.001$, when comparing the modified model to the original, and fit indices were noticeably improved (CFI = 0.950, RMSEA = 0.074, SRMR = 0.046) although the degree of misfit was still significant, χ^2 (97, N = 241) = 224.83, $p < 0.001$. Fit indices in cross-validation of the modified model, which involved only one change to the original, indicated adequate fit (CFI = 0.960, RMSEA = 0.068, SRMR = 0.050) with no apparent shrinkage, but misfit was significant, χ^2 (97, N = 235) = 203.26, $p < 0.001$. Factor loadings for derivation and validation samples were very similar, including the loadings for the residual factor that was added to the original model to improve fit.

Table 3 presents results of a CFA of the modified model for 16 scales on data from the full sample (N = 476). The model-implied covariance matrix was significantly at variance with the data, χ^2 (97,

TABLE 2 Standardized factor loadings for confirmatory factor analysis of items that assess Approach and Relaxation responses to pain ($N = 476$)

Item	Factors							
	Approach Thoughts	Approach Affect	Approach Behavioural Intentions	Approach Valence-Associated Thoughts	Relaxation Thoughts	Relaxation Affect	Relaxation Behavioural Intentions	Relaxation Valence-Associated Thoughts
I think that I am still able to accomplish my life goals.	0.70							
I think about all the reasons I have to keep going.	0.73							
I believe that I can keep going, even with the pain.	0.90							
I think that I can live a meaningful life, even with pain.	0.96							
I remain happy.		0.92						
I am able to feel joy.		0.96						
I can be enthusiastic.		0.97						
I am still able to feel a sense of pleasure.		0.95						
I still feel like accomplishing my goals.			0.88					
I want to keep going.			0.90					
I stay motivated.			0.94					
I stay determined.			0.94					
I can still feel optimistic.				0.89				
I can feel hope.				0.95				
I feel confident.				0.92				
I feel self-assured.				0.90				
I think that the pain is not so bad.					0.78			
I think that I am going to be okay.	0.53				0.47			
I don't think that the pain has to affect me one way or the other.					0.88			
I view the pain as not having any influence on my well-being.					0.89			
I am able to feel calm.						0.94		
I am able to feel serene.						0.92		
I can maintain a sense of ease.						0.95		

TABLE 2 (Continued)

Item	Factors							
	Approach Thoughts	Approach Affect	Approach Behavioural Intentions	Approach Valence-Associated Thoughts	Relaxation Thoughts	Relaxation Affect	Relaxation Behavioural Intentions	Relaxation Valence-Associated Thoughts
I can maintain a sense of wellbeing.						0.97		
I want to just go with the flow							0.81	
I have a desire to not respond to the pain, one way or the other.							0.66	
I experience a sense of acceptance of the pain.								0.87
I am accepting of the pain.								0.91
I just let the pain be.								0.76
I recognize the pain as simply sensations.								0.74

Note: Each item has the phrase 'When in pain' at the beginning. All factor loadings are significant at $p < 0.001$. Correlated errors were specified for five item pairs. Factor loadings less than 0.30 are not listed for clarity of presentation.

$N = 476) = 310.97$, $p < 0.001$, but fit indices (CFI = 0.958, RMSEA = 0.068, SRMR = 0.044) were comparable with those obtained in the separate analyses of the split sample data. The factor labelled 'Despondent' was loaded most strongly by the Despondent-Thoughts and Despondent-Affect scales, and an Escape factor had its highest loadings from the Escape-Thoughts and Escape-Affect scales. The residual factor, which was labelled 'Reduced Activity', had substantial loadings from Despondent-Behavioural Intentions and Escape-Behavioural Intentions. Thus, Reduced Activity explains an important amount of covariance that was otherwise not explained by the four-factor oblique model. The highest loadings for the Approach factor were from the Approach-Affect, Approach-Behavioural Intentions and Approach-Valance-Associated Thoughts items, whereas the Relaxation factor had its highest loading from the items from the Relaxation-Affect scale. Correlations between the Despondent and Escape factors and between Approach and Relaxation factors ($r = 0.88$ and $r = 0.87$, respectively) were very high but significantly less than unity. The residual Reduced Activity factor was specified as uncorrelated with all other factors, and the other four factors had correlations ranging from $r = -0.31$ to $r = -0.47$.

Table 4 displays the means from the full sample ($N = 476$) for the 16 scales, where each scale score was computed as the mean of the item scores comprising that scale. Table 5 presents scale correlations and reliabilities of the 16 scales. Reliabilities (α coefficients) are on the diagonal in Table 5, and scale correlations are below the diagonal. Above the diagonal are scale correlations after correction for attenuation due to unreliability. As evident from the data in Table 5, a number of correlations are very high. In every case, these high correlations are between scales assessing the same over-arching domain.

The interrelationships among the scales can be also represented by a hierarchical model with two second-order factors to explain covariances between first-order factors. That hierarchical model, shown in Figure 2, was constructed by adding Negative Valence and Positive Valence second-order factors and restricting to equality the two loadings on each factor. The equality constraints were added to prevent Heywood cases (i.e., negative variances) and to achieve convergence. The second-order model did not fit quite as well as the four-factor oblique model from which it was derived. The significant Satorra-Bentler difference test, $\chi^2(3, N = 476) = 320.65$, $p < 0.001$, indicated that the increased simplicity of the model (i.e., reduction in the df) came at the cost of significantly reduced model fit. Nevertheless, the fit of the hierarchical model was reasonably satisfactory (CFI = .956, RMSEA = 0.069, SRMR = .051), and it permits an estimate of the correlation

TABLE 3 Standardized factor loadings for confirmatory factor analysis of 16 scales ($N = 476$)

Scale	Factors				
	Despondent	Escape	Approach	Relaxation	Reduced Activity
Despondent—Thoughts	0.91				
Despondent—Affect	0.86				
Despondent—Behavioural Intentions	0.75				0.49
Despondent—Affect-Associated Thoughts	0.78				
Escape—Thoughts		0.91			
Escape—Affect		0.89			
Escape—Behavioural Intentions		0.61			0.49
Escape—Affect-Associated Thoughts		0.79			
Approach—Thoughts			0.83		
Approach—Affect			0.90		
Approach—Behavioural Intentions			0.94		
Approach—Affect-Associated Thoughts			0.93		
Relaxation—Thoughts				0.80	
Relaxation—Affect				0.88	
Relaxation—Behavioural Intentions				0.80	
Relaxation—Affect-Associated Thoughts				0.62	

Note: All factor loadings are significant at $p < 0.001$. The Reduced Activity factor is orthogonal to the other factors, which are correlated. Factor loadings less than 0.30 are not listed for clarity of presentation.

TABLE 4 Means and standard deviations for 16 Scales ($N = 476$)

Scale	Mean	SD
1. Despondent—Affect	1.66	1.05
2. Despondent—Thoughts	1.61	1.22
3. Despondent—Behavioural Intentions	1.26	1.16
4. Despondent—Affect-Associated Thoughts	1.98	1.14
5. Escape—Affect	1.24	1.14
6. Escape—Thoughts	1.09	1.08
7. Escape—Behavioural Intentions	1.81	1.12
8. Escape—Affect-Associated Thoughts	1.02	1.09
9. Approach—Thoughts	2.74	0.98
10. Approach—Affect	2.75	1.03
11. Approach—Behavioural Intentions	2.73	1.01
12. Approach—Affect-Associated Thoughts	2.67	1.07
13. Relaxation—Thoughts	2.06	1.02
14. Relaxation—Affect	2.38	1.08
15. Relaxation—Behavioural Intentions	2.36	1.02
16. Relaxation—Affect-Associated Thoughts	2.11	1.05

($r = -0.44$) between factors that represent negative valence and positive valence scales. See the supplementary materials for a copy of the developed PRS.

3.5 | Construction of short-form scales

Because clinicians and researchers may wish to assess only the more global aspects of content from the 62 items of the 16 scales, short-form scales were constructed to represent the four oblique factors given in Table 3, which broadly correspond to the four quadrants in the model shown in Figure 1. Generally, the highest loading item was chosen from each scale to compose four scales with four items each; however, where two items demonstrated similar loadings, the authors assessed the two items and came to consensus about which item contained content that best represented the construct as intended. The selected items and results of a CFA applied to those items are given in Table 6. The results for these items correspond well with the scale results that are displayed in Table 3. Model fit was fair (CFI = 0.983, RMSEA = 0.069, WRMR = 1.032) but significantly at variance with the data, χ^2 (97, $N = 476$) = 313.72, $p < 0.001$. Factor correlations were $r = 0.89$ for Despondent with Escape and for Approach with Relaxation, and the other four factor correlations ranged from −0.36 to −0.51. Internal consistency reliabilities were at least adequate for scales based on these four factors ($\alpha = 0.84$ for Despondent; $\alpha = 0.81$ for Escape; $\alpha = 0.93$ for Approach; $\alpha = 0.79$ for Relaxation). See the supplementary materials for a copy of the PRS-Short Form.

3.6 | Associations between the long- and short-form scales and pain intensity and pain interference

To evaluate the potentially adaptive versus maladaptive nature of the derived purportedly ‘positive valence’ and ‘negative valence’ long- and short-form versions of the scales, correlations were computed with pairwise deletion. The mean, NRS average pain intensity score (in the past week) for this sample was $M = 5.25$ (SD = 1.95) and the mean PROMIS Pain Interference t-score was $M = 60.94$ (SD = 7.19). The correlation coefficients are given in Table 7. Each of the short- and long-form scale was significantly associated with the pain outcome variables. Each of the negative valence scales demonstrated positive correlations with pain intensity and pain interference (i.e., supporting the potentially maladaptive nature of these responses), while each of the positive valence scales demonstrated negative correlations (i.e., supporting the potentially adaptive nature of these responses).

4 | DISCUSSION

This study aimed to build on our prior BIS-BAS framework and a related measure (Jensen et al., 2016, 2017) to develop the PRS assessing four quadrants of a revised BIS-BAS model of pain (Figure 1). The PRS affords the capacity to disentangle the role of multifaceted combinations of the activation and/or deactivation of both positive- and negative- valence cognitive, emotional and behavioural intention responses to pain and environmental cues.

The study resulted in a long-form version of the PRS that comprises 16 scales assessing thoughts, affective responses, behavioural intentions, and valance-associated cognitive responses that mapped on to each quadrant of the model. As anticipated, we found stronger associations between the scale scores within each quadrant than between the scale scores across quadrants. These findings support the existence of four relatively independent response clusters. Further support for this clustering was demonstrated via the finding that the scales scores—as hypothesized—loaded onto the four overarching domains of Escape (negative valence-activation quadrant), Despondent (negative valence-deactivation quadrant), Approach (positive valence-activation quadrant) and Relaxation (positive valence-deactivation quadrant) responses, with the emerging short-forms assessing these overarching factors.

Within the Escape quadrant, the four scales demonstrated good to excellent internal consistency reliability; the short-form scale also demonstrated good internal consistency. The Escape-Thoughts scale assesses the thought that pain represents a threat, while the related Escape-Affect scale assesses fear and anxiety-related emotional responses. Given the ‘isolation’ of threat-related cognitions in the absence of an associated fear response is unlikely, the emergence of the valance-associated thoughts scales is of note. We are conceptualizing these scales as assessing a unitary experience comprised of a combination of both cognitions and associated affect, akin to Beckian notions of ‘affect-laden cognitions’ (Beck, 1995). That these items loaded onto a factor distinct from the other factors suggests that they represent a construct that is unique from what is assessed by stems asking about emotions or thoughts only. The Escape-Valence-Associated Thoughts scale thus assesses a sense of cognitive-emotive ‘dread’ in response to pain, with this belief accompanied by underlying unease/apprehension. The last scale in this quadrant—the Escape-Behavioural Intention scale—assesses the desired escape/avoidance-related behavioural response to pain.

This study also resulted in four scales that map onto the Despondent quadrant, with the internal consistency reliabilities for these scales ranging from good to excellent, and the short-form scale also demonstrating good reliability. The Despondent-Thoughts scale assesses a cognitive despondence corresponding to the belief of a lack of control in response to pain and of not being able to manage pain effectively. While the Despondent-Affect scale assesses emotional sadness and depressed mood, the Valence-Associated Thoughts scale assesses a more complex despondency associated with a negative affect valence, when one believes one is not capable of impacting pain. A lack of a motivational drive to undertake tasks/activities is assessed by the last scale in this cluster, the Despondent-Behavioural Intention scale, which also may tap features of apathy (i.e., a loss of motivation, indifference etc.) when considered in a combinatorial profile with blunted/low scores on affective domain scales.

Taken together, the negative valence scales are theoretically consistent with the Fear Avoidance Model (Vlaeyen & Linton, 2000, 2012). Further, the Escape scales represent potentially useful mechanism measures for interventions focussed on exposure techniques, as the constructs targeted via such interventions typically focus on reducing fear, avoidance and dread, as well as threat-related cognitions (Schemer et al., 2018). The Despondent scales might be the useful mechanism measures in studies testing interventions that increase drive and engagement in activity (e.g., behavioural activation, Motivational Interviewing; Fordyce, 1976; Jensen et al., 2003) and those emphasizing bolstering self-efficacy beliefs (e.g., cognitive therapy; Thorn, 2017).

An important contribution of this study is the development of scales assessing pain responses that have positive valence. The emerging four Approach scales, and

TABLE 5 Pearson correlations and internal consistency reliabilities (α coefficients) for 16 Scales ($N = 476$)

	Scale						
Scale	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Despondent—Affect	0.83	0.72	0.80	0.74	0.66	0.72	0.65
2. Despondent—Thoughts	0.65	0.96	0.82	0.72	0.72	0.62	0.54
3. Despondent—Behavioural Intentions	0.71	0.78	0.94	0.72	0.73	0.75	0.57
4. Despondent—Affect-Associated Thoughts	0.64	0.68	0.67	0.92	0.61	0.58	0.72
5. Escape—Affect	0.58	0.69	0.68	0.57	0.94	0.73	0.60
6. Escape—Thoughts	0.62	0.58	0.69	0.53	0.67	0.90	0.54
7. Escape—Behavioural Intentions	0.56	0.50	0.53	0.66	0.55	0.49	0.90
8. Escape—Affect-Associated Thoughts	0.59	0.66	0.74	0.54	0.83	0.72	0.52
9. Approach—Thoughts	−0.22	−0.17	−0.23	−0.18	−0.14	−0.26	−0.01
10. Approach—Affect	−0.26	−0.28	−0.32	−0.25	−0.24	−0.29	−0.09
11. Approach—Behavioural Intentions	−0.31	−0.27	−0.35	−0.29	−0.20	−0.30	−0.11
12. Approach—Affect-Associated Thoughts	−0.33	−0.33	−0.40	−0.32	−0.27	−0.34	−0.14
13. Relaxation—Thoughts	−0.40	−0.36	−0.36	−0.38	−0.25	−0.32	−0.25
14. Relaxation—Affect	−0.38	−0.37	−0.38	−0.34	−0.36	−0.35	−0.22
15. Relaxation—Behavioural Intentions	−0.26	−0.25	−0.29	−0.23	−0.18	−0.25	−0.13
16. Relaxation—Affect-Associated Thoughts	−0.24	−0.19	−0.18	−0.21	−0.18	−0.21	−0.13

Note: Correlations (*r*s) are below, dis-attenuated correlations are above, and α reliabilities (underlined) are on the diagonal. If $r \geq 0.09$, $p < 0.05$.

associated short form, measured the increased activation, positive valence response quadrant in the model; each demonstrated good to excellent internal consistency reliability. The Approach-Thoughts scale assesses the general belief that one can persist, have a meaningful life and accomplish valued goals despite pain. The related Approach-Behavioural Intentions scale assesses the desire to stay motivated and determined to achieve these goals. The item content for the Approach-Affect scale assesses the degree to which one is still able to maintain a sense of happiness and joy even in the presence of pain. The more complex, cognitive-affective response to pain associated with this quadrant—assessed by the Approach-Valence-Associated Thoughts scale—measures valence-associated cognitions related to optimism and self-assurance. To our knowledge, this is the first pain-specific scale to assess this complex, positive valence response. This scale is potentially useful given a systematic review highlighted the protective role of optimism in relation to pain, as well as how associated positive expectancies might drive motivation and behaviour to more effectively cope with pain (Basten-Gunther et al., 2019).

The final four scales assess the deactivation, positive valence responses quadrant in the model and measure a general, overarching Relaxation-oriented response as assessed in the short-form. The scales demonstrated good to excellent internal consistency reliability, with the exception of the Relaxation-Behavioural Intentions scale, which evidenced a low reliability coefficient. However, adequate internal consistency reliability was found for the short-form. The Relaxation-Thoughts scale assesses the belief that pain does not affect one's overall sense of self/well-being; related to this, the Relaxation-Affect scale measures feeling calm and at ease despite pain. Mapping on to these two scales, the Relaxation-Valence-Associated Thoughts scale assesses a sense of acceptance of the pain, without needing it to be other than it is. While four-items loaded on to each of these aforementioned Relaxation scales, only two-items loaded on to the Relaxation-Behavioural Intentions scale, with these items assessing the intention to 'just go with the flow' and not respond directly to the pain. More research to further develop this scale to improve its internal consistency reliability would be useful.

These positive valence quadrant scales provide a more nuanced assessment tool for measuring adaptive pain coping than the Positive Responses scale (Jensen et al., 2017) which failed to obtain a reliable measure of cognitive responses. The scales emerging from the current research also assess constructs targeted by treatments such as cognitive-behavioural, acceptance-and mindfulness-based interventions. For example, the Approach-Thoughts scale may represent the adaptive cognitions emerging from cognitive restructuring (Thorn, 2017). Use of this scale in mechanism studies examining cognitive restructuring would provide the opportunity to test not only if maladaptive cognitions are reduced (i.e., decreased pain catastrophizing), but also whether the goal of increasing approach-oriented coping was achieved (i.e., an increase

8	9	10	11	12	13	14	15	16
0.68	−0.26	−0.29	−0.35	−0.37	−0.47	−0.43	−0.36	−0.28
0.70	−0.18	−0.29	−0.29	−0.35	−0.39	−0.38	−0.32	−0.21
0.79	−0.25	−0.34	−0.37	−0.43	−0.40	−0.40	−0.37	−0.20
0.59	−0.20	−0.27	−0.32	−0.34	−0.43	−0.36	−0.31	−0.24
0.89	−0.15	−0.25	−0.21	−0.28	−0.28	−0.38	−0.24	−0.20
0.79	−0.29	−0.31	−0.33	−0.37	−0.36	−0.38	−0.33	−0.24
0.56	−0.02	−0.10	−0.11	−0.15	−0.28	−0.24	−0.18	−0.15
0.93	−0.21	−0.29	−0.29	−0.34	−0.32	−0.36	−0.22	−0.21
−0.19	0.87	0.83	0.89	0.82	0.64	0.68	0.76	0.53
−0.27	0.75	0.96	0.88	0.88	0.66	0.77	0.84	0.51
−0.27	0.80	0.83	0.94	0.94	0.69	0.76	0.84	0.52
−0.32	0.74	0.84	0.88	0.95	0.71	0.80	0.83	0.51
−0.28	0.55	0.60	0.62	0.64	0.87	0.77	0.88	0.62
−0.33	0.61	0.74	0.72	0.76	0.70	0.95	0.88	0.58
−0.17	0.56	0.65	0.65	0.64	0.65	0.69	0.64	0.79
−0.19	0.46	0.46	0.46	0.46	0.53	0.52	0.58	0.86

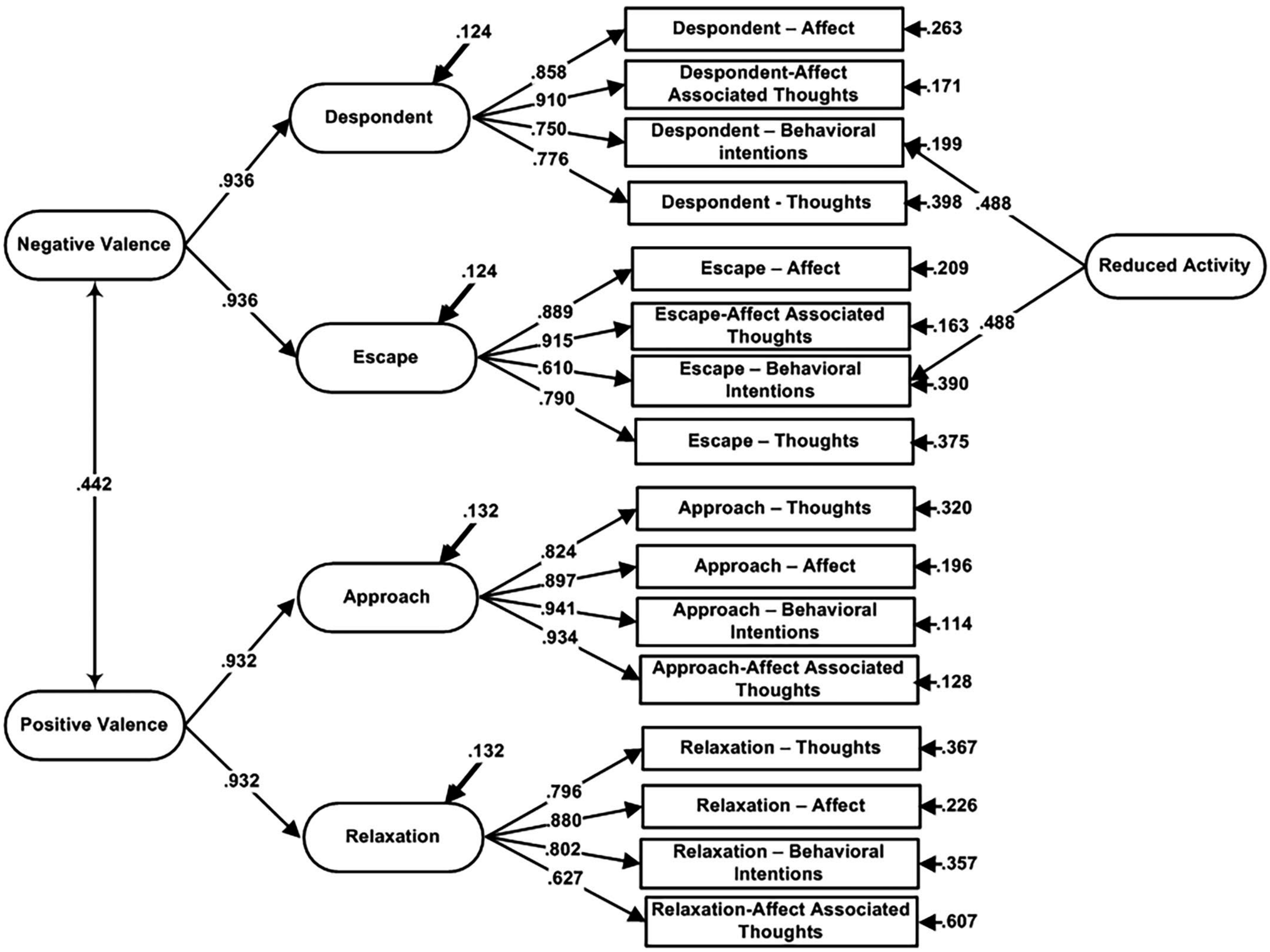

FIGURE 2 Hierarchical model for 16 scales ($N = 476$)

TABLE 6 Standardized factor loadings for confirmatory factor analysis of 16 items for short-form scales ($N = 476$)

	Factors				
Scale	**Despondent**	**Escape**	**Approach**	**Relaxation**	**Reduced Activity**
I feel that the pain is controlling me.	0.74				
I feel sad.	0.84				
I don't feel like doing anything.	0.70				0.47
I feel hopeless.	0.91				
I expect the worst.		0.82			
I feel fear.		0.90			
I feel an urge to stop what I am doing.		0.57			0.47
I feel uneasy.		0.85			
I think that I can live a meaningful life, even with pain.			0.88		
I can be enthusiastic.			0.89		
I stay motivated.			0.91		
I can feel hope.			0.92		
I view the pain as not having any influence on my well-being.				0.69	
I can maintain a sense of well-being.				0.92	
I want to just go with the flow.				0.79	
I am accepting of the pain.				0.57	

Note: All factor loadings are significant at $p < 0.001$. The Reduced Activity factor is orthogonal to the other factors, which are correlated. Factor loadings less than 0.30 are not listed for clarity of presentation.

in the general belief that one is able to persist despite the pain) and the degree to which this was associated with improved outcomes. This scale also maps on to acceptance principles, for example, values-based action (McCracken & Morley, 2014; McCracken & Vowels, 2014). Further, the Relaxation-Valence-Associated Thoughts scale provides a global measure of pain acceptance.

Finally, that these scales are pain specific and have further advantages. For example, the Relaxation-Thoughts scale has relevance in relation to mindfulness theory (Day et al., 2014), where meditation practice cultivates an observing of pain such that the sensation becomes decoupled from an emotional reaction. This is in contrast to the more general measures typically used to assess this construct in trials testing mindfulness interventions (e.g., Five-Facet Mindfulness Questionnaire; Baer et al., 2008). Further, it is possible that the pain-specific short-form scales (which are comprised of items assessing thoughts, affect, behavioural responses) might map on to a tripartite model of attitudes which conceptualize an 'attitude' as exactly this: a combination of cognitive, affective and behavioural responses (Eagly & Chaiken, 2007). Future research examining these short-form scales in relation to established measures of pain attitudes, such as the Survey of Pain Attitudes (Jensen et al., 1987), would shed further light on this possibility.

A final aim was to evaluate the associations between the scales developed in this research with two important pain-related outcomes: pain intensity and interference. The results showed that, as expected, higher scores on the negative valence scales were associated with worse pain intensity and interference. At the same time, higher scores on the positive valence scales were associated with lower levels of pain intensity and interference, providing preliminary support for the hypothesized protective nature of the constructs assessed by these scales. Additionally, the negative valence scales generally showed larger effect size associations with the pain outcomes than the positive valence scales, which is consistent with the tenets of the BIS-BAS model of pain (Jensen et al., 2016). A caveat to interpreting these findings is that participants generally scored higher on the Approach and Relaxation scales than on the Despondent and Escape scales, which is somewhat at odds with what one might expect based on prior research (e.g., with findings indicating that elevated levels of negative affect co-occur with pain; Goesling et al., 2018; Siqveland et al., 2017). Despite the moderate pain intensity ratings and elevated pain interference scores, these findings suggest that on average the participants included in this study may have been coping well with their pain. Future research using treatment-seeking pain samples

TABLE 7 Pearson correlations between the long- and short-form versions of the scales with pain intensity and pain interference ($N = 476$)

	NRS Pain Intensity	PROMIS Pain Interference
Despondent—Thoughts	0.38	0.59
Despondent—Affect	0.18	0.47
Despondent—Affect-Associated Thoughts	0.27	0.52
Despondent—Behavioural Intentions	0.29	0.61
Escape—Affect	0.24	0.43
Escape—Thoughts	0.30	0.46
Escape—Behavioural Intentions	0.26	0.55
Escape—Affect-Associated Thoughts	0.23	0.42
Approach—Thoughts	−0.20	−0.18
Approach—Affect	−0.16	−0.20
Approach—Behavioural Intentions	−0.25	−0.26
Approach—Affect-Associated Thoughts	−0.21	−0.26
Relaxation—Thoughts	−0.28	−0.41
Relaxation—Affect	−0.27	−0.35
Relaxation—Behavioural Intentions	−0.18	−0.30
Relaxation—Affect-Associated Thoughts	−0.18	−0.24
Giving up—Short-Form	0.33	0.61
Escape—Short-Form	0.26	0.51
Approach—Short-Form	−0.22	−0.25
Relaxation—Short-Form	−0.25	−0.37
NRS Pain Intensity	1.00	0.45
PROMIS Pain Interference	0.45	1.00

Note: $r \geq 0.09$ is significant at $p < 0.05$.

is needed to further examine this pattern of findings. Research to establish the convergent and divergent validity of the PRS scales with measures of related constructs (e.g., self-efficacy, pain catastrophizing, acceptance) is also needed. Such research would inform how the constructs assessed by the PRS are theoretically linked to other constructs shown to be important in pain.

4.1 | Limitations

The data were cross-sectional. Thus, it is not possible to determine the test–retest reliability of the PRS scales or draw any causal conclusions. Also, although we have discussed the potential usefulness of these scales for evaluating the mechanisms of pain treatments, the sensitivity of these measures to treatment-related changes will need to be determined. The validity of these affect-focussed scales within populations with co-morbid alexithymia, including individuals with both chronic pain and alexithymia (Di Tella & Castelli, 2016; Shibata et al., 2014), needs to be established. Finally, one of the scales—the Relaxation-Behavioural Intentions scale—had just two items. It may be necessary to further develop this scale with additional items to reliably assess this domain in future research, potentially also while taking into account and controlling for the possible influence of a blunted emotional response.

5 | CONCLUSIONS

We anticipate that the revised BIS-BAS model of pain and PRS scales will be useful for understanding how various psychosocial pain treatments are similar and different with respect to their underlying mechanisms. The PRS scales uniquely contribute to this research priority as they provide a comprehensive assessment of combinatorial pain-response profiles based on both valence (negative-positive) and degree of activation (activation-deactivation) across cognitions, affect and behavioural intentions. Advancing our capacity to more precisely assess treatment mechanisms has implications for streamlining treatments and facilitating the development of patient-treatment matching algorithms.

CONFLICTS OF INTEREST

The authors have no other conflicts of interest to report.

AUTHOR CONTRIBUTIONS

All of the authors have contributed in the relative weight as represented in authorship order (i.e., first, last, second, third, etc.), to the conceptualization and writing of the manuscript. All authors discussed the results and commented on the manuscript, and approved the paper for submission.

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ENDNOTE

[1] Each item of the residual, or minor, factor specifies equal loadings to achieve identification and retains a loading on the oblique factor as originally specified. The residual factor is statistically equivalent to a correlated error term.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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