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Development of a Chronic Pain Specific Version of the Sickness Impact Profile

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ABSTRACT

Objective: Given the prevalence and complexity of chronic pain, there is a need for measures of disability that: (1) provide comprehensive, useful clinical information with regard to patient functioning, and (2) do so as briefly as possible to minimize respondent burden. The primary objective of this study was to reduce the length of a well-known, highly detailed measure of disability, the 136-item Sickness Impact Profile (SIP), and develop a psychometrically sound short form for use in chronic pain (SIP for Chronic Pain, SIP-CP). **Methods:** A 2-parameter logistic item response theory model was used to develop the SIP-CP in a sample of adults presenting for treatment at an interdisciplinary rehabilitation program (N = 723). Items were assessed for inclusion at the subscale level; poorly contributing items were removed sequentially and model fit was evaluated at each step until adequate fit was achieved. Finally, linear regressions examined the variance accounted for by the SIP-CP in relation to the full-length SIP in measures of patient functioning. **Results:** The SIP-CP contains 42 items that yield seven subscale scores and two summary dimension scores, Physical and Psychosocial disability. Acceptable reliability and evidence of convergent and divergent validity were demonstrated for each component. The SIP-CP accounted for a similar amount of the variance in measures of depression, pain-related anxiety, pain acceptance, classes of prescribed analgesics, and pain-related medical visits as the full-length SIP. **Conclusions:** The SIP-CP appears to provide robust clinical information with little loss of association with other key aspects of functioning, while substantially lowering response burden.

Keywords: chronic pain, assessment, item response theory, disability, functioning, Sickness Impact Profile

Development of a chronic pain specific version of the Sickness Impact Profile

Chronic pain affects an estimated 100 million adults in the US, more than the total affected by heart disease, cancer, and diabetes combined (Gaskin & Richard, 2012), and can be highly complex and debilitating. In contrast to acute pain, chronic pain persists beyond the expected time for healing and does not appear to serve any adaptive function (Ashburn & Staats, 1999). The impacts of chronic pain can be substantial and widespread, often leading to significant disability across multiple domains of functioning (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Fredheim et al., 2008; Gaskin & Richard, 2012; Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Reducing disability is therefore a priority goal for treatment.

Broadly speaking, there is no single measure that serves as the gold standard for assessing disability in chronic pain, particularly for non-headache pain (De Bruin, De Witte, Stevens, & Diederiks, 1992; Jensen, Turner, Romano, & Fisher, 1999). One of the most established measures of illness-related disability is the Sickness Impact Profile (Bergner, Bobbitt, Carter, & Gilson, 1981). The SIP was designed to provide a broad assessment of how illness disrupts daily activities in physical, psychological, and social domains (Bergner, 1993; Bergner et al., 1981; Bergner, Bobbitt, Kressel, et al., 1976; Bergner, Bobbitt, Pollard, Martin, & Gilson, 1976). Completion of the 136-item measure yields an overall score indicating total disability, three dimension scores assessing Physical, Psychosocial, and Independence/other disability, and 12 subscale scores including Ambulation, Mobility, Body Care and Movement, Communication, Alertness Behavior, Emotional Behavior, Social Interaction, Sleep and Rest, Eating, Work, Home Management, and Recreation and Pastimes. All scores range from 0 to 1 with higher scores representing greater disability due to health concerns. To date, few alternative measures are as thorough and informative as the SIP.

The SIP has been widely used in the area of chronic pain, where it appears to provide a broader and more detailed assessment of patient functioning than other clinical assessments (De Bruin et al., 1992; Lindeboom et al., 2004; Lipsett et al., 2000; Watt-Watson & Graydon, 1989).

From a psychometric perspective, the SIP has demonstrated acceptable content and criterion validity along with good test-retest reliability in chronic pain (Deyo, Inui, Leininger, & Overman, 1982; Deyo, Inui, Leininger, & Overman, 1983; Follick, Smith, & Ahern, 1985; Sullivan, Ahlmen, & Bjelle, 1990). The SIP has also demonstrated good sensitivity and specificity in chronic pain, with the ability to detect clinically and statistically significant changes in functioning (Deyo & Inui, 1984; Follick et al., 1985; Sullivan et al., 1990; Vowles & McCracken, 2008; Vowles, Witkiewitz, Sowden, & Ashworth, 2014).

While the SIP appears useful in chronic pain settings, there are at least four key limitations. First, the factor structure has not been supported (De Bruin, Diederiks, De Witte, Stevens, & Philipsen, 1994; Lindeboom et al., 2004; Nanda, McLendon, Andresen, & Armbrecht, 2003). Second, the scoring method includes potentially arbitrary item weights, which were based on healthcare provider judgments of severity. Lacking empirical support, this may contribute to the aforementioned factor instability (De Bruin et al., 1994; Lindeboom et al., 2004; MacKenzie, Charlson, DiGioia, & Kelley, 1986; Pollard & Johnston, 2001). Third, the SIP includes items that may not be widely pertinent to chronic pain and therefore add unnecessarily to the response burden (Deyo, 1986; Deyo et al., 1982). Fourth and finally, the SIP is lengthy, requiring substantial time to complete and score, which makes it less acceptable to patients and providers (Busija et al., 2011; Damiano, 1996; De Bruin, Diederiks, De Witte, Stevens, & Philipsen, 1997; Deyo et al., 1983; Lipsett et al., 2000; Read, Quinn, & Hoefer, 1987). At present, the only abbreviated version of the SIP specific to chronic pain is the Roland Morris Disability Questionnaire (Roland & Fairbank, 2000; Roland & Morris, 1983), which covers only a limited range of activities in the physical functioning domain and does not assess psychological or social functioning (Stratford, Solomon, Binkley, Finch, & Gill, 1993).

To summarize, the SIP has a number of strengths regarding use in chronic pain, chiefly the broad clinical information that it provides and extensive assessment across areas of functioning. It also has a number of limitations, including factor structure, relevance of certain items for this population, and length. The current study sought to derive a chronic pain specific version of the SIP, the SIP-CP, which retains the strengths of the original SIP while minimizing the limitations. Notably, prior studies failing to replicate the factor structure of the SIP have relied on classical test theory (CTT) methodology. The present study utilized item response theory (IRT) to evaluate and reduce items, a psychometric method widely used in education assessment which allows for more complex (nonlinear) models. In addition, a series of follow-up correlation and regression analyses were performed to evaluate the association of the SIP-CP, both alone and in contrast to the original SIP, with key aspects of patient functioning, including depression, pain-related anxiety, pain acceptance, classes of prescribed analgesics, and number of pain-related medical visits.

Method

Participants

Participants included 723 patients presenting for treatment at an interdisciplinary pain treatment center in the United Kingdom between 2005 and 2012. Prior to an individual intake interview with a psychologist, all participants completed a battery of self-report questionnaires. The study was approved by the Bath and Northeast Somerset NHS Research Ethics Board. The sample was primarily White European (97.5%), female (65.7%), and married (63%). Mean participant age was 46.4 years (*SD* = 12.1) and mean education was 12.3 years (*SD* = 2.5). Median duration of pain was 84 months (ranging from 7 to 660); many patients were not currently working (50.6%) or had retired early (20.8%) due to pain. The most commonly reported pain site was lower back (48%), followed by lower limbs (14.6%), full body (11.7%), and upper limbs (10.5%). Reported average pain intensity over the past week on a 0 (no pain) to 10 (maximal pain possible) rating scale was 7.2 (*SD* = 1.8).

Measures

Demographic and clinical information. Demographic variables collected included participant age, sex, years of education, employment status, and ethnic/racial background. Self-reported pain-related data included duration of pain in months, location(s) of pain, average pain intensity over the past week, and the number of medical visits over the past six months related to pain. Analgesic medications were tallied via chart review with the total number of classes of analgesic medications (e.g., opioids, NSAIDS, tricyclic antidepressants, muscle relaxants, sedatives, anticonvulsants, selective serotonin reuptake inhibitors, over-the-counter analgesics) taken for pain coded according to the British National Formulary (bnf.org).

Sickness Impact Profile (Bergner et al., 1981). As noted, the 136 items of the SIP are written in a yes/no response format, with a “yes” response indicating greater disability. Respondents are asked to indicate which items apply to them on a given day in relation to their current health.

Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a 21-item measure of depression with well-established psychometric properties (Beck, Steer, & Carbin, 1988). Scores range from 0 to 63 with larger values indicating more severe symptoms. Of note, the treatment program changed measures of depression midway through the collection of data for this study, so BDI-II data was available for only a subset of 355 individuals. Cronbach's alpha in the sample was .88.

British Columbia Major Depression Inventory (BCMDI; Iverson & Remick, 2004). The BCMDI is a 16-item index of depression based on the Diagnostic and Statistical Manual for Mental Disorders-IV (DSM-IV; American Psychiatric Association, 2000) criteria for Major Depressive Disorder. Scores range from 0 to 120 with higher scores indicating more severe symptoms. The BCMDI has demonstrated adequate internal consistency, test-retest reliability, and good sensitivity and specificity (Iverson & Remick, 2004). Due to changes in measure selection for depression, BCMDI data was available for a subset of 358 individuals who did not complete the BDI-II. Cronbach's alpha for the BCMDI in the sample was .86.

Pain Anxiety Symptoms Scale-20 (PASS-20; McCracken & Dhingra, 2002). The PASS-20 is a 20 item measure of fear, anxiety, and avoidance responses specific to pain. Scores range from 0 to 100 with higher scores indicating greater symptoms. The PASS-20 is strongly correlated with the original 40-item PASS (McCracken, Zayfert, & Gross, 1992) and other measures of functioning and has demonstrated strong internal consistency and reliability with good predictive and construct validity (McCracken & Dhingra, 2002; Roelofs et al., 2004). Cronbach's alpha was .85 in this sample.

Chronic Pain Acceptance Questionnaire (CPAQ; McCracken, Vowles, & Eccleston, 2004). The CPAQ is a 20-item measure of pain-related acceptance. Total scores range from 0 to 120 with higher scores indicating greater acceptance and have been significantly correlated with measures of physical and emotional functioning. The measure has demonstrated adequate factor structure as well as acceptable internal consistency and test-retest reliability (McCracken & Eccleston, 2005; McCracken et al., 2004; Vowles, McCracken, McLeod, & Eccleston, 2008). Cronbach's alpha for the CPAQ total score was .73 for this sample.

Statistical Analyses

All IRT analyses were performed using Mplus software (Muthén & Muthén, 2012). Correlation and regression analyses were performed using SPSS, Version 21 (IBM Corporation).

IRT analyses of the SIP subscales. An IRT approach was used to examine the relative usefulness of each item and guide selection of items for a shortened version of the SIP specific for a treatment seeking chronic pain population. IRT utilizes mathematical models that describe the relation between an individual's response to an item and their level of the hypothetical latent trait being assessed in probabilistic terms (Hays, Morales, & Reise, 2000), and provides the opportunity to either select items that provide an accurate assessment across the entire range of a trait or items that provide maximum discriminatory value surrounding a critical range of a trait (e.g., a clinical cutoff score). In the present study, the goal was to minimize patient burden by reducing the length of the measure while capturing as much breadth of clinical information as possible. Accordingly, IRT was used to identify items that weren't providing any significant information about the trait of interest (i.e., disability associated with chronic pain) and could therefore be eliminated, as well as items which provided an accurate assessment across a broad range of disability in chronic pain and should therefore be retained. Given that the item weights of the original SIP were arbitrarily determined during its construction by healthcare providers and have not been psychometrically supported, no item weights were used.

Core fundamental assumptions for using IRT include unidimensionality and local independence, which were verified by examining eigenvalues during preliminary exploratory factor analysis. Other assumptions of IRT include monotonicity, which requires that the probability of endorsing an item increases along with increases in the underlying latent trait, and parameter invariance across groups, which allows for the comparing of scores across respondents endorsing different items and modeling change over time (Hays et al., 2000). Accordingly, item response theory is well suited for the selection of items to retain on a measure. Advantages of IRT in the present study include the use of non-linear modeling (as opposed to the linear relation presumed in CTT) and the ability to estimate a trait of interest (disability in chronic pain) with fewer items (Hays et al., 2000).

Given the forced choice format of the SIP (i.e., yes/no), a two-parameter logistic IRT model was used to provide estimates for two independent aspects of each item: difficulty and discrimination value. Within IRT, the difficulty and discrimination of each item is graphically represented in an item characteristic curve (ICC), a non-linear regression line representing the likelihood of endorsing that particular item as a function of the underlying trait. ICCs for dichotomous items like those on the SIP form an S-shaped curve; in the center of this curve, small changes in the level of the underlying trait are associated with large changes in the probability of endorsing that item (Embretson & Reise, 2000). The exact shape and location of the S-shaped curve for each item depends on the estimated difficulty and discrimination parameters; a reverse S-shaped curve indicates negative discrimination, which suggests a poorly performing item that is best excluded. Curves that form a straight horizontal line indicate that the item provides no discrimination or is undefined, while a straight vertical line indicates perfect discrimination just above and below that point, but no ability to distinguish between those with levels of the latent trait further above or below it. See Ainsworth (2011) for a detailed discussion.

Items were evaluated at the level of the subscale with the intent of maintaining the broad framework of the SIP. Inadequate items were removed individually based on manual inspection of ICCs. Because ICCs on a subscale are a function of how those items work together (and not just the sum of individual ICCs), subscale ICCs were re-evaluated after each step in the reduction process.

Fit was initially evaluated using chi-square analyses, with non-significant values indicating appropriate model fit. However, since the significance of χ^2 model fit tends to increase with larger sample sizes, the priority was to achieve consensus among root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI) fit indices. For RMSEA, good fit was defined as a test statistic ≤ .05, with values ≤ .08 considered adequate fit (Bryne, 2001). Good fit for CFI and TLI was defined by a test statistic ≥ .95, with adequate fit attained by values of ≥ .90 or larger (Hu & Bentler, 1999). Following the removal of all poorly functioning items as demonstrated by model fit indices and visual inspection of ICCs, chi-square difference tests were conducted to determine whether the removal of additional items significantly improved model fit across further iterations of the subscale. For instances in which two items shared the same ICC characteristics (suggesting potential redundancy), items were evaluated for uniqueness relative to other items and clinical relevance for chronic pain and retained or removed accordingly. Since this process was exploratory in nature, removal of items occasionally produced changes in ICCs which suggested that inclusion of that item may yield better model fit. In such cases, effects of re-adding these items to the subscale on ICCS and subsequent model fit were examined to determine whether they should be retained for the SIP-CP. This procedure was followed for each of the 12 original subscales of the SIP. In cases where item removal was straightforward (e.g., negatively sloping ICC), the item was removed without the need for study team discussion. In cases where there was ambiguity or where items shared ICC characteristics, the first and second authors made a joint determination of the most appropriate course of action in terms of item removal and retention.

Evaluation of SIP-CP Dimension and Total Scores. Following the evaluation of model fit of items at the subscale level, overall fit of the dimension scores (i.e., Physical, Psychosocial, and Independence/other disability) and total disability was assessed. To further aid in evaluation of the revised scores, correlation coefficients were calculated amongst the SIP and SIP-CP with the included measures of depression, pain-related anxiety, pain acceptance, classes of prescribed analgesics, and number of pain-related medical visits. Any dimension score that did not achieve adequate fit and was not correlated consistently with measures of functioning was removed from further analyses.

Finally, a series of linear regressions was performed to investigate the variance accounted for by the SIP and SIP-CP scores in measures of depression, pain-related anxiety, pain acceptance, number of classes of pain medications, and number of pain-related medical visits. These analyses served two primary purposes. The first was to examine whether there were differences in the amount of variance accounted for by the original SIP and the SIP-CP, since it is possible that a substantial reduction in the number of items on the SIP-CP would adversely affect variance accounted for in aspects of patient functioning. On the other hand, if the IRT analyses were useful in reducing the number of unimportant or redundant items on the SIP, then variance should not be greatly reduced on the SIP-CP. The second purpose of the regression analyses was to investigate aspects of convergent validity of the SIP-CP after controlling for relevant background variables, including gender, age, pain duration, and pain intensity.

Results

Descriptive Information

Means and *SD*s for all study measures are displayed in Supplementary Table 1[1]. All distributions appeared normally distributed with no evidence of kurtosis.

IRT Analyses of the SIP Subscales

The final version of the SIP-CP is displayed in the online Supplementary Appendix. The item reduction process is described below and a representative example is shown in Figure 1 and Table 1 for the Mobility subscale. Item reduction details for each subscale, which show step by step item removal and resultant model fit, as well as ICC details are available as supplementary files (Supplementary Tables 2-10; Supplementary Figures).

Mobility. The Mobility subscale assesses the range of one's ability to get around within and outside the home. The original subscale consisted of 10 items with adequate fit, χ^2 (35) = 127.11, $p < .001$, RMSEA = .06, CFI = .93, TLI = .91. Following the IRT analyses displayed in Table 1, the subscale was reduced to five items with evidence of good fit, χ^2 (5) = 9.09, $p = .106$, RMSEA = .03, CFI = .99, TLI = .98). All ICC's are displayed in Figure 1. The figure displays ICC's for the original 10 items in the upper pane and the five retained items in the lower pane.

Ambulation. The Ambulation subscale assesses various aspects of walking (e.g., distance, speed, use of assistive devices). Model fit of the original 12 items was poor, χ^2 (2) = 838.16, $p \leq 0.001$, RMSEA = .14, CFI = .65, TLI = .57; indices for the four items retained for the SIP-CP indicated excellent fit, χ^2 (2) = 3.4, $p = 0.18$, RMSEA = .03, CFI = .99, TLI = .99.

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[1] Given that approximately half of the sample experienced low back pain, we investigated whether diagnosis or pain location was associated with differences in the measures utilized in the present study. Overall, differences were significant only for the number of classes of pain medications taken; those with back pain (M = 2.84, SD = 1.48) were taking significantly more medication classes than patients with pain in other areas (M = 2.53 SD = 1.51), t (716) = 2.79, p = .005. Similarly, patients with a spine or back-related diagnosis (M = 3.58, SD = 1.66) were taking significantly more medication classes than those with other diagnoses (M = 2.87, SD = 1.62), t (334) = 31.12, p = .002.

Body Care and Movement. The Body Care and Movement subscale of the SIP assesses aspects of dressing (e.g., requiring full or partial assistance), standing (from sitting or lying down), and toileting behavior. The 23 items on the original subscale approached adequate fit, χ^2 (230) = 731.95, $p < .001$, RMSEA = .06, CFI = .89, TLI = .88, while the seven items retained after IRT analyses demonstrated good fit, χ^2 (14) = 36.65, $p < .001$, RMSEA = .05, CFI = .99, TLI = .99.

Communication. The Communication subscale assesses difficulties with written (e.g., trouble writing or typing) and oral (e.g., difficulty speaking, understood with difficulty) communication. The nine items on the original subscale demonstrated good fit across RMSEA and CFI indices and adequate fit on the TLI, χ^2 (27) = 64.93, $p < .001$, RMSEA = .04, CFI = .95, TLI = .94. IRT analyses reduced this to six items with good fit, χ^2 (9) = 17.14, $p < .001$, RMSEA = .04, CFI = .99, TLI = .98.

Alertness Behavior. The Alertness Behavior subscale assesses difficulty with cognitive abilities often associated with executive functioning (e.g., confusion, forgetfulness, difficulty concentrating or sustaining attention). The original 10 items demonstrated good fit on CFI and TLI indices and adequate fit on RMSEA, χ^2 (35) = 130.64, $p < .001$, RMSEA = .06, CFI = .98, TLI = .97. IRT analyses reduced this to seven items which had good fit across indices, χ^2 (14) = 25.04, $p < .001$, RMSEA = .05, CFI = .99, TLI = .99.

Emotional Behavior. The Emotional Behavior subscale assesses various forms of psychological distress (e.g., acting nervous or restless, irritability and impatience, talking about hopelessness). The original nine items exhibited adequate fit, χ^2 (27) = 113.59, $p < .001$, RMSEA = .07, CFI = .91, TLI = .89; IRT analyses reduced this to six items that demonstrated good fit, χ^2 (14) = 33.26, $p < .001$, RMSEA = .04, CFI = .97, TLI = .96.

Social Interaction. The Social Interaction subscale assesses changes in the frequency and other aspects of social interactions with friends (e.g., going out less to visit people, avoiding social visits from others) and family members (e.g., have frequent outbursts of anger, not joking with family members the way I usually do, refuse contact with my family). The original 20 items failed to demonstrate adequate model fit, χ^2 (170) = 748.09, p < .001, RMSEA = .07, CFI = .86, TLI = .85. IRT analyses reduced this subscale to seven items which demonstrated good fit across all indices, χ^2 (14) = 30.72, p < .001, RMSEA = .04, CFI = .98, TLI = .97.

Sleep and Rest. The Sleep and Rest subscale assesses changes in sleep habits (e.g., spending much of the day lying down to rest, sleeping less at night). The original seven items indicated poor fit, χ^2 (14) = 104.12, p < .001, RMSEA = .09, CFI = .43, TLI = .15, while the revised four item subscale of the SIP-CP demonstrated good fit, χ^2 (2) = 2.37, p < .001, RMSEA = .02, CFI = .99, TLI = .96.

Home Management. The Home Management subscale assesses the degree to which one is able to perform typical household chores (e.g., doing less of the regular daily work around the house than usual, have given up taking care of personal/household business affairs such as paying bills, etc.). The original 10 item subscale failed to demonstrate adequate fit, χ^2 (35) = 412.80, p < .001, RMSEA = .12, CFI = .89, TLI = .85. More importantly, ICCs for eight of the 10 items included on this subscale were reverse S-shaped curves, indicating highly problematic items. Without a sufficient number of items left to define the model, the subscale was dropped from the SIP-CP.

Work. The original Work subscale of the SIP contains nine items assessing changes in work-related functioning (e.g., working shorter hours, taking frequent rests, not accomplishing as much as usual, acting irritable toward work associates). Notably, participants not currently working outside of the home are automatically scored as having a set level of disability in this area, regardless of their reason for not working (e.g., homemaker, retired not due to pain, etc.). Further, the original construction of this subscale was such that endorsement of item 1 (“I am not working at all”) yielded a work disability score of .70 (as noted, on a 0 – 1 scale) with instructions to skip the remaining eight items of the subscale. Perhaps unsurprisingly, ICCs showed that these eight items were problematic as indicated by reverse S-shaped curves. With only the first item functioning as intended, a model for this subscale could not be properly defined and was thus dropped from the SIP-CP.

Recreation and Pastimes. The Recreation and Pastimes subscale assesses changes in the frequency and duration of engagement in personal hobbies or recreational activities (e.g., going out for entertainment less often, doing more inactive pastimes in place of my usual activities, not doing any of my usual inactive pastimes). The original eight item subscale demonstrated poor fit, χ^2 (20) = 279.45, $p < .001$, RMSEA = .13, CFI = .55, TLI = .37. IRT analyses produced a four item subscale which demonstrated good fit, χ^2 (2) = 4.79, $p < .001$, RMSEA = .04, CFI = .99, TLI = .97.

Eating. The Eating subscale assesses one's ability to feed themselves (e.g., feed myself with the help of someone else, do not feed myself at all and must be fed) along with changes in eating habits (e.g., eating much less than usual, eating special or different foods, drinking less fluids). The original nine item subscale demonstrated good fit for both RMSEA and CFI with adequate fit on TLI, χ^2 (14) = 21.50, $p = .09$, RMSEA = .03, CFI = .95, TLI = .92. The revised four item Eating subscale demonstrated good fit across all indices, χ^2 (2) = 2.59, $p = .091$, RMSEA = .02, CFI = .99, TLI = .99.

Evaluation of SIP-CP Dimension and Total Disability Scores

Physical dimension score. The original Physical dimension score contained 45 items across three subscales (Mobility, Ambulation, and Body Care and Movement) which failed to demonstrate adequate model fit, χ^2 (945) = 3109.62, $p < .001$, RMSEA = .06, CFI = .78, TLI = .77. As previously described, IRT analyses were able to shorten and retain all three of these subscales with adequate fit consistent across RMSEA, CFI, and TLI at the subscale level. This produced the resulting 16 item Physical dimension score for the SIP-CP which also demonstrated adequate fit across RMSEA, CFI, and TLI, χ^2 (104) = 448.81, $p < .001$, RMSEA = .07, CFI = .92, TLI = .91. Physical dimension scores for SIP and SIP-CP were significantly correlated ($r = .95$, $p < .001$); subscale scores between the two versions were also significantly correlated (range: .85 -

.86; all *p*s < .001). The SIP and SIP-CP Physical dimension scores were also significantly correlated with all measures of patient functioning (see Table 2 for details). Overall, the magnitude of correlations with measures of patient functioning were equivalent between the SIP and SIP-CP, with the latter being marginally smaller in some cases. Internal consistency of the SIP-CP Physical dimension score was acceptable, Cronbach's α = .81.

Psychosocial dimension score. The original Psychosocial dimension score consisted of 48 items across four subscales (Communication, Alertness Behavior, Emotional Behavior, and Social Interaction) which demonstrated good fit on RMSEA and close to adequate fit on both the CFI and TLI, χ^2 (1080) = 2484.19, $p < .001$, RMSEA = .04, CFI = .88, TLI = .87. As previously described, IRT analyses were able to shorten and retain all four subscales with adequate fit consistent across RMSEA, CFI, and TLI. In total, there were 26 items retained for the SIP-CP Psychosocial dimension score with adequate model fit across indices, χ^2 (299) = 1002.50, $p < .001$, RMSEA = .06, CFI = .89, TLI = .89. As was the case with the Physical dimension scores, Psychosocial dimension scores for the SIP and SIP-CP were significantly correlated ($r = .96$, $p < .001$); subscale scores between the two versions were also significantly correlated (range: .86 - .95; all *p*s < .001). The SIP and SIP-CP Psychosocial dimension scores were both significantly correlated with all included measures of patient functioning (see Table 3 for details). Consistent with the findings for the Physical dimension scores, the overall magnitude of correlations with measures of patient functioning were close between the SIP and SIP-CP, with the only difference being that the SIP-CP correlations were marginally smaller in all cases. Internal consistency of the dimension score was acceptable, with Cronbach's α = .86.

Independence/other dimension score. The original Independence/other dimension score contained 43 items across five subscales (Sleep and Rest, Home Management, Work, Recreation and Pastimes, and Eating) and demonstrated poor model fit, χ^2 (779) = 3714.93, $p < .001$, RMSEA = .07, CFI = .58, TLI = .55. Work and Home Management were removed due to a lack of adequately performing items, while the remaining three subscales (Sleep and Rest, Recreation and Pastimes, and Eating) each demonstrated good fit at the subscale level. The resulting 12 item Independence/other dimension score, however, failed to achieve adequate model fit, χ^2 (54) = 241.09, $p < .001$, RMSEA = .07, CFI = .63, TLI = .55, with poor internal consistency (Cronbach's α = .48). Given the poor fit criteria, the dimension was discarded[2].

Total disability score. The total disability score of all 136 SIP items demonstrated unacceptable fit for all indices with the exception of RMSEA, χ^2 (8777) = 15509.41, $p < .001$, RMSEA = .03, CFI = .70, TLI = .69. Fit for total disability remained poor when using the two retained dimension scores of the SIP-CP, χ^2 (819) = 2883.33, $p < .001$, RMSEA = .06, CFI = .79, TLI = .78. Given poor fit for the total disability score across all versions tested (including a SIP-CP model with all three dimension scores – see Footnote 2), the total score was not retained as a scoring method for the SIP-CP. Instead, the Physical and Psychosocial Disability dimension scores were retained, and were significantly and moderately correlated with one another, $r = .47$, $p < .001$.

Regression Analyses. The final analyses consisted of a series of multiple linear regressions to compare the variance accounted for by the Physical and Psychosocial dimension scores of the SIP and SIP-CP in measures of patient functioning, after controlling for demographic and pain-related variables (i.e., participant age, sex, pain duration and pain

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[2]Attempts to integrate the Independence/other subscales with good fit into Physical and Psychosocial dimension scores were unsuccessful; all attempts to redistribute these subscales resulted in poorer (non-adequate) fit across CFI and TLI indices. Overall model fit for SIP-CP total disability score (54 items including Physical, Psychosocial and Independence/other dimension scores) was also poor, with only the RMSEA indicating adequate fit, χ^2 (1377) = 3481.84, $p < .001$, RMSEA = .05, CFI = .79, TLI = .78.

intensity). In each regression, age, sex, and pain duration were entered as a block in the first step, pain intensity was entered in the second step, and Physical and Psychosocial dimension scores were then entered as a block in the third step. All regression results are displayed in Table 3.

Variance accounted for by the SIP-CP was smaller than the SIP for five of the six measures of functioning, and equivalent for classes of pain medications. The magnitude of reductions in variance accounted for between the SIP and SIP-CP appeared modest with an average reduction of 2.7% across the five regression analyses (range of reduction = 0.7% for the number of medical visits related to pain to 7.3% for the BDI-II; values in table have been rounded). In each case, the variance accounted for by the SIP-CP remained statistically significant in the prediction of criterion variables.

The regression analyses were also conducted to investigate the utility of the SIP-CP in relation to other aspects of functioning that are important in those with chronic pain. The variance accounted for by the two domain scores of the SIP-CP independently accounted for an average r^2 of .31 across the four self-report measures (range r^2 = .15 for pain acceptance to .41 for the BCMDI) and was .06 for both the pain medications and pain-related medical visits variables. Significant regression coefficients were indicated across all six analyses. In most cases, both Physical and Psychosocial Disability had statistically significant coefficients with only two exceptions, including the regression coefficient of Physical Disability for the BDI (p = .06) and the coefficient of Psychosocial Disability for the pain medications variable (p = .29).

Discussion

The goal in the development of the SIP-CP was to create a shortened measure to reduce patient response burden while retaining as much of the breadth and depth of the clinical information captured by the SIP as possible. Previous attempts to shorten the SIP have all relied on classical test theory, a test-centered approach that presumes a linear relationship in which the test score is the sum of a respondent's true score and error score. Item response theory, in contrast, uses nonlinear mathematical models to describe the relationship between the likelihood of endorsing an item and level of the underlying latent trait (Embretson & Reise, 2000). The use of IRT in the present analyses allowed items to be evaluated in a way that has not been a part of previous attempts to shorten the SIP and remains absent in many other measures of disability for chronic pain.

With the focus on retaining a full range of clinical information, item selection was based on model fit at the subscale level. Good model fit across RMSEA, CFI, and TLI indices were initially obtained for 10 of the 12 subscales in the original SIP, with adequate psychometric support to retain seven of the 12 original subscales in the final SIP-CP. Physical and Psychosocial dimension scores demonstrated adequate model fit according to RMSEA, CFI, and TLI fit indices, while the Independence/other disability score and the total disability score had poor fit with the data and were both dropped from the SIP-CP and further analyses. Overall, the regression analyses suggest a reasonable tradeoff between patient burden and breadth of clinical information, as a 69.1% reduction in the number of items from the SIP (136 items) to the SIP-CP (42 items) was associated with an average loss of only 2.7% of the variance in measures of patient functioning, including depression, pain-related anxiety, pain acceptance, classes of pain medications, and number of pain-related medical visits over the previous six months. Psychometric characteristics of the SIP-CP, as measured by internal consistency and fit indices, were also greatly improved relative to the SIP. In sum, these results appear to provide robust support for the utility of the SIP-CP.

As part of the evaluation process, two subscales, Work and Home Management, were dropped from further analysis as an adequate fitting set of items could not be specified. Eventually, the Independence/Other dimension score was also dropped due to clearly poor fitting models. Unfortunately, these exclusions involved areas of importance in chronic pain. In the case of the Work subscale, the original construction was a likely culprit for unacceptable performance, as respondents were instructed to skip eight of nine items if the initial item (“I am not working at all") was positively endorsed. It may be that a single item of work disability (assessing employment/unemployment in a similar manner) is enough to provide useful information in this area. Certainly current work status is a useful marker regarding current functioning and treatment outcomes (Hoffman, Papas, Chatkoff, & Kerns, 2007; Vowles, Gross, & Sorrell, 2004; Wideman & Sullivan, 2011).

The exclusion of the Home Management subscale, and eventually the Independence/other dimension score, including the Sleep and Rest, Eating, and Recreation and Pastimes subscales, suggest that there is potentially room for the development of additional items or subscales for the SIP-CP directed at these areas. While the development of new items was not a part of the present step toward questionnaire development, it could certainly be addressed in future data collection. As discussed previously, the IRT approach is particularly well suited to both identification of "high performing" items and constructing subscales that make use of such items. While the exclusion of poorly performing item sets presents potential limitations in terms of the breath of information provided, the fact that the SIP-CP accounted for variance rates that were remarkably similar to the SIP suggests that the loss of these items did not contribute to substantial losses in convergent validity.

There are several objectives to pursue in the future with regard to the utility of the SIP-CP. Although measurements in IRT are based on items rather than the sample, there is still a need to ensure the heterogeneity of this sample by testing whether the factor structure of the SIP-CP can be replicated in another large, independent sample of individuals seeking treatment for chronic pain. Formal testing of the local independence assumption for dimension scores should examine whether there are highly similar or highly correlated items across subscales, while testing for parameter invariance by examining differential item functioning across groups (by age, sex, socioeconomic status, pain duration, etc.) would further establish whether the SIP-CP can be applied to a broader population of individuals with chronic pain. Sensitivity to treatment-related change, a strength of the original SIP, should also be examined in the SIP-CP. In addition, the

SIP-CP does not include item weights, as those used in the SIP were based on expert judgment, rather than empirical inquiry. Further efforts to determine and test empirically supported item weights, like those generated through IRT methods by Lindeboom and colleagues (2004), may be of use.

Finally, tests examining the relative utility of the SIP-CP in relation to other measures of disability may be informative. For example the SF-36 (Ruta, Garratt, Abdalla, Buckingham, & Russell, 1993) and US National Institutes of Health-sponsored PROMIS Pain Interference (Amtmann et al., 2010) measures, along with many other options, are available and it is not clear that the item burden of the SIP-CP, which is greater than most other available measures, offers more useful or broad information with regard to assessing changes in individual patient functioning. Our clinical experience suggests that the SIP (and now SIP-CP) provides a richer source of information and stands to offer greater utility clinical and research endeavors, but future work will have to evaluate the accuracy of those observations empirically.

There are limitations to consider. First, the majority of data collected were self-report and there may be inaccuracies in reporting or recall. Second, item selection prioritized the maximization of fit at the level of the subscale (rather than at the level of the dimension or total scores). This decision was pragmatic in nature given the need to have an overarching organizational structure during the evaluation of 136 items. That being said, it is possible that item evaluation at higher order levels may have identified a differing item set. As noted, the results of the regression analyses suggest that the pragmatic decision to focus on subscale level of analysis did not contribute to substantial losses at the level of relations with other measures of functioning. In addition, we did not collect data across multiple time points, which precludes evaluation of temporal stability (e.g., test-retest reliability) or change over time. Finally, it is worth noting that this measure was developed in and intended for individuals with chronic pain actively seeking treatment for their condition. Accordingly, it may not be appropriate for use in those with less severe levels of disability.

To summarize, the present study found that an IRT derived shortened version of the SIP for individuals with chronic pain seeking treatment, the SIP-CP, was psychometrically supported and reduced patient response burden while accounting for a similar proportion of the variance across several measures of patient functioning. Two higher order dimension scores, Physical and Psychosocial Disability, were supported, along with seven lower-order subscale scores, including Body Care and Movement, Mobility, Ambulation, Communication, Alertness Behavior, Emotional Behavior, and Social Interaction. The performance of the SIP-CP warrants future use to further evaluate its validity and clinical utility in this area.

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Table 1

Item Selection Process for Mobility Subscale

Iteration	Original	1	2	3	4	Final
Item number & adjustment (+/-)	N/A	-7	-9	-10	-3	-5
χ^2	127.107	104.926	80.481	46.603	27.496	9.085
df	35	27	20	14	9	5
p-value	< .0001	< .0001	< .0001	< .0001	.0012	.1057
RMSEA	.060	.063	.065	.057	.053	.034
CFI	.926	.934	.937	.959	.973	.992
TLI	.905	.912	.912	.938	.955	.984

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Table 2

SIP and SIP-CP Correlations with Clinical Measures

	Physical Disability		Psychosocial Disability	
	SIP	SIP-CP	SIP	SIP-CP
Depression				
BDI-II (n = 355)	.40	.35	.67	.60
BCMDI (n = 358)	.52	.47	.73	.69
Pain-related anxiety	.44	.40	.55	.53
Pain-related acceptance	-.35	-.34	-.48	-.43
Classes of pain medication	.29	.29	.19	.17
Pain-related medical visits	.28	.26	.28	.26

Note. All correlations statistically significant, $p < .001$. $N = 723$ unless otherwise noted.

Table 3

Results of the Linear Regression Analyses for the SIP and SIP-CP Predicting Functioning

		SIP		SIP-CP	
Step	Predictor	Δ r^2	*B* (final)	Δ r^2	*B* (final)
		Depression – BDI-II			
1	Age	.03*	-.16***	.03*	-.18***
	Sex		.04		.04
	Pain Duration		.02		.03
2	Pain Intensity	.05***	.06	.05***	.05
3	Physical Disability	.40***	.03	.32***	.09$^+$
	Psychosocial Disability		.63***		.54***
	Total R^2	.47		.40	
		Depression – BCMDI			
1	Age	.02*	-.02	.02*	-.03
	Sex		-.05		-.05
	Pain Duration		-.02		-.02
2	Pain Intensity	.08***	.12**	.08***	.13***
3	Physical Disability	.45***	.11*	.41***	.15***
	Psychosocial Disability		.63***		.58***
	Total R^2	.56		.52	
		Pain-Related Anxiety			
1	Age	.01	< -.01	.01	-.01
	Sex		-.07$^+$		-.06
	Pain Duration		< .01		.01
2	Pain Intensity	.08***	.14***	.08***	.14***
3	Physical Disability	.26***	.14***	.25***	.16***
	Psychosocial Disability		.43***		.42***
	Total R^2	.34		.33	

(*Tables continues)*

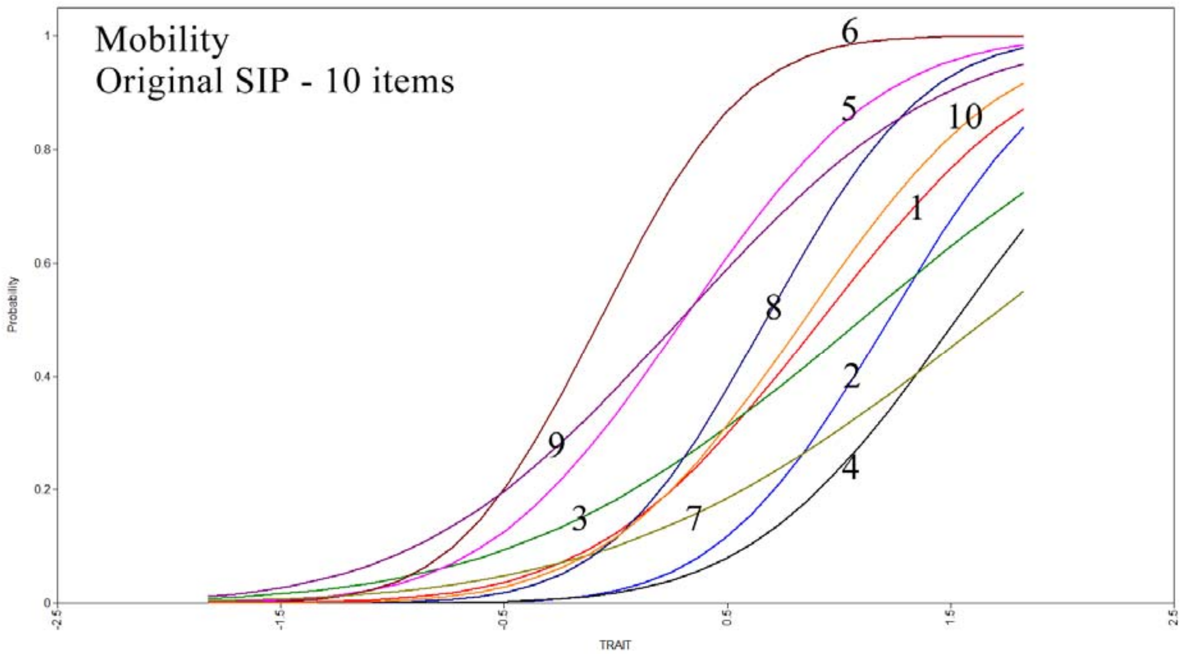
Table 3 (con't)

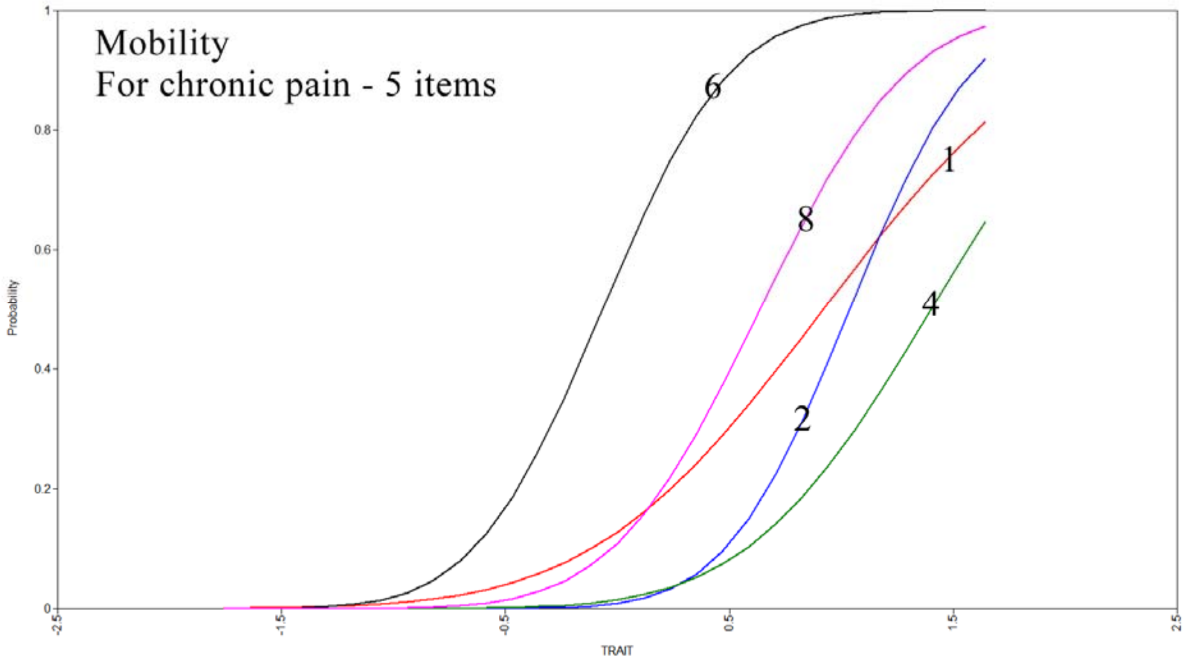
		SIP		SIP-CP	
Step	Predictor	Δr^2	*B* (final)	Δr^2	*B* (final)
		Pain Acceptance			
1	Age	.04***	.03	.04***	.04
	Sex		.18***		.18***
	Pain Duration		< .01		< .01
2	Pain Intensity	.06***	-.14***	.06***	-.14***
3	Physical Disability	.18***	-.08$^+$	.15***	-.15***
	Psychosocial Disability		-.39***		-.32***
	Total R^2	.29		.26	
		Classes of Pain Medication			
1	Age	< .01	.02	< .01	.02
	Sex		-.03		-.02
	Pain Duration		-.02		-.01
2	Pain Intensity	.04***	.10*	.04***	.10**
3	Physical Disability	.06***	.24***	.06***	.23***
	Psychosocial Disability		.03		.04
	Total R^2	.10		.10	
		Pain-Related Medical Visits			
1	Age	.01*	-.11***	.01*	-.12***
	Sex		<.01		.01
	Pain Duration		.03		.03
2	Pain Intensity	.04***	.11**	.04***	.11**
3	Physical Disability	.07***	.16***	.06***	.15***
	Psychosocial Disability		.15***		.16***
	Total R^2	.12		.12	

+ $p \leq .10$, * $p \leq .05$, ** $p \leq .005$, ***$p \leq .001$

Figure 1

Item Characteristic Curves for SIP and SIP-CP Mobility Subscale





SIP for Chronic Pain (SIP-CP)

PLEASE RESPOND TO (TICK) ONLY THOSE STATEMENTS THAT YOU ARE SURE DESCRIBE YOU TODAY AND ARE RELATED TO YOUR STATE OF HEALTH.

EB

1 ☐ I say how bad or useless I am, for example, that I am a burden to others.

2 ☐ I laugh or cry suddenly.

3 ☐ I often moan and groan in pain or discomfort.

5 ☐ I act nervous or restless.

7 ☐ I act irritable and impatient with myself; for example, I talk badly about myself, swear at myself, and blame myself for things that happen.

9 ☐ I get sudden frights.

BCM

1 ☐ I make difficult moves with help, for example, getting into or out of cars, the bath.

2 ☐ I do not move in or out of a bed or chair by myself but am moved by another person or mechanical aid.

6 ☐ I stand up only with someone's help.

14 ☐ I do not bathe myself completely, for example, I require assistance with bathing

17 ☐ I have trouble getting shoes, socks, stocking on.

19 ☐ I do not fasten my clothing, for example, I require assistance with buttons, zippers, and shoelaces.

23 ☐ I get dressed only with someone's help.

☐ **TICK HERE WHEN YOU HAVE READ ALL STATEMENTS ON THIS PAGE**

This group of statements is to do with anything you usually do in caring for your home or garden. Considering just those things that you do, please respond by ticking only those statements that you are sure describe you today and are related to your state of health.

M

1 ☐ I am getting around only within one building.

2 ☐ I stay within one room.

4 ☐ I am staying in bed most of the time.

6 ☐ I stay at home most of the time.

8 ☐ I am not going in to town.

SI

3 ☐ I show less interest in other people's problems, for example, I don't listen when they tell me about their problems, I don't offer to help.

4 ☐ I often act irritable to those around me, for example, snap at people, give sharp answers, criticize easily.

5 ☐ I show less affection.

9 ☐ My sexual activity is decreased.

12 ☐ I make many demands, for example, insist that people do things for me, tell them how to do things.

15 ☐ I have frequent outbursts of anger at family members, for example, strike at them, scream, or throw things at them.

20 ☐ I am not joking with my family members as I usually do.

A

2 ☐ I do not walk up or down hills.

3 ☐ I use stairs only with mechanical support, for example, handrails, stick, crutches.

7 ☐ I walk by myself, but with some difficulty, for example, limp, wobble, stumble, have stiff legs.

11 ☐ I get around only by using a walker, crutches, stick, walls, or furniture.

☐ **TICK HERE WHEN YOU HAVE READ ALL STATEMENTS ON THIS PAGE**

AB

1 ☐ I am confused and start several actions at a time.

3 ☐ I react slowly to things that are said or done.

4 ☐ I do not finish things that I start.

5 ☐ I have difficulty reasoning and solving problems, for example, making plans, making decisions, learning new things.

8 ☐ I do not keep my attention on activities for long.

9 ☐ I make more mistakes than usual.

10 ☐ I have difficulty doing activities that involve concentration and thinking.

C

1 ☐ I am having trouble writing or typing.

2 ☐ I communicate mostly by gestures, for example, moving head, pointing, sign language.

4 ☐ I often lose control of my voice when I talk; for example, my voice gets louder, or softer, trembles, changes unexpectedly

7 ☐ I have difficulty speaking, for example, get stuck, stutter, stammer, slur my words.

8 ☐ I am understood with difficulty.

9 ☐ I do not speak clearly when I am under stress.

Now can you please review the questions to be certain that you have filled out all the information?

Look at the last tick box on each sheet to make sure that you have not missed a page.

☐ **TICK HERE WHEN YOU HAVE READ ALL STATEMENTS ON THIS PAGE**

Supplementary Table 1

Summary of Psychometric Data (N = 723)

	Mean	SD
Classes of pain medication	2.680	1.500
Medical visits for pain in the last 6 months	6.726	7.159
SIP total disability	.265	.128
Physical dimension	.231	.151
Body Care and Movement	.215	.164
Mobility	.228	.202
Ambulation	.273	.171
Psychosocial dimension	.272	.169
Communication	.105	.143
Alertness Behavior	.378	.302
Emotional Behavior	.330	.229
Social interaction	.270	.189
Independence/Other dimension	.299	.114
Sleep and Rest	.261	.174
Home Management	.359	.224
Work	.570	.250
Recreation and Pastimes	.343	.193
Eating	.046	.067
Depression[a]		
BDI-II (n=355)	20.575	9.891
BCMDI (n=358)	26.879	14.555
Pain-related anxiety (PASS-20)	47.594	19.184
Pain-related acceptance (CPAQ)	47.175	18.764

[a] Depression measures changed midway through data collection; participants received either the BDI-II or BCMDI, but not both.

Supplementary Table 2

Item Selection Process for Ambulation Subscale

Iteration	Original	1	2	3	4	5	6	7	8	9	10	Final
Item number & adjustment (+/-)	N/A	-6	-5	-10	-4	-8	-1	+1, -7	-1	-12	+7	-9
χ^2	838.16	663.11	328.46	157.91	126.57	107.55	86.32	90.80	62.80	13.88	37.15	3.402
df	54	44	35	27	20	14	9	9	5	2	5	2
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	.001	<.0001	.1825
RMSEA	.142	.140	.108	.082	.086	.096	.109	.112	.127	.091	.094	.031
CFI	.648	.685	.839	.926	.936	.941	.936	.928	.931	.977	.955	.997
TLI	.570	.607	.793	.901	.911	.912	.893	.882	.862	.930	.911	.991

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 3

Item Selection Process for Body Care and Movement Subscale

Iteration	Original	1	2	3	4	5	6	7	8	9	10	11
Item number & adjustment (+/-)	N/A	-12	-16	-3	-21	-18	-11	+18, +11, -7	-22	-18	-11	-20
χ^2	731.95	679.36	676.45	614.7	511.39	494.45	462.37	403.49	285.1	265.29	229.42	214.49
df	230	209	189	170	152	135	119	135	119	104	90	77
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
RMSEA	.055	.056	.060	.060	.057	.061	.063	.052	.044	.046	.046	.050
CFI	.890	.898	.898	.905	.921	.920	.992	.939	.960	.961	.961	.965
TLI	.869	.887	.886	.893	.911	.909	.911	.931	.955	.954	.954	.958

(Table continues)

Supplementary Table 3 (con't)

Iteration	12	13	14	15	16	17	18	19	20	21	22	23	Final
Item number & adjustment (+/-)	-8	-5	-6	-15	+6, +15, -4	-9	-10	-13	-6	-15	+6, +15, -19	-15	+19
χ^2	207.66	178.84	174.01	90.01	114.09	97.37	60.90	47.42	39.65	27.51	42.08	32.03	36.652
df	65	54	44	35	44	35	27	20	14	9	14	9	14
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	.0002	.0005	.0003	.0012	.0001	.0002	.0008
RMSEA	.055	.057	.064	.047	.047	.050	.042	.044	.050	.053	.053	.060	.047
CFI	.962	.965	.961	.983	.979	.981	.988	.990	.990	.992	.986	.987	.991
TLI	.954	.958	.951	.978	.974	.976	.984	.986	.984	.986	.979	.979	.986

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 4

Item Selection Process for Communication Subscale

Iteration	Original	1	2	Final
Item number & adjustment (+/-)	N/A	-6	-3	-5
χ^2	64.931	51.404	46.389	17.139
df	27	20	14	9
p-value	.0001	.0001	<.0001	.0466
RMSEA	.044	.047	.057	.035
CFI	.951	.959	.957	.988
TLI	.935	.943	.935	.980

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 5

Item Selection Process for Alertness Behavior Subscale

Iteration	Original	1	2	Final
Item number & adjustment (+/-)	N/A	-2	-7	-6
χ^2	80.075	55.384	46.167	25.038
df	35	27	20	14
p-value	<.0001	.001	.008	.0342
RMSEA	.065	.054	.060	.047
CFI	.975	.985	.985	.992
TLI	.968	.980	.978	.989

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 6

Item Selection Process for Emotional Behavior Subscale

Iteration	Original	1	2	3	4	Final
Item number & adjustment (+/-)	N/A	-6	-3	-8	+3, +8 -2	+2, -8
χ^2	113.591	48.069	39.869	25.811	40.366	33.259
df	27	20	14	9	14	14
p-value	<.0001	.0004	.0003	.0022	.0002	.0026
RMSEA	.067	.044	.051	.051	.051	.044
CFI	.914	.969	.969	.973	.962	.972
TLI	.885	.957	.953	.955	.943	.959

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 7

Item Selection Process for Social Interaction Subscale

Iteration	Original	1	2	3	4	5	6	7
Item number & adjustment (+/-)	N/A	-2	-13	-11	-10	-1	-7	-6
χ^2	748.09	631.60	568.40	527.25	491.34	362.78	231.23	201.88
df	170	152	135	119	104	90	77	65
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
RMSEA	.069	.066	.067	.069	.072	.065	.053	.054
CFI	.862	.883	.888	.875	.874	.904	.941	.945
TLI	.846	.868	.873	.857	.854	.888	.931	.934

(Table continues)

Supplementary Table 7 (con't)

Iteration	8	9	10	11	12	13	14	Final
Item number & adjustment (+/-)	-19	-8	-16	-18	-14	-15	-9	+15, +9, -17
χ^2	156.97	118.24	82.56	69.64	34.38	9.87	6.24	30.72
df	54	44	35	27	20	14	9	14
p-value	<.0001	<.0001	<.0001	<.0001	.0237	.7714	.7154	.0061
RMSEA	.051	.048	.043	.047	.032	<.0001	<.0001	.041
CFI	.956	.963	.972	.974	.988	1	1	.983
TLI	.946	.953	.964	.966	.983	1.006	1.005	.974

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 8

Selection Process for Sleep and Rest Subscale

Iteration	Original	1	2	Final
Item number & adjustment (+/-)	N/A	-1	-6	-5
χ^2	104.115	12.647	11.369	2.368
df	14	9	5	2
p-value	<.0001	.1792	.0445	.3061
RMSEA	.094	.024	.042	.016
CFI	.430	.957	.925	.988
TLI	.145	.928	.851	.964

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 9

Selection Process for Recreation and Pastimes Subscale

Iteration	Original	1	2	3	Final
Item number & adjustment (+/-)	N/A	-4	-8	-3	-7
χ^2	279.454	252.094	52.936	12.772	4.792
df	20	14	9	5	2
p-value	<.0001	<.0001	<.0001	.0256	.0911
RMSEA	.134	.153	.082	.046	.044
CFI	.549	.591	.905	.981	.991
TLI	.368	.386	.841	.961	.974

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

Supplementary Table 10

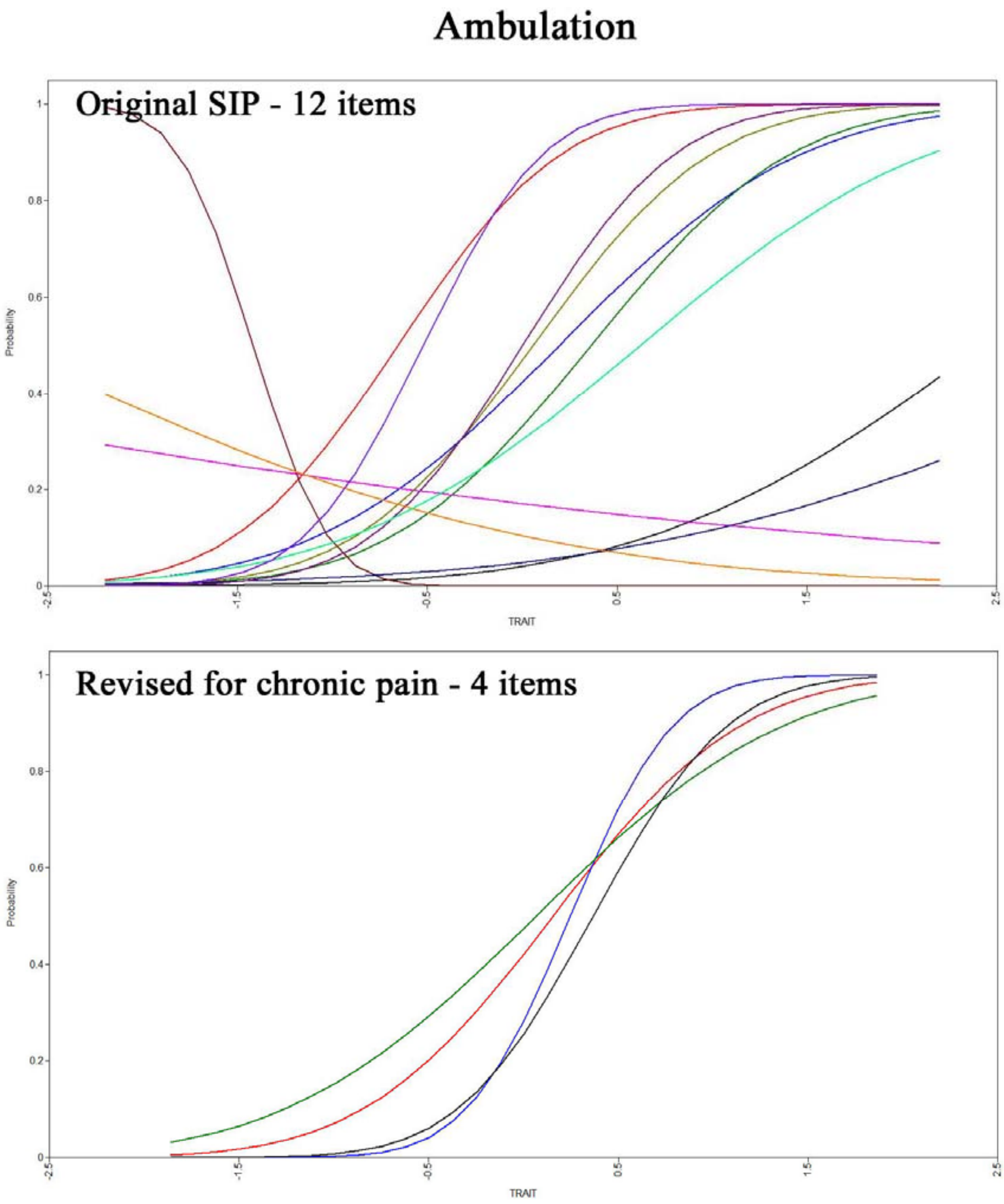
Selection Process for Eating Subscale

Iteration	Original	1	2	3	Final
Item number & adjustment (+/-)	N/A	-3	-4	-7	+7, -2
χ^2	21.495	13.773	7.133	0.872	2.588
df	14	9	5	2	2
p-value	.0896	.1306	.2109	.6468	.2742
RMSEA	.027	.027	.024	<.0001	.020
CFI	.948	.967	.984	1	.996
TLI	.922	.945	.969	1.025	.988

Note. RMSEA <.05, CFI >.95, TLI >.95 constitute good fit.

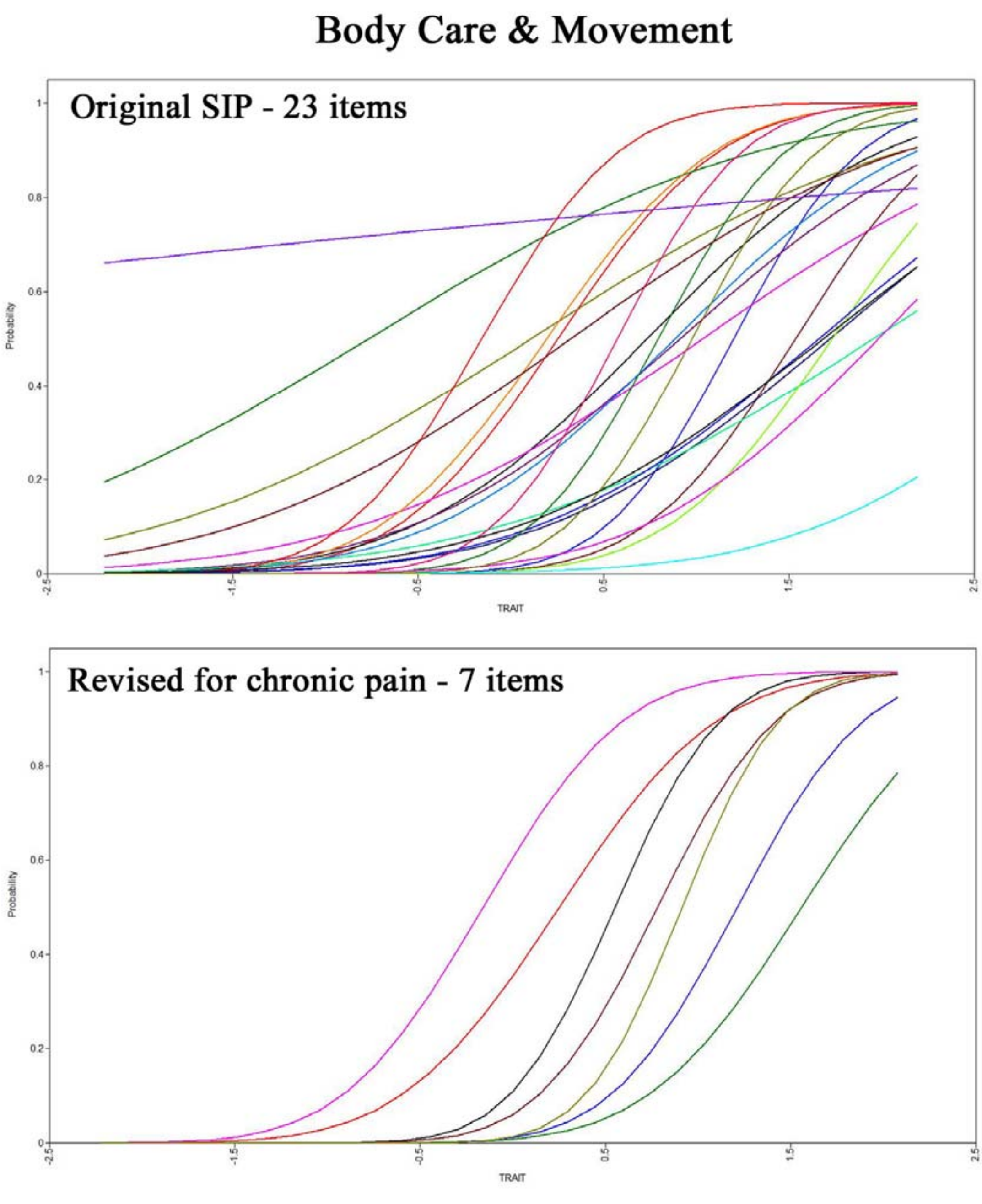
Supplementary Figure 1

Item Characteristic Curves for SIP and SIP-CP Ambulation Subscale



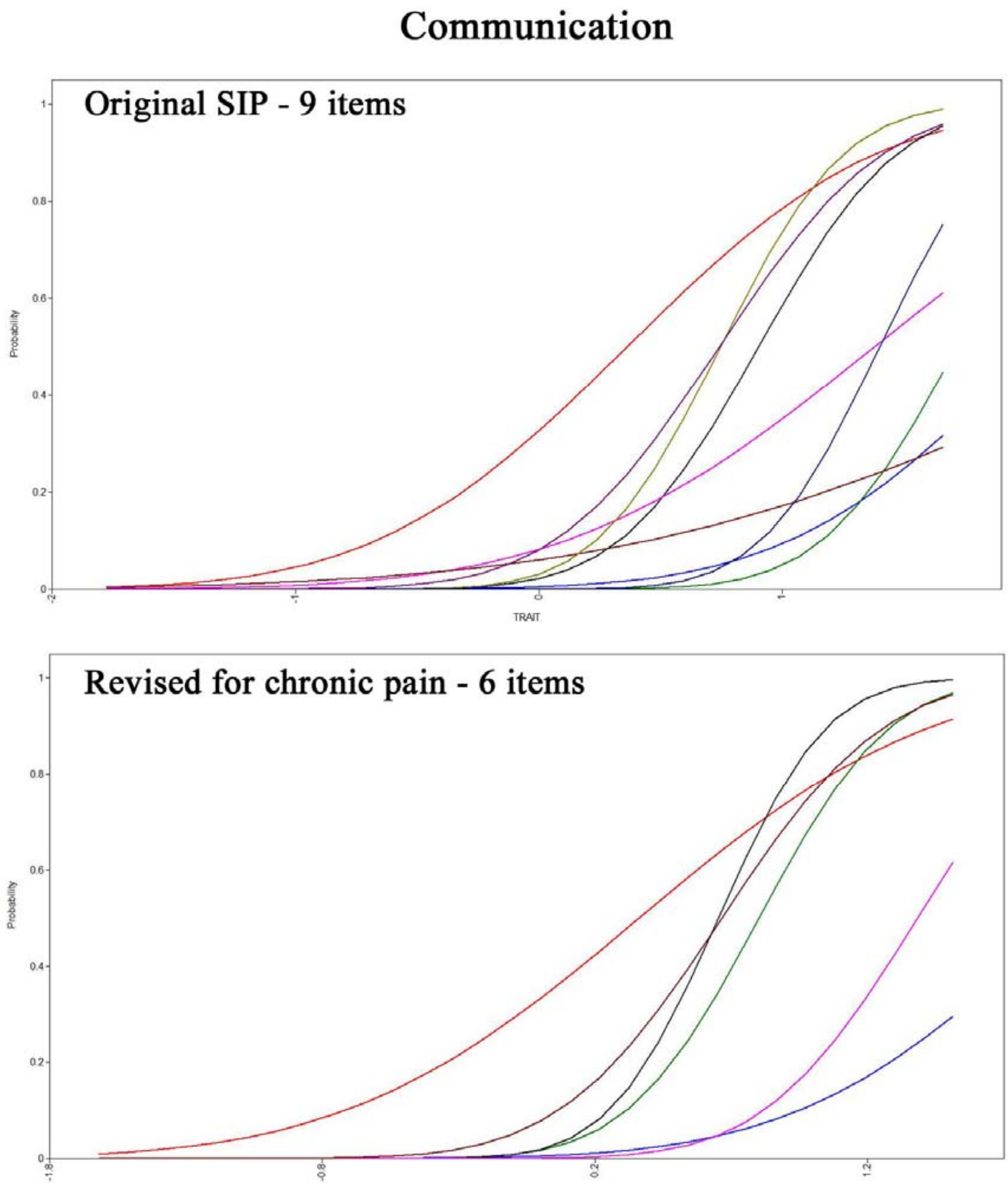
Supplementary Figure 2

Item Characteristic Curves for SIP and SIP-CP Body Care and Movement Subscale



Supplementary Figure 3

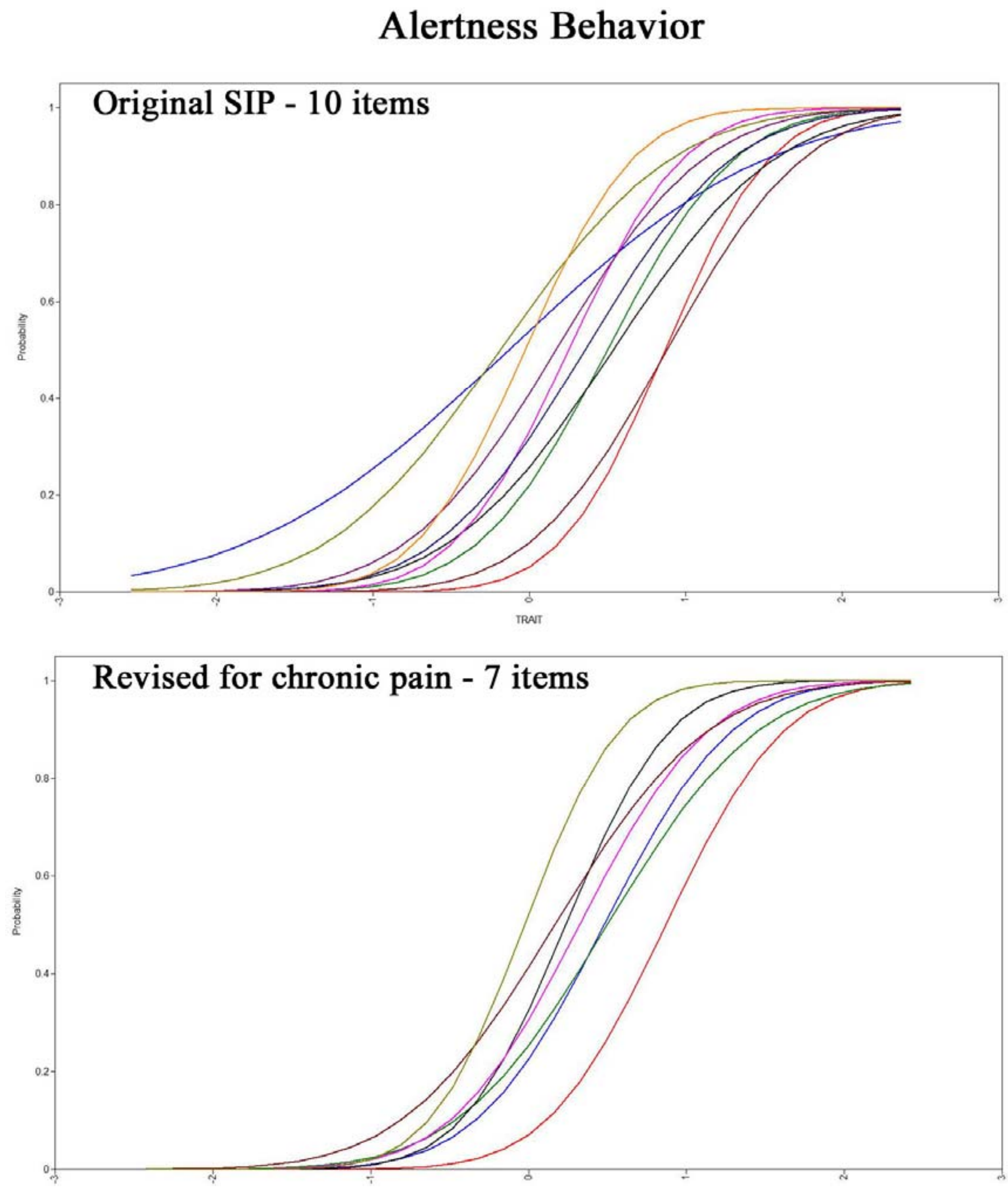
Item Characteristic Curves for SIP and SIP-CP Communication Subscale



Note. Scale changes along X-axis.

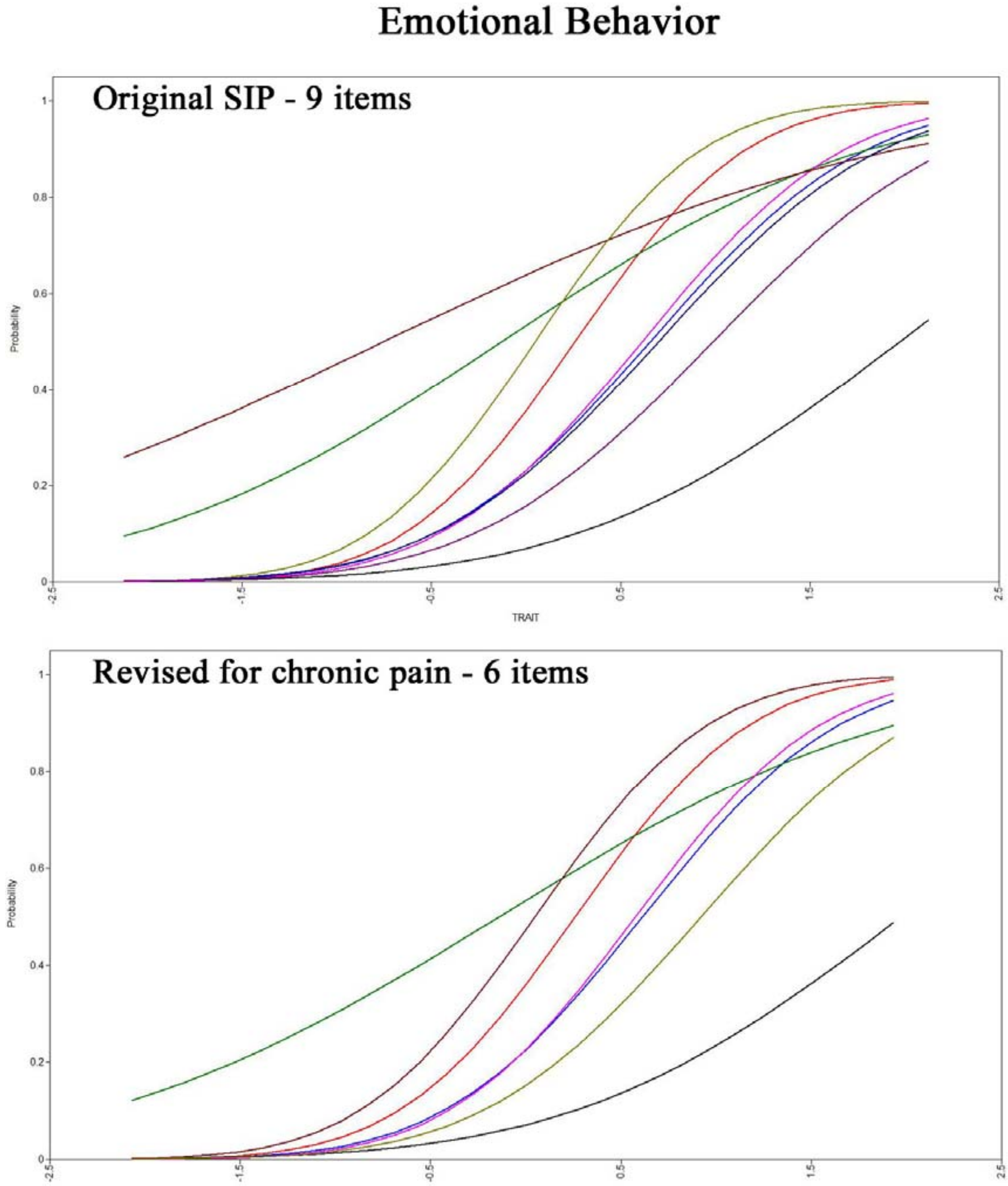
Supplementary Figure 4

Item Characteristic Curves for SIP and SIP-CP Alertness Behavior Subscale



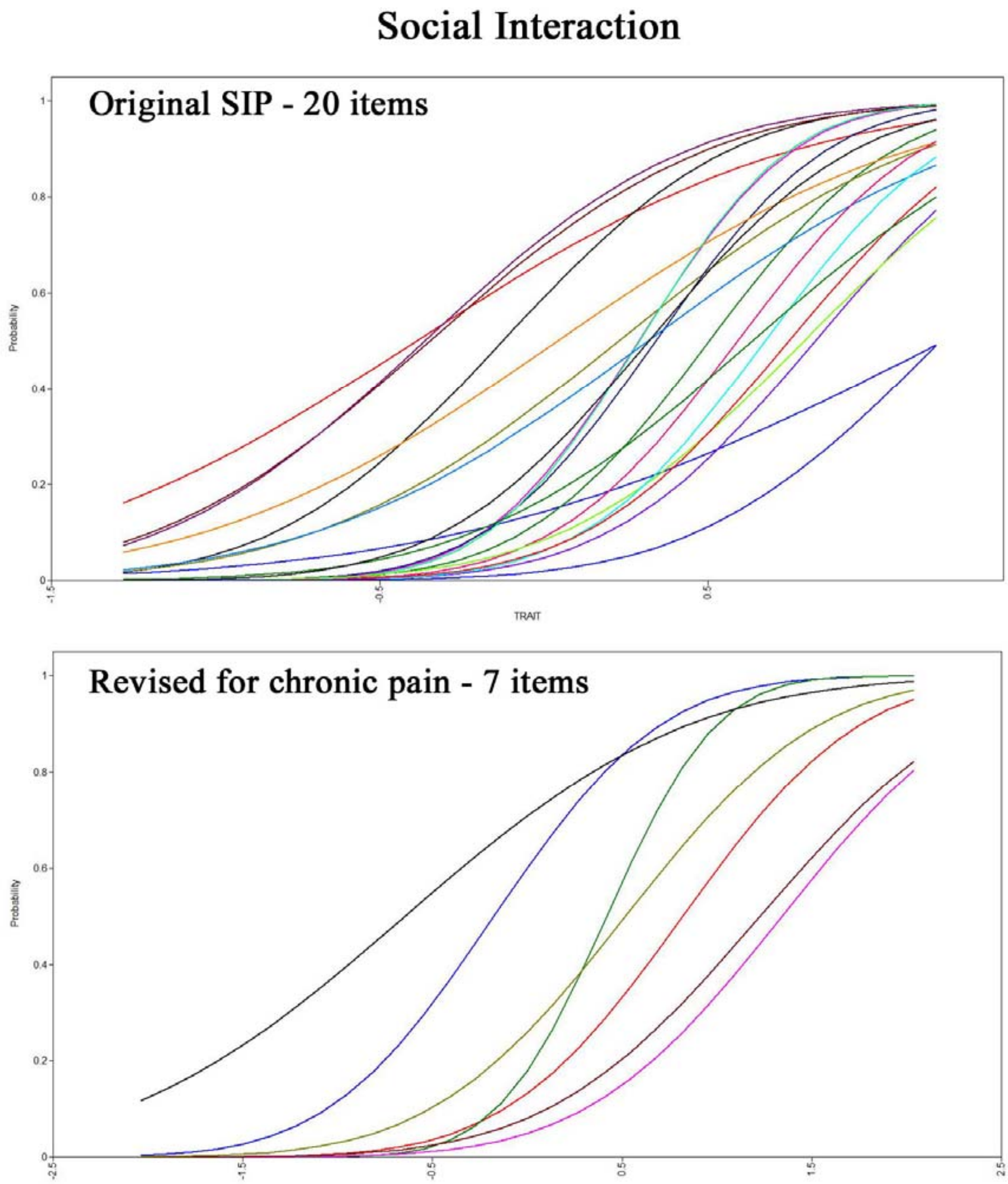
Supplementary Figure 5

Item Characteristic Curves for SIP and SIP-CP Emotional Behavior Subscale



Supplementary Figure 6

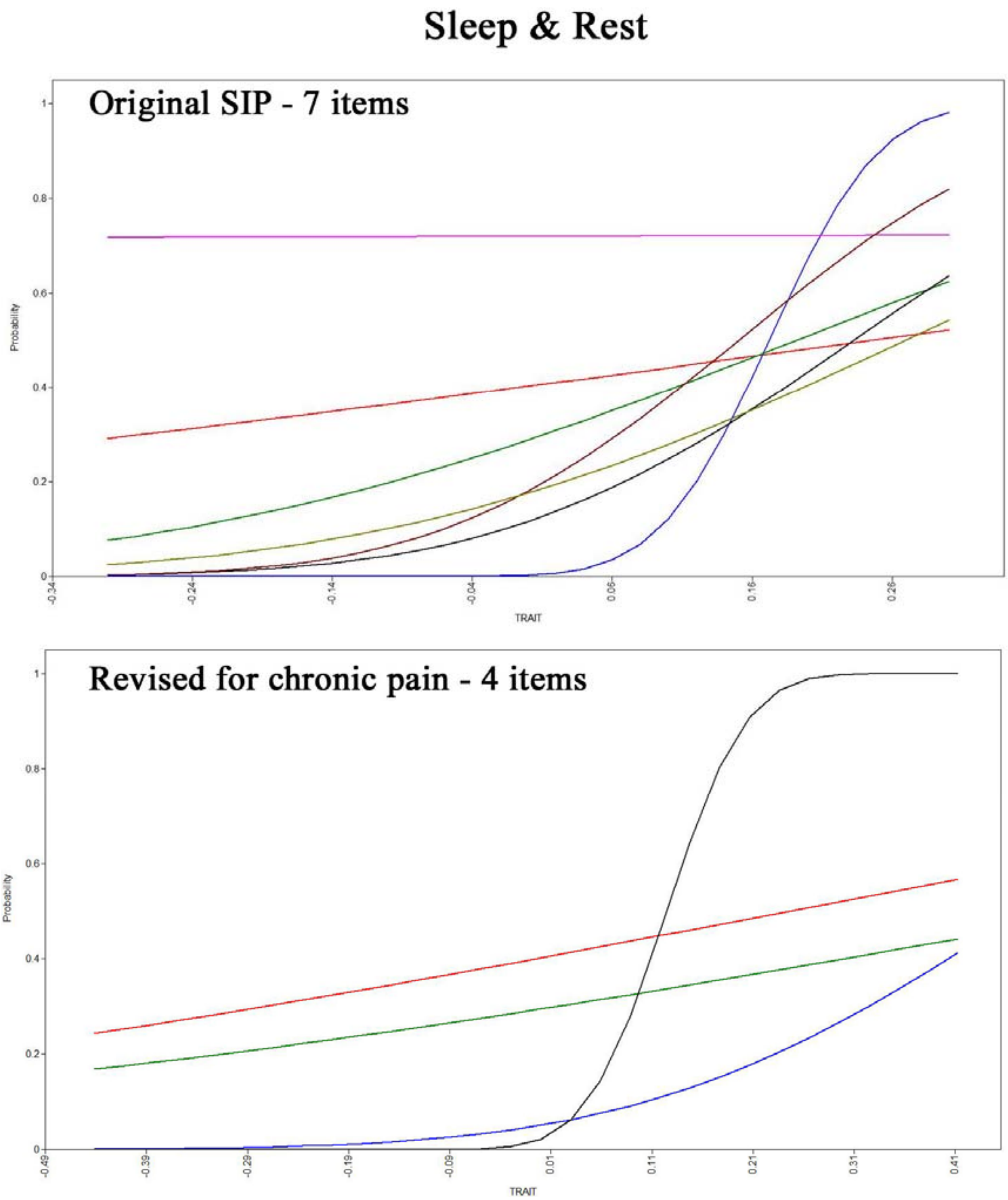
Item Characteristic Curves for SIP and SIP-CP Social Interaction Subscale



Note. Scale changes along X-axis.

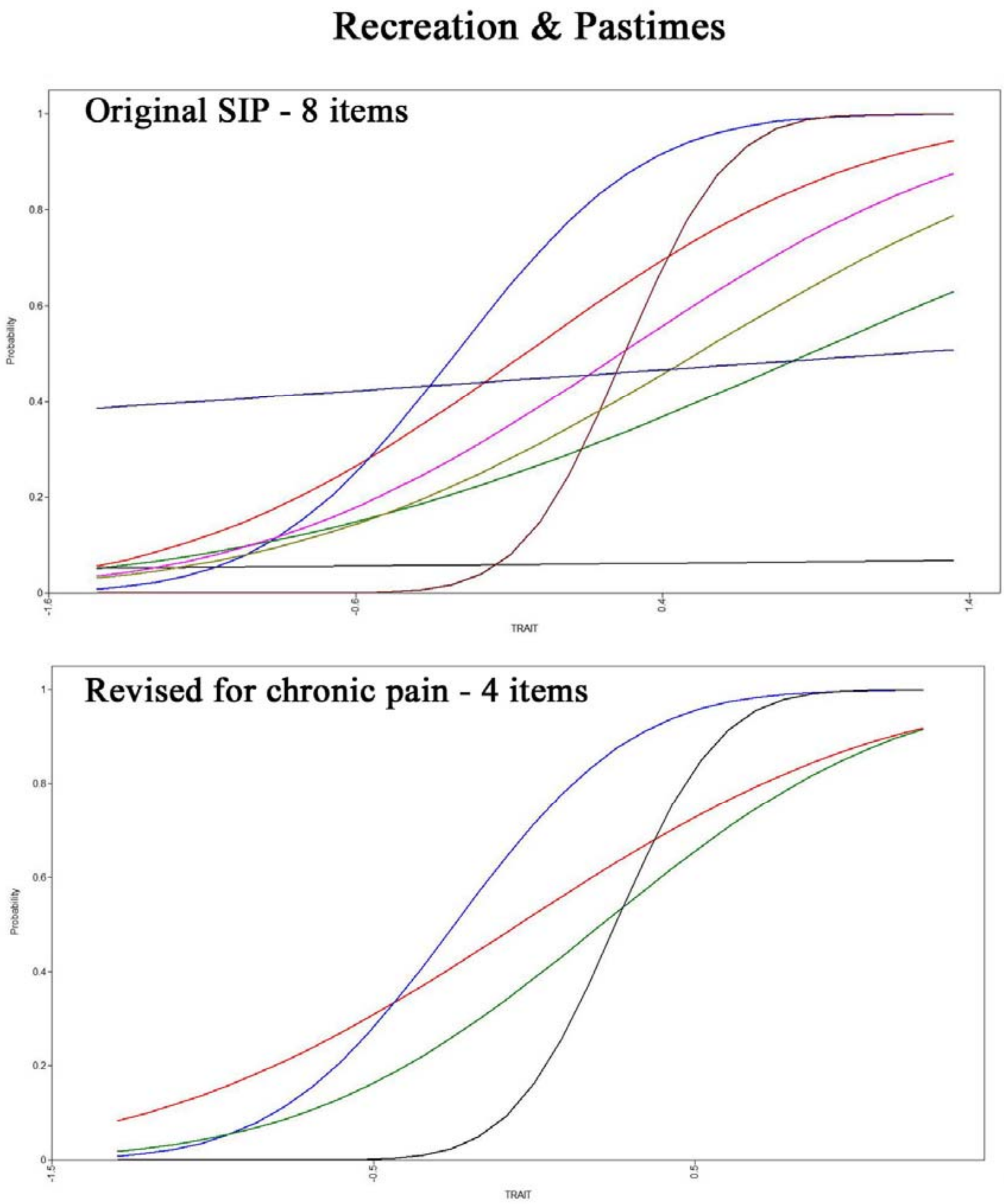
Supplementary Figure 7

Item Characteristic Curves for SIP and SIP-CP Sleep and Rest Subscale



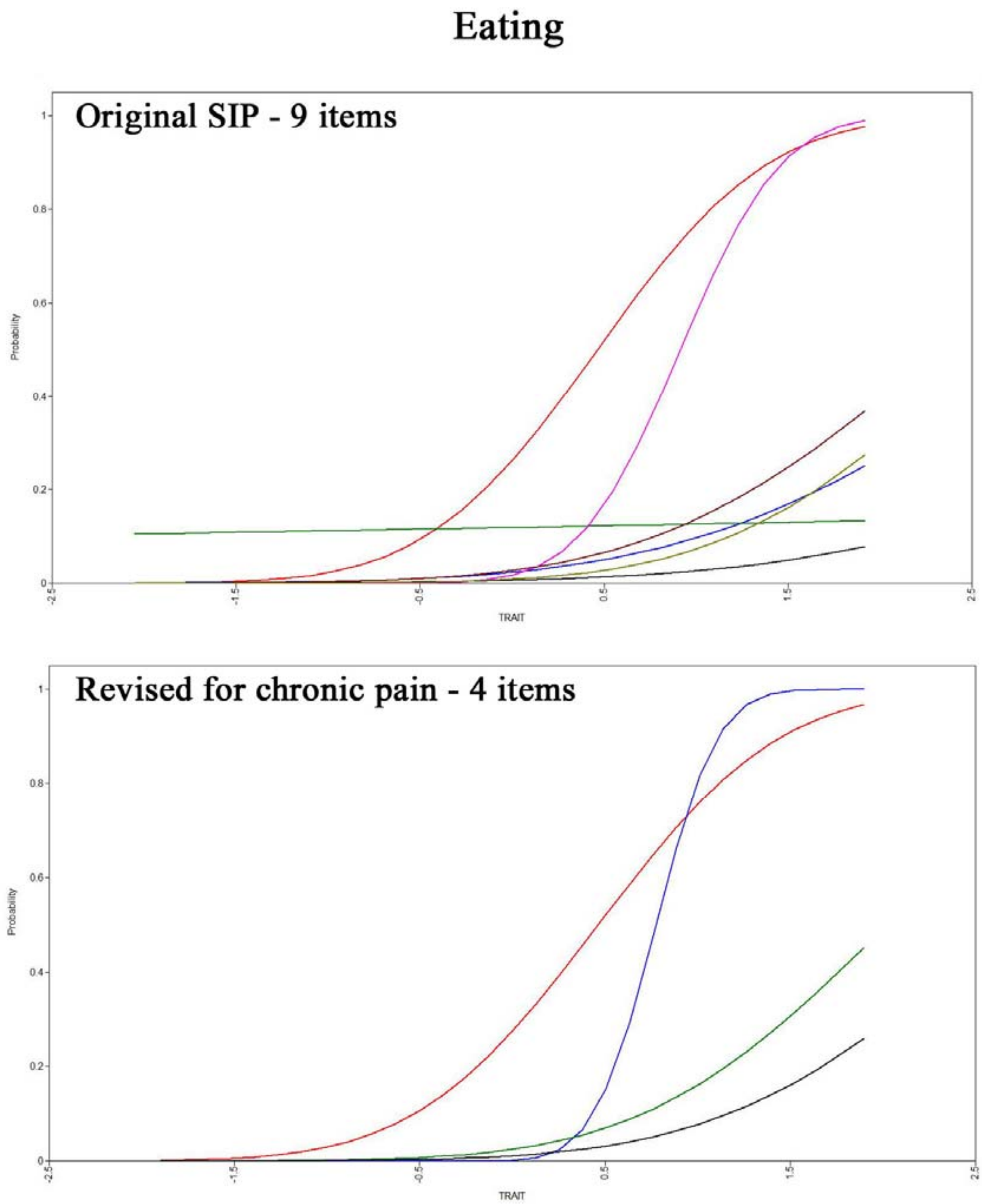
Supplementary Figure 8

Item Characteristic Curves for SIP and SIP-CP Recreation and Pastimes Subscale



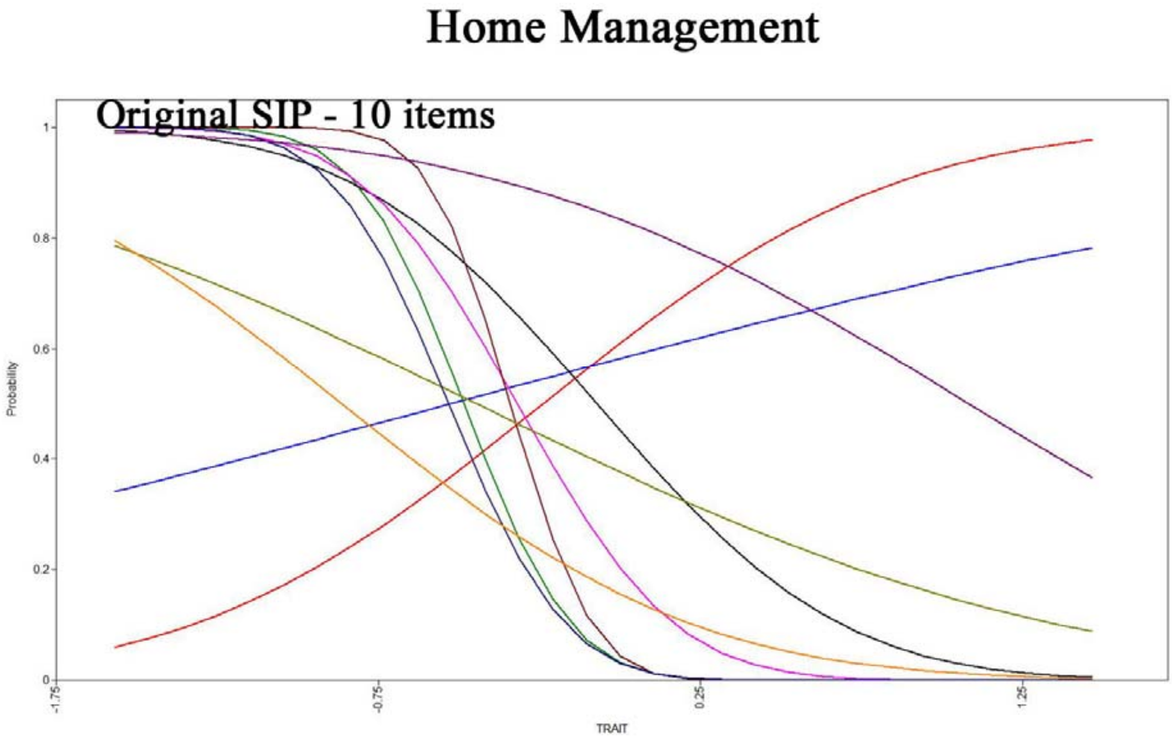
Supplementary Figure 9

Item Characteristic Curves for SIP and SIP-CP Eating Subscale



Supplementary Figure 10

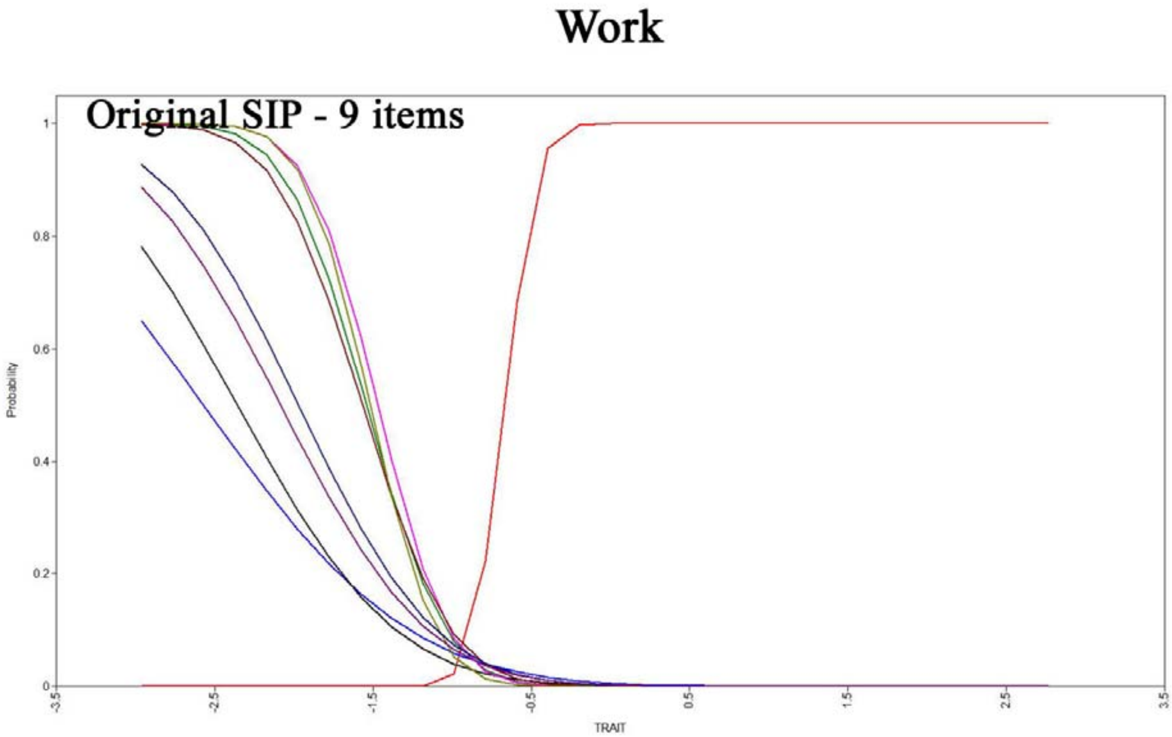
Item Characteristic Curves for SIP Home Management Subscale



Note. Subscale dropped from SIP-CP due to lack of adequately performing items (indicated by S-shaped curves) needed to define the model.

Supplementary Figure 11

Item Characteristic Curves for SIP Work Subscale



Note. Subscale dropped from SIP-CP due to lack of adequately performing items (indicated by S-shaped curves) needed to define the model.

Development of a Chronic Pain Specific Version of the Sickness Impact Profile

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ABSTRACT

Objective: Given the prevalence and complexity of chronic pain, there is a need for measures of disability that: (1) provide comprehensive, useful clinical information with regard to patient functioning, and (2) do so as briefly as possible to minimize respondent burden. The primary objective of this study was to reduce the length of a well-known, highly detailed measure of disability, the 136-item Sickness Impact Profile (SIP), and develop a psychometrically sound short form for use in chronic pain (SIP for Chronic Pain, SIP-CP). **Methods:** A 2-parameter logistic item response theory model was used to develop the SIP-CP in a sample of adults presenting for treatment at an interdisciplinary rehabilitation program (N = 723). Items were assessed for inclusion at the subscale level; poorly contributing items were removed sequentially and model fit was evaluated at each step until adequate fit was achieved. Finally, linear regressions examined the variance accounted for by the SIP-CP in relation to the full-length SIP in measures of patient functioning. **Results:** The SIP-CP contains 42 items that yield seven subscale scores and two summary dimension scores, Physical and Psychosocial disability. Acceptable reliability and evidence of convergent and divergent validity were demonstrated for each component. The SIP-CP accounted for a similar amount of the variance in measures of depression, pain-related anxiety, pain acceptance, classes of prescribed analgesics, and pain-related medical visits as the full-length SIP. **Conclusions:** The SIP-CP appears to provide robust clinical information with little loss of association with other key aspects of functioning, while substantially lowering response burden.

*Keywords***:** chronic pain, assessment, item response theory, disability, functioning, Sickness Impact Profile

Development of a chronic pain specific version of the Sickness Impact Profile

Chronic pain affects an estimated 100 million adults in the US, more than the total affected by heart disease, cancer, and diabetes combined (Gaskin & Richard, 2012), and can be highly complex and debilitating. In contrast to acute pain, chronic pain persists beyond the expected time for healing and does not appear to serve any adaptive function (Ashburn & Staats, 1999). The impacts of chronic pain can be substantial and widespread, often leading to significant disability across multiple domains of functioning (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Fredheim et al., 2008; Gaskin & Richard, 2012; Gatchel, Peng, Peters, Fuchs, & Turk, 2007). Reducing disability is therefore a priority goal for treatment.

Broadly speaking, there is no single measure that serves as the gold standard for assessing disability in chronic pain, particularly for non-headache pain (De Bruin, De Witte, Stevens, & Diederiks, 1992; Jensen, Turner, Romano, & Fisher, 1999). One of the most established measures of illness-related disability is the Sickness Impact Profile (Bergner, Bobbitt, Carter, & Gilson, 1981). The SIP was designed to provide a broad assessment of how illness disrupts daily activities in physical, psychological, and social domains (Bergner, 1993; Bergner et al., 1981; Bergner, Bobbitt, Kressel, et al., 1976; Bergner, Bobbitt, Pollard, Martin, & Gilson, 1976). Completion of the 136-item measure yields an overall score indicating total disability, three dimension scores assessing Physical, Psychosocial, and Independence/other disability, and 12 subscale scores including Ambulation, Mobility, Body Care and Movement, Communication, Alertness Behavior, Emotional Behavior, Social Interaction, Sleep and Rest, Eating, Work, Home Management, and Recreation and Pastimes. All scores range from 0 to 1 with higher scores representing greater disability due to health concerns. To date, few alternative measures are as thorough and informative as the SIP.

The SIP has been widely used in the area of chronic pain, where it appears to provide a broader and more detailed assessment of patient functioning than other clinical assessments (De Bruin et al., 1992; Lindeboom et al., 2004; Lipsett et al., 2000; Watt-Watson & Graydon, 1989). From a psychometric perspective, the SIP has demonstrated acceptable content and criterion validity along with good test-retest reliability in chronic pain (Deyo, Inui, Leininger, & Overman, 1982; Deyo, Inui, Leininger, & Overman, 1983; Follick, Smith, & Ahern, 1985; Sullivan, Ahlmen, & Bjelle, 1990). The SIP has also demonstrated good sensitivity and specificity in chronic pain, with the ability to detect clinically and statistically significant changes in functioning (Deyo & Inui, 1984; Follick et al., 1985; Sullivan et al., 1990; Vowles & McCracken, 2008; Vowles, Witkiewitz, Sowden, & Ashworth, 2014).

While the SIP appears useful in chronic pain settings, there are at least four key limitations. First, the factor structure has not been supported (De Bruin, Diederiks, De Witte, Stevens, & Philipsen, 1994; Lindeboom et al., 2004; Nanda, McLendon, Andresen, & Armbrecht, 2003). Second, the scoring method includes potentially arbitrary item weights, which were based on healthcare provider judgments of severity. Lacking empirical support, this may contribute to the aforementioned factor instability (De Bruin et al., 1994; Lindeboom et al., 2004; MacKenzie, Charlson, DiGioia, & Kelley, 1986; Pollard & Johnston, 2001). Third, the SIP includes items that may not be widely pertinent to chronic pain and therefore add unnecessarily to the response burden (Deyo, 1986; Deyo et al., 1982). Fourth and finally, the SIP is lengthy, requiring substantial time to complete and score, which makes it less acceptable to patients and providers (Busija et al., 2011; Damiano, 1996; De Bruin, Diederiks, De Witte, Stevens, & Philipsen, 1997; Deyo et al., 1983; Lipsett et al., 2000; Read, Quinn, & Hoefer, 1987). At present, the only abbreviated version of the SIP specific to chronic pain is the Roland Morris Disability Questionnaire (Roland & Fairbank, 2000; Roland & Morris, 1983), which covers only a limited range of activities in the physical functioning domain and does not assess psychological or social functioning (Stratford, Solomon, Binkley, Finch, & Gill, 1993).

To summarize, the SIP has a number of strengths regarding use in chronic pain, chiefly the broad clinical information that it provides and extensive assessment across areas of functioning. It also has a number of limitations, including factor structure, relevance of certain items for this population, and length. The current study sought to derive a chronic pain specific version of the SIP, the SIP-CP, which retains the strengths of the original SIP while minimizing the limitations. Notably, prior studies failing to replicate the factor structure of the SIP have relied on classical test theory (CTT) methodology. The present study utilized item response theory (IRT) to evaluate and reduce items, a psychometric method widely used in education assessment which allows for more complex (nonlinear) models. In addition, a series of follow-up correlation and regression analyses were performed to evaluate the association of the SIP-CP, both alone and in contrast to the original SIP, with key aspects of patient functioning, including depression, pain-related anxiety, pain acceptance, classes of prescribed analgesics, and number of pain-related medical visits.

Method

Participants

Participants included 723 patients presenting for treatment at an interdisciplinary pain treatment center in the United Kingdom between 2005 and 2012. Prior to an individual intake interview with a psychologist, all participants completed a battery of self-report questionnaires. The study was approved by the Bath and Northeast Somerset NHS Research Ethics Board. The sample was primarily White European (97.5%), female (65.7%), and married (63%). Mean participant age was 46.4 years (*SD* = 12.1) and mean education was 12.3 years (*SD* = 2.5). Median duration of pain was 84 months (ranging from 7 to 660); many patients were not currently working (50.6%) or had retired early (20.8%) due to pain. The most commonly reported pain site was lower back (48%), followed by lower limbs (14.6%), full body (11.7%), and upper limbs (10.5%). Reported average pain intensity over the past week on a 0 (no pain) to 10 (maximal pain possible) rating scale was 7.2 (*SD* = 1.8).

Measures

Demographic and clinical information. Demographic variables collected included participant age, sex, years of education, employment status, and ethnic/racial background. Self-reported pain-related data included duration of pain in months, location(s) of pain, average pain intensity over the past week, and the number of medical visits over the past six months related to pain. Analgesic medications were tallied via chart review with the total number of classes of analgesic medications (e.g., opioids, NSAIDS, tricyclic antidepressants, muscle relaxants, sedatives, anticonvulsants, selective serotonin reuptake inhibitors, over-the-counter analgesics) taken for pain coded according to the British National Formulary (bnf.org).

Sickness Impact Profile (Bergner et al., 1981). As noted, the 136 items of the SIP are written in a yes/no response format, with a “yes” response indicating greater disability. Respondents are asked to indicate which items apply to them on a given day in relation to their current health.

Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). The BDI-II is a 21-item measure of depression with well-established psychometric properties (Beck, Steer, & Carbin, 1988). Scores range from 0 to 63 with larger values indicating more severe symptoms. Of note, the treatment program changed measures of depression midway through the collection of data for this study, so BDI-II data was available for only a subset of 355 individuals. Cronbach's alpha in the sample was .88.

British Columbia Major Depression Inventory (BCMDI; Iverson & Remick, 2004). The BCMDI is a 16-item index of depression based on the Diagnostic and Statistical Manual for Mental Disorders-IV (DSM-IV; American Psychiatric Association, 2000) criteria for Major Depressive Disorder. Scores range from 0 to 120 with higher scores indicating more severe symptoms. The BCMDI has demonstrated adequate internal consistency, test-retest reliability, and good sensitivity and specificity (Iverson & Remick, 2004). Due to changes in measure selection for depression, BCMDI data was available for a subset of 358 individuals who did not complete the BDI-II. Cronbach's alpha for the BCMDI in the sample was .86.

Pain Anxiety Symptoms Scale-20 (PASS-20; McCracken & Dhingra, 2002). The PASS-20 is a 20 item measure of fear, anxiety, and avoidance responses specific to pain. Scores range from 0 to 100 with higher scores indicating greater symptoms. The PASS-20 is strongly correlated with the original 40-item PASS (McCracken, Zayfert, & Gross, 1992) and other measures of functioning and has demonstrated strong internal consistency and reliability with good predictive and construct validity (McCracken & Dhingra, 2002; Roelofs et al., 2004). Cronbach's alpha was .85 in this sample.

Chronic Pain Acceptance Questionnaire (CPAQ; McCracken, Vowles, & Eccleston, 2004). The CPAQ is a 20-item measure of pain-related acceptance. Total scores range from 0 to 120 with higher scores indicating greater acceptance and have been significantly correlated with measures of physical and emotional functioning. The measure has demonstrated adequate factor structure as well as acceptable internal consistency and test-retest reliability (McCracken & Eccleston, 2005; McCracken et al., 2004; Vowles, McCracken, McLeod, & Eccleston, 2008). Cronbach's alpha for the CPAQ total score was .73 for this sample.

Statistical Analyses

All IRT analyses were performed using Mplus software (Muthén & Muthén, 2012). Correlation and regression analyses were performed using SPSS, Version 21 (IBM Corporation).

IRT analyses of the SIP subscales. An IRT approach was used to examine the relative usefulness of each item and guide selection of items for a shortened version of the SIP specific for a treatment seeking chronic pain population. IRT utilizes mathematical models that describe the relation between an individual's response to an item and their level of the hypothetical latent trait being assessed in probabilistic terms (Hays, Morales, & Reise, 2000), and provides the opportunity to either select items that provide an accurate assessment across the entire range of a trait or items that provide maximum discriminatory value surrounding a critical range of a trait (e.g., a clinical cutoff score). In the present study, the goal was to minimize patient burden by reducing the length of the measure while capturing as much breadth of clinical information as possible. Accordingly, IRT was used to identify items that weren't providing any significant information about the trait of interest (i.e., disability associated with chronic pain) and could therefore be eliminated, as well as items which provided an accurate assessment across a broad range of disability in chronic pain and should therefore be retained.

Given that the item weights of the original SIP were arbitrarily determined during its construction by healthcare providers and have not been psychometrically supported, no item weights were used.

Core fundamental assumptions for using IRT include unidimensionality and local independence, which were verified by examining eigenvalues during preliminary exploratory factor analysis. Other assumptions of IRT include monotonicity, which requires that the probability of endorsing an item increases along with increases in the underlying latent trait, and parameter invariance across groups, which allows for the comparing of scores across respondents endorsing different items and modeling change over time (Hays et al., 2000). Accordingly, item response theory is well suited for the selection of items to retain on a measure. Advantages of IRT in the present study include the use of non-linear modeling (as opposed to the linear relation presumed in CTT) and the ability to estimate a trait of interest (disability in chronic pain) with fewer items (Hays et al., 2000).

Given the forced choice format of the SIP (i.e., yes/no), a two-parameter logistic IRT model was used to provide estimates for two independent aspects of each item: difficulty and discrimination value. Within IRT, the difficulty and discrimination of each item is graphically represented in an item characteristic curve (ICC), a non-linear regression line representing the likelihood of endorsing that particular item as a function of the underlying trait. ICCs for dichotomous items like those on the SIP form an S-shaped curve; in the center of this curve, small changes in the level of the underlying trait are associated with large changes in the probability of endorsing that item (Embretson & Reise, 2000). The exact shape and location of the S-shaped curve for each item depends on the estimated difficulty and discrimination parameters; a reverse S-shaped curve indicates negative discrimination, which suggests a poorly performing item that is best excluded. Curves that form a straight horizontal line indicate that the item provides no discrimination or is undefined, while a straight vertical line indicates perfect discrimination just above and below that point, but no ability to distinguish between those with levels of the latent trait further above or below it. See Ainsworth (2011) for a detailed discussion.

Items were evaluated at the level of the subscale with the intent of maintaining the broad framework of the SIP. Inadequate items were removed individually based on manual inspection of ICCs. Because ICCs on a subscale are a function of how those items work together (and not just the sum of individual ICCs), subscale ICCs were re-evaluated after each step in the reduction process.

Fit was initially evaluated using chi-square analyses, with non-significant values indicating appropriate model fit. However, since the significance of χ^2 model fit tends to increase with larger sample sizes, the priority was to achieve consensus among root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI) fit indices. For RMSEA, good fit was defined as a test statistic ≤ .05, with values ≤ .08 considered adequate fit (Bryne, 2001). Good fit for CFI and TLI was defined by a test statistic ≥ .95, with adequate fit attained by values of ≥ .90 or larger (Hu & Bentler, 1999). Following the removal of all poorly functioning items as demonstrated by model fit indices and visual inspection of ICCs, chi-square difference tests were conducted to determine whether the removal of additional items significantly improved model fit across further iterations of the subscale. For instances in which two items shared the same ICC characteristics (suggesting potential redundancy), items were evaluated for uniqueness relative to other items and clinical relevance for chronic pain and retained or removed accordingly. Since this process was exploratory in nature, removal of items occasionally produced changes in ICCs which suggested that inclusion of that item may yield better model fit. In such cases, effects of re-adding these items to the subscale on ICCS and subsequent model fit were examined to determine whether they should be retained for the SIP-CP. This procedure was followed for each of the 12 original subscales of the SIP. In cases where item removal was straightforward (e.g., negatively sloping ICC), the item was removed without the need for study team discussion. In cases where there was ambiguity or where items shared ICC characteristics, the first and second authors made a joint determination of the most appropriate course of action in terms of item removal and retention.

Evaluation of SIP-CP Dimension and Total Scores. Following the evaluation of model fit of items at the subscale level, overall fit of the dimension scores (i.e., Physical, Psychosocial, and Independence/other disability) and total disability was assessed. To further aid in evaluation of the revised scores, correlation coefficients were calculated amongst the SIP and SIP-CP with the included measures of depression, pain-related anxiety, pain acceptance, classes of prescribed analgesics, and number of pain-related medical visits. Any dimension score that did not achieve adequate fit and was not correlated consistently with measures of functioning was removed from further analyses.

Finally, a series of linear regressions was performed to investigate the variance accounted for by the SIP and SIP-CP scores in measures of depression, pain-related anxiety, pain acceptance, number of classes of pain medications, and number of pain-related medical visits. These analyses served two primary purposes. The first was to examine whether there were differences in the amount of variance accounted for by the original SIP and the SIP-CP, since it is possible that a substantial reduction in the number of items on the SIP-CP would adversely affect variance accounted for in aspects of patient functioning. On the other hand, if the IRT analyses were useful in reducing the number of unimportant or redundant items on the SIP, then variance should not be greatly reduced on the SIP-CP. The second purpose of the regression analyses was to investigate aspects of convergent validity of the SIP-CP after controlling for relevant background variables, including gender, age, pain duration, and pain intensity.

Results

Descriptive Information

Means and *SD*s for all study measures are displayed in Supplementary Table 1[1]. All distributions appeared normally distributed with no evidence of kurtosis.

[1] Given that approximately half of the sample experienced low back pain, we investigated whether diagnosis or pain location was associated with differences in the measures utilized in the present study.

IRT Analyses of the SIP Subscales

The final version of the SIP-CP is displayed in the online Supplementary Appendix. The item reduction process is described below and a representative example is shown in Figure 1 and Table 1 for the Mobility subscale. Item reduction details for each subscale, which show step by step item removal and resultant model fit, as well as ICC details are available as supplementary files (Supplementary Tables 2-10; Supplementary Figures).

Mobility. The Mobility subscale assesses the range of one's ability to get around within and outside the home. The original subscale consisted of 10 items with adequate fit, χ^2 (35) = 127.11, $p <$ .001, RMSEA = .06, CFI = .93, TLI = .91. Following the IRT analyses displayed in Table 1, the subscale was reduced to five items with evidence of good fit, χ^2 (5) = 9.09, p = .106, RMSEA = .03, CFI = .99, TLI = .98). All ICC's are displayed in Figure 1. The figure displays ICC's for the original 10 items in the upper pane and the five retained items in the lower pane.

Ambulation. The Ambulation subscale assesses various aspects of walking (e.g., distance, speed, use of assistive devices). Model fit of the original 12 items was poor, χ^2 (2) = 838.16**,** $p \leq 0.001$, RMSEA = .14, CFI = .65, TLI = .57; indices for the four items retained for the SIP-CP indicated excellent fit, χ^2 (2) = 3.4**,** p = 0.18, RMSEA = .03, CFI = .99, TLI = .99.

Body Care and Movement. The Body Care and Movement subscale of the SIP assesses aspects of dressing (e.g., requiring full or partial assistance), standing (from sitting or lying down), and toileting behavior. The 23 items on the original subscale approached adequate fit, χ^2 (230) = 731.95, p

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Overall, differences were significant only for the number of classes of pain medications taken; those with back pain (M = 2.84, SD = 1.48) were taking significantly more medication classes than patients with pain in other areas (M = 2.53 SD = 1.51), t (716) = 2.79, p = .005. Similarly, patients with a spine or back-related diagnosis (M = 3.58, SD = 1.66) were taking significantly more medication classes than those with other diagnoses (M = 2.87, SD = 1.62), t (334) = 31.12, p = .002.

< .001, RMSEA = .06, CFI = .89, TLI = .88, while the seven items retained after IRT analyses demonstrated good fit, χ^2 (14) = 36.65, p < .001, RMSEA = .05, CFI = .99, TLI = .99.

Communication. The Communication subscale assesses difficulties with written (e.g., trouble writing or typing) and oral (e.g., difficulty speaking, understood with difficulty) communication. The nine items on the original subscale demonstrated good fit across RMSEA and CFI indices and adequate fit on the TLI, χ^2 (27) = 64.93, p < .001, RMSEA = .04, CFI = .95, TLI = .94. IRT analyses reduced this to six items with good fit, χ^2 (9) = 17.14, p < .001, RMSEA = .04, CFI = .99, TLI = .98.

Alertness Behavior. The Alertness Behavior subscale assesses difficulty with cognitive abilities often associated with executive functioning (e.g., confusion, forgetfulness, difficulty concentrating or sustaining attention). The original 10 items demonstrated good fit on CFI and TLI indices and adequate fit on RMSEA, χ^2 (35) = 130.64, p < .001, RMSEA = .06, CFI = .98, TLI = .97. IRT analyses reduced this to seven items which had good fit across indices, χ^2 (14) = 25.04, p < .001, RMSEA = .05, CFI = .99, TLI = .99.

Emotional Behavior. The Emotional Behavior subscale assesses various forms of psychological distress (e.g., acting nervous or restless, irritability and impatience, talking about hopelessness). The original nine items exhibited adequate fit, χ^2 (27) = 113.59, p < .001, RMSEA = .07, CFI = .91, TLI = .89; IRT analyses reduced this to six items that demonstrated good fit, χ^2 (14) = 33.26, p < .001, RMSEA = .04, CFI = .97, TLI = .96.

Social Interaction. The Social Interaction subscale assesses changes in the frequency and other aspects of social interactions with friends (e.g., going out less to visit people, avoiding social visits from others) and family members (e.g., have frequent outbursts of anger, not joking with family members the way I usually do, refuse contact with my family). The original 20 items failed to demonstrate adequate model fit, χ^2 (170) = 748.09, p < .001, RMSEA = .07, CFI = .86, TLI = .85. IRT analyses reduced this subscale to seven items which demonstrated good fit across all indices, χ^2 (14) = 30.72, p < .001, RMSEA = .04, CFI = .98, TLI = .97.

Sleep and Rest. The Sleep and Rest subscale assesses changes in sleep habits (e.g., spending much of the day lying down to rest, sleeping less at night). The original seven items indicated poor fit, χ^2 (14) = 104.12, $p < .001$, RMSEA = .09, CFI = .43, TLI = .15, while the revised four item subscale of the SIP-CP demonstrated good fit, χ^2 (2) = 2.37, $p < .001$, RMSEA = .02, CFI = .99, TLI = .96.

Home Management. The Home Management subscale assesses the degree to which one is able to perform typical household chores (e.g., doing less of the regular daily work around the house than usual, have given up taking care of personal/household business affairs such as paying bills, etc.). The original 10 item subscale failed to demonstrate adequate fit, χ^2 (35) = 412.80, $p < .001$, RMSEA = .12, CFI = .89, TLI = .85. More importantly, ICCs for eight of the 10 items included on this subscale were reverse S-shaped curves, indicating highly problematic items. Without a sufficient number of items left to define the model, the subscale was dropped from the SIP-CP.

Work. The original Work subscale of the SIP contains nine items assessing changes in work-related functioning (e.g., working shorter hours, taking frequent rests, not accomplishing as much as usual, acting irritable toward work associates). Notably, participants not currently working outside of the home are automatically scored as having a set level of disability in this area, regardless of their reason for not working (e.g., homemaker, retired not due to pain, etc.). Further, the original construction of this subscale was such that endorsement of item 1 ("I am not working at all") yielded a work disability score of .70 (as noted, on a 0 – 1 scale) with instructions to skip the remaining eight items of the subscale. Perhaps unsurprisingly, ICCs showed that these eight items were problematic as indicated by reverse S-shaped curves. With only the first item functioning as intended, a model for this subscale could not be properly defined and was thus dropped from the SIP-CP.

Recreation and Pastimes. The Recreation and Pastimes subscale assesses changes in the frequency and duration of engagement in personal hobbies or recreational activities (e.g., going out for entertainment less often, doing more inactive pastimes in place of my usual activities, not doing any of my usual inactive pastimes). The original eight item subscale demonstrated poor fit, χ^2 (20) = 279.45,

$p < .001$, RMSEA = .13, CFI = .55, TLI = .37. IRT analyses produced a four item subscale which demonstrated good fit, χ^2 (2) = 4.79, $p < .001$, RMSEA = .04, CFI = .99, TLI = .97.

Eating. The Eating subscale assesses one's ability to feed themselves (e.g., feed myself with the help of someone else, do not feed myself at all and must be fed) along with changes in eating habits (e.g., eating much less than usual, eating special or different foods, drinking less fluids). The original nine item subscale demonstrated good fit for both RMSEA and CFI with adequate fit on TLI, χ^2 (14) = 21.50, $p = .09$, RMSEA = .03, CFI = .95, TLI = .92. The revised four item Eating subscale demonstrated good fit across all indices, χ^2 (2) = 2.59, $p = .091$, RMSEA = .02, CFI = .99, TLI = .99.

Evaluation of SIP-CP Dimension and Total Disability Scores

Physical dimension score. The original Physical dimension score contained 45 items across three subscales (Mobility, Ambulation, and Body Care and Movement) which failed to demonstrate adequate model fit, χ^2 (945) = 3109.62, $p < .001$, RMSEA = .06, CFI = .78, TLI = .77. As previously described, IRT analyses were able to shorten and retain all three of these subscales with adequate fit consistent across RMSEA, CFI, and TLI at the subscale level. This produced the resulting 16 item Physical dimension score for the SIP-CP which also demonstrated adequate fit across RMSEA, CFI, and TLI, χ^2 (104) = 448.81, $p < .001$, RMSEA = .07, CFI = .92, TLI = .91. Physical dimension scores for SIP and SIP-CP were significantly correlated ($r = .95$, $p < .001$); subscale scores between the two versions were also significantly correlated (range: .85 - .86; all *p*s < .001). The SIP and SIP-CP Physical dimension scores were also significantly correlated with all measures of patient functioning (see Table 2 for details). Overall, the magnitude of correlations with measures of patient functioning were equivalent between the SIP and SIP-CP, with the latter being marginally smaller in some cases. Internal consistency of the SIP-CP Physical dimension score was acceptable, Cronbach's $\alpha = .81$.

Psychosocial dimension score. The original Psychosocial dimension score consisted of 48 items across four subscales (Communication, Alertness Behavior, Emotional Behavior, and Social Interaction) which demonstrated good fit on RMSEA and close to adequate fit on both the CFI and

TLI, χ^2 (1080) = 2484.19, *p* < .001, RMSEA = .04, CFI = .88, TLI = .87. As previously described, IRT analyses were able to shorten and retain all four subscales with adequate fit consistent across RMSEA, CFI, and TLI. In total, there were 26 items retained for the SIP-CP Psychosocial dimension score with adequate model fit across indices, χ^2 (299) = 1002.50, *p* < .001, RMSEA = .06, CFI = .89, TLI = .89. As was the case with the Physical dimension scores, Psychosocial dimension scores for the SIP and SIP-CP were significantly correlated (*r* = .96, *p* < .001); subscale scores between the two versions were also significantly correlated (range: .86 - .95; all *p*s < .001). The SIP and SIP-CP Psychosocial dimension scores were both significantly correlated with all included measures of patient functioning (see Table 3 for details). Consistent with the findings for the Physical dimension scores, the overall magnitude of correlations with measures of patient functioning were close between the SIP and SIP-CP, with the only difference being that the SIP-CP correlations were marginally smaller in all cases. Internal consistency of the dimension score was acceptable, with Cronbach's α = .86.

Independence/other dimension score. The original Independence/other dimension score contained 43 items across five subscales (Sleep and Rest, Home Management, Work, Recreation and Pastimes, and Eating) and demonstrated poor model fit, χ^2 (779) = 3714.93, *p* < .001, RMSEA = .07, CFI = .58, TLI = .55. Work and Home Management were removed due to a lack of adequately performing items, while the remaining three subscales (Sleep and Rest, Recreation and Pastimes, and Eating) each demonstrated good fit at the subscale level. The resulting 12 item Independence/other dimension score, however, failed to achieve adequate model fit, χ^2 (54) = 241.09, *p* < .001, RMSEA = .07, CFI = .63, TLI = .55, with poor internal consistency (Cronbach's α = .48). Given the poor fit criteria, the dimension was discarded[2].

[2]Attempts to integrate the Independence/other subscales with good fit into Physical and Psychosocial dimension scores were unsuccessful; all attempts to redistribute these subscales resulted in poorer (non-adequate) fit across CFI and TLI indices. Overall model fit for SIP-

Total disability score. The total disability score of all 136 SIP items demonstrated unacceptable fit for all indices with the exception of RMSEA, χ^2 (8777) = 15509.41, $p < .001$, RMSEA = .03, CFI = .70, TLI = .69. Fit for total disability remained poor when using the two retained dimension scores of the SIP-CP, χ^2 (819) = 2883.33, $p < .001$, RMSEA = .06, CFI = .79, TLI = .78. Given poor fit for the total disability score across all versions tested (including a SIP-CP model with all three dimension scores – see Footnote 2), the total score was not retained as a scoring method for the SIP-CP. Instead, the Physical and Psychosocial Disability dimension scores were retained, and were significantly and moderately correlated with one another, $r = .47$, $p < .001$.

Regression Analyses. The final analyses consisted of a series of multiple linear regressions to compare the variance accounted for by the Physical and Psychosocial dimension scores of the SIP and SIP-CP in measures of patient functioning, after controlling for demographic and pain-related variables (i.e., participant age, sex, pain duration and pain intensity). In each regression, age, sex, and pain duration were entered as a block in the first step, pain intensity was entered in the second step, and Physical and Psychosocial dimension scores were then entered as a block in the third step. All regression results are displayed in Table 3.

Variance accounted for by the SIP-CP was smaller than the SIP for five of the six measures of functioning, and equivalent for classes of pain medications. The magnitude of reductions in variance accounted for between the SIP and SIP-CP appeared modest with an average reduction of 2.7% across the five regression analyses (range of reduction = 0.7% for the number of medical visits related to pain

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CP total disability score (54 items including Physical, Psychosocial and Independence/other dimension scores) was also poor, with only the RMSEA indicating adequate fit, χ^2 (1377) = 3481.84, $p < .001$, RMSEA = .05, CFI = .79, TLI = .78.

to 7.3% for the BDI-II; values in table have been rounded). In each case, the variance accounted for by the SIP-CP remained statistically significant in the prediction of criterion variables.

The regression analyses were also conducted to investigate the utility of the SIP-CP in relation to other aspects of functioning that are important in those with chronic pain. The variance accounted for by the two domain scores of the SIP-CP independently accounted for an average r^2 of .31 across the four self-report measures (range $r^2 = .15$ for pain acceptance to .41 for the BCMDI) and was .06 for both the pain medications and pain-related medical visits variables. Significant regression coefficients were indicated across all six analyses. In most cases, both Physical and Psychosocial Disability had statistically significant coefficients with only two exceptions, including the regression coefficient of Physical Disability for the BDI ($p = .06$) and the coefficient of Psychosocial Disability for the pain medications variable ($p = .29$).

Discussion

The goal in the development of the SIP-CP was to create a shortened measure to reduce patient response burden while retaining as much of the breadth and depth of the clinical information captured by the SIP as possible. Previous attempts to shorten the SIP have all relied on classical test theory, a test-centered approach that presumes a linear relationship in which the test score is the sum of a respondent's true score and error score. Item response theory, in contrast, uses nonlinear mathematical models to describe the relationship between the likelihood of endorsing an item and level of the underlying latent trait (Embretson & Reise, 2000). The use of IRT in the present analyses allowed items to be evaluated in a way that has not been a part of previous attempts to shorten the SIP and remains absent in many other measures of disability for chronic pain.

With the focus on retaining a full range of clinical information, item selection was based on model fit at the subscale level. Good model fit across RMSEA, CFI, and TLI indices were initially obtained for 10 of the 12 subscales in the original SIP, with adequate psychometric support to retain seven of the 12 original subscales in the final SIP-CP. Physical and Psychosocial dimension scores demonstrated adequate model fit according to RMSEA, CFI, and TLI fit indices, while the Independence/other disability score and the total disability score had poor fit with the data and were both dropped from the SIP-CP and further analyses. Overall, the regression analyses suggest a reasonable tradeoff between patient burden and breadth of clinical information, as a 69.1% reduction in the number of items from the SIP (136 items) to the SIP-CP (42 items) was associated with an average loss of only 2.7% of the variance in measures of patient functioning, including depression, pain-related anxiety, pain acceptance, classes of pain medications, and number of pain-related medical visits over the previous six months. Psychometric characteristics of the SIP-CP, as measured by internal consistency and fit indices, were also greatly improved relative to the SIP. In sum, these results appear to provide robust support for the utility of the SIP-CP.

As part of the evaluation process, two subscales, Work and Home Management, were dropped from further analysis as an adequate fitting set of items could not be specified. Eventually, the Independence/Other dimension score was also dropped due to clearly poor fitting models. Unfortunately, these exclusions involved areas of importance in chronic pain. In the case of the Work subscale, the original construction was a likely culprit for unacceptable performance, as respondents were instructed to skip eight of nine items if the initial item ("I am not working at all") was positively endorsed. It may be that a single item of work disability (assessing employment/unemployment in a similar manner) is enough to provide useful information in this area. Certainly current work status is a useful marker regarding current functioning and treatment outcomes (Hoffman, Papas, Chatkoff, & Kerns, 2007; Vowles, Gross, & Sorrell, 2004; Wideman & Sullivan, 2011).

The exclusion of the Home Management subscale, and eventually the Independence/other dimension score, including the Sleep and Rest, Eating, and Recreation and Pastimes subscales, suggest that there is potentially room for the development of additional items or subscales for the SIP-CP directed at these areas. While the development of new items was not a part of the present step toward questionnaire development, it could certainly be addressed in future data collection. As discussed previously, the IRT approach is particularly well suited to both identification of “high performing” items and constructing subscales that make use of such items. While the exclusion of poorly performing item sets presents potential limitations in terms of the breath of information provided, the fact that the SIP-CP accounted for variance rates that were remarkably similar to the SIP suggests that the loss of these items did not contribute to substantial losses in convergent validity.

There are several objectives to pursue in the future with regard to the utility of the SIP-CP. Although measurements in IRT are based on items rather than the sample, there is still a need to ensure the heterogeneity of this sample by testing whether the factor structure of the SIP-CP can be replicated in another large, independent sample of individuals seeking treatment for chronic pain. Formal testing of the local independence assumption for dimension scores should examine whether there are highly similar or highly correlated items across subscales, while testing for parameter invariance by examining differential item functioning across groups (by age, sex, socioeconomic status, pain duration, etc.) would further establish whether the SIP-CP can be applied to a broader population of individuals with chronic pain. Sensitivity to treatment-related change, a strength of the original SIP, should also be examined in the SIP-CP. In addition, the SIP-CP does not include item weights, as those used in the SIP were based on expert judgment, rather than empirical inquiry. Further efforts to determine and test empirically supported item weights, like those generated through IRT methods by Lindeboom and colleagues (2004), may be of use.

Finally, tests examining the relative utility of the SIP-CP in relation to other measures of disability may be informative. For example the SF-36 (Ruta, Garratt, Abdalla, Buckingham, & Russell, 1993) and US National Institutes of Health-sponsored PROMIS Pain Interference (Amtmann et al., 2010) measures, along with many other options, are available and it is not clear that the item burden of the SIP-CP, which is greater than most other available measures, offers more useful or broad information with regard to assessing changes in individual patient functioning. Our clinical experience suggests that the SIP (and now SIP-CP) provides a richer source of information and stands to offer greater utility clinical and research endeavors, but future work will have to evaluate the accuracy of those observations empirically.

There are limitations to consider. First, the majority of data collected were self-report and there may be inaccuracies in reporting or recall. Second, item selection prioritized the maximization of fit at the level of the subscale (rather than at the level of the dimension or total scores). This decision was pragmatic in nature given the need to have an overarching organizational structure during the evaluation of 136 items. That being said, it is possible that item evaluation at higher order levels may have identified a differing item set. As noted, the results of the regression analyses suggest that the pragmatic decision to focus on subscale level of analysis did not contribute to substantial losses at the level of relations with other measures of functioning. In addition, we did not collect data across multiple time points, which precludes evaluation of temporal stability (e.g., test-retest reliability) or change over time. Finally, it is worth noting that this measure was developed in and intended for individuals with chronic pain actively seeking treatment for their condition. Accordingly, it may not be appropriate for use in those with less severe levels of disability.

To summarize, the present study found that an IRT derived shortened version of the SIP for individuals with chronic pain seeking treatment, the SIP-CP, was psychometrically supported and reduced patient response burden while accounting for a similar proportion of the variance across several measures of patient functioning. Two higher order dimension scores, Physical and Psychosocial Disability, were supported, along with seven lower-order subscale scores, including Body Care and Movement, Mobility, Ambulation, Communication, Alertness Behavior, Emotional Behavior, and Social Interaction. The performance of the SIP-CP warrants future use to further evaluate its validity and clinical utility in this area.

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