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Reading Words Hurts: The impact of pain sensitivity on people's ratings of pain-related words

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Abstract

This study explores the relation between pain sensitivity and the cognitive processing of words. 130 participants evaluated the pain-relatedness of a total of 600 two-syllabic nouns, and subsequently reported on their own pain sensitivity. The results demonstrate that pain-sensitive people (based on their self-report) associate words more strongly with pain than less sensitive people. In particular, concrete nouns like syringe, wound, knife, and cactus, are considered to be more pain-related for those who are more pain-sensitive. We discuss our results in the light of three theoretical frameworks – cognitive bias, prototype theory, embodied account. We argue that the latter is best suited to explain the results of this study in the sense in which it implies the principle of body specificity, according to which different bodily characteristics lead to corresponding differences in the way in which people construct concepts and word meanings.

Keywords: Pain, pain-sensitivity; semantic processing; cognitive biases; prototype theory; embodied account; body specificity.

Introduction

The last few decades have amassed data on the influence of affective states like emotions and pain on semantic processes, but also the reverse influence of semantic processes on the perception of emotional and painful stimuli. E.g., Dillmann et al. (2000) investigated the effects of different semantic primes on the processing of painful stimuli; using a sentence completion task, Rusu et al. (2012) demonstrated that participants with pain and depression exhibit a cognitive bias specific to negative aspects of health; Niedenthal et al. (1997) provide evidence that being in an emotional state facilitates responses to words categorically associated with that emotion. More recently, researchers have also focused on the impact of emotional *sensitivity* on the cognitive processing of emotion words. Instead of inducing certain emotions to test whether and how strongly cognitive processes are inhibited or facilitated while undergoing certain emotions, researchers have investigated the importance of people's emotional sensitivity for specific cognitive tasks. E.g. Silva et al. (2012) have found that sensitivity to disgust affects lexical decision performance; Rak et al. (2013) show that people's ability to feel empathy with others exerts an influence on the integration of emotion words. Despite these advances in the study of emotions, little research has been devoted to questions regarding the relation between the semantic processing of words on the one hand, and pain sensitivity on the other, where pain sensitivity is generally assumed to refer to subjects' responsiveness to noxious stimuli. Our study intends to fill this lacuna.

Three theoretical frameworks have often been drawn upon to account for individual differences regarding the language processing of pain-related or emotion-related stimuli. (1) Cognitive bias: Subjects with different inclinations, tendencies, etc. will show cognitive biases towards stimuli that are in accordance with their inclinations. E.g., studies with healthy subjects showed that individuals, who are more pain sensitive, are also more strongly engaged with pain-related stimuli (Baum et al., 2011). (2) Prototype Analysis: According to prototype theory, conceptual representations are encoded in a prototypical fashion and consist of various features, some of which are more central than others (Sloman et al., 1998), e.g. having a sharp tip is more central to the concept of a nail than having a silver colour. The degree of centrality of the features of conceptual representations, however, varies between different people given the different exposure to examplars of a certain concept. Thus, differences in the semantic processing of pain-related words need to take into account the inter-individual differences in which concepts are stored. (3) Embodied Cognition: the processing of linguistic meaning essentially involves perceptual, motoric and emotional brain regions corresponding to the contents of the words to be comprehended. E.g. Richter et al. (2010) have shown that when people are presented with pain words, there is substantial activity in the pain matrix that is also active when people feel a pain. The activation of these brain regions during semantic processing has been taken as evidence of the fact that reading words "hurts". This finding opens the way to the fascinating issue of whether people show individual differences in the degree to which they are hurt by words. According to the body specificity hypothesis (Casasanto, 2011) they should: if concepts and word meanings are at least partially constituted by implicit simulations of bodily experiences, as stated by the supporters of the embodied account, then individual differences in the way in which people experience the world should lead to corresponding differences in the way in which they construct concepts and word meanings.The primary aim of our study was to investigate the hitherto unexplored question of whether individual differences in pain sensitivity, as measured by people's self-report, have a substantial influence on the cognitive processing of words, as measured by people's ratings of the pain-relatedness of words. We were also particularly interested in whether pain sensitivity has a differential influence on the processing of abstract vs. concrete nouns. After presenting the experiment in the next section, we will discuss our results in light of the theories that we mentioned above. Collecting people's evaluations of the pain-relatedness of words, our secondary aim was to build a large database of pain-related words, which could be later used by researchers interested in the cognitive processing of pain-related semantic stimuli for future research needs.

Methods

Participants

189 participants took part in our survey. We only collected responses from those 141 participants who completed the survey. 10 further subjects had to be excluded from our analysis because they were not German native speakers, and data of another subject had to be dismissed because the person stopped responding differentially after 25% of the words were presented. Of the remaining 130 people, 70 were female, 18 years or older, with a mean age of 28.04 years (SD = 8.97). All subjects who participated in our survey were recruited through the Ruhr University Bochum and were mostly students. They were not reimbursed for their participation, but among all participants who submitted their email address, four book vouchers were drawn.

Stimuli

We assembled a list of 330 German pain words. All words were two-syllabic nouns and fell roughly into three categories: (A) nouns that refer to objects, the use of or contact with which, may be associated with having pain, e.g. thorn (Dorne), hail (Hagel), hammer (Hammer), crutch (Krücken), tank (Panzer), snake (Schlange), shard (Scherbe). (B) nouns that refer to body parts or inflictions of body parts that are often associated with having pain, e.g. appendix (Blinddarm), pus (Eiter), neck (Genick), bone (Knochen), scar (Narbe). (C) abstract nouns that refer to states of affairs that often involve being in pain, e.g. birth (Geburt), emergency (Notfall), epidemic (Seuche), torture (Folter). We then supplemented this list with 270 two-syllabic nouns of which 90 words have a positive valence, e.g. eagle (Adler), spring (Frühjahr), saphire (Saphir), 90 words with neutral valence, e.g. herring (Hering), magnifying glass (Lupe), pendulum (Pendel), and 90 words with a negative valence but presumably not pain-related, e.g. wrinkle (Falte), race (Rasse), spy (Spion). Whereas the pain-relatedness of the 330 "pain-words" was not independently determined (as far as we know, no similar list has so far been assembled), the 270 additional words were randomly selected from the Berlin Affective Word List (Võ et al., 2009).

Procedure

The list of 600 words was divided into six surveys including 100 words (55 pain-related nouns, 15 positive, 15 neutral and 15 negative nouns were randomly put together). Each participant was randomly assigned to one of the six surveys that they filled out using the survey platform *kwiksurvey*. Before they were presented with the list of words, they were informed that they would be asked to rate the **physical** pain that they associate with that concept. After reading each word x, the person was asked to answer the question "How strongly do you associate a x with pain?" (*Wie stark assoziieren Sie ein(e) x mit Schmerzen?*) on a 5-point Likert scale (1 = not at all, 2 = slightly, 3 = medium, 4 = strongly, 5 = very strongly). Figure 1 depicts the mean values for each of the 600 words that were evaluated during the study. The average rating for all words and all subjects was 2.37 (SD = 0.99).

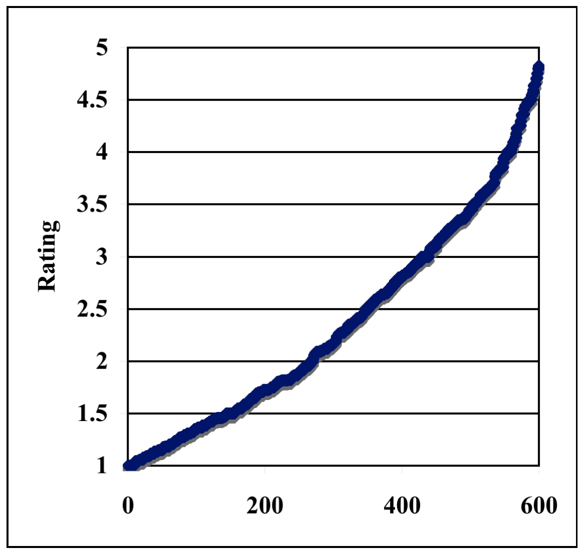

Figure 1: Mean values for all 600 presented words.

After evaluating 100 words, participants were prompted to provide demographical data on age, gender, and mother tongue. Subsequently, they were asked to self-assess their pain sensitivity: Would you consider yourself to be pain sensitive? (*Würden Sie sich als schmerzempfindlich bezeichnen?*). Possible responses were: (a) yes, (b) not so much (c) definitely not, and (d) I don't know. While a person's pain sensitivity is usually assessed in the laboratory setting using controlled experimental stimuli in a number of stimulus modalities, such as heat, cold and pressure, it has been shown that the use of self-reports to assess pain sensitivity is a viable means (Ruscheweyh et al, 2009, 2011, but see Edwards (2007)). We furthermore asked subjects to report on the frequency with which they feel pain. How often do you experience pain? (*Wie oft haben Sie Schmerzen?*). Possible responses were (a) very rarely (b) now and then, (c) quite often, (d) chronic pain. The completion of the survey took between 10 and 25 minutes.

Results

Main Effect

Average values for participant's ratings of the pain-relatedness of all 600 nouns are depicted in Figure 2. Participants were divided into three groups (High (N=31), Moderate (N=78), Low (N=12)) depending on their self-assessment of their pain sensitivity (see Procedure above). [1] In order to analyze the influence of self-assessed *Pain Sensitivity* on people's mean *Rating*, we applied an ANOVA with participants' *Rating* as the dependent measure.

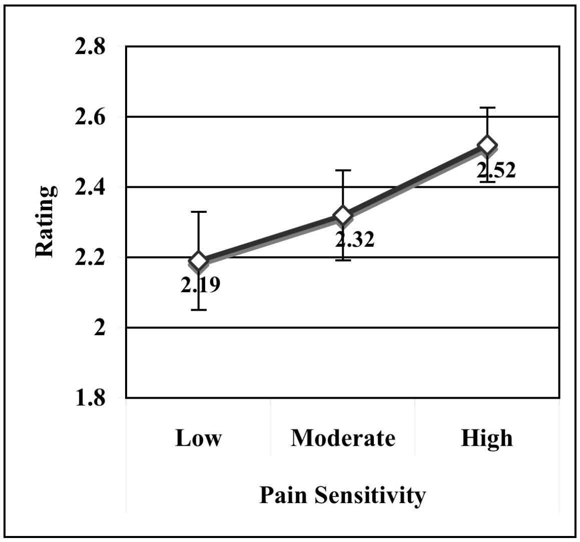

Figure 2: Effect of pain sensitivity on average pain-ratings.

There was a significant main effect of *Pain Sensitivity*, F (2,120) = 3.813, p = .025. A LSD post-hoc test revealed significant differences between the High and Moderate group (p=.023) as well as between High and Low (p=.018) but no significant result between Moderate and Low (p=.293).

Comparison 'Pain-Words' vs. Random Nouns

We divided the list of words into those that were preselected as being likely to be associated with pain, so called pain-words, and those that were randomly selected to complement the list (see also Stimuli section). All average values are displayed in Figure 3. Regardless of pain sensitivity, pain-related words are evaluated to be more strongly associated with pain, 2.87 (SE = .15), compared to control words, 1.88 (SE = .14). We ran two ANOVAs for 'pain-words' and for controls with independent factor *Pain Sensitivity* (High, Moderate, Low), and participant's rating as the dependent measure: Whereas Pain Sensitivity has a significant effect on the evaluations when only pain words are considered, (F(2,120) = 3,786 p = .025), no significant effect was obtained for the group of random words (F (2,120) = 1.216, p = 0.300).

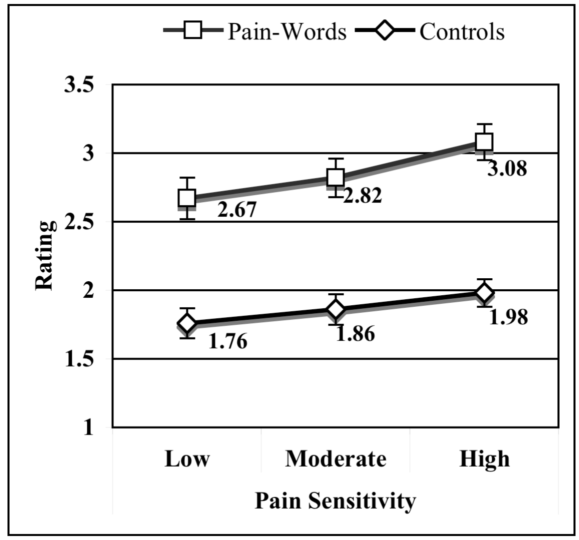

Figure 3: Comparing pain-words with control words.

Abstract vs. Concrete Nouns

Participants were presented with both concrete pain-related nouns, e.g. syringe, cactus, but also abstract pain-related nouns, e.g. birth, emergency. Given the divergent predictions different theories make regarding the processing of abstract and concrete nouns (see Discussion), we were particularly interested in whether there is any difference between people's ratings of abstract and concrete words.[2] The mean values are depicted in Figure 4. The average value of ratings for abstract nouns is considerable higher, 3.27 (SE = .17, compared to concrete nouns, 2.64 (SE = .14). While there is a highly significant result for concrete nouns, F(2,120) = 5.048, p = .008, no significant result could be obtained for people's ratings on abstract nouns, F (2,120) = 1.618, p = .203. We also analyzed whether abstract words that were not strongly associated with pain show a significant difference with regards to people's pain sensitivity. An ANOVA that was performed on 60 less pain-related words demonstrates that no such influence seems to exist. F(2,120) = 1.401, p = .250).

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[1] Only 12 people evaluated their pain sensitivity as low. This can be explained by the actual wording of the response options. Arguably, fewer people are willing to state that they do not consider themselves to be pain sensitive than having a low pain sensitivity. Nine subjects, who claimed not to know whether they were pain sensitive, were excluded from statistical analysis.

[2] To test the influence of concept type on people's pain rating we used 108 abstract words and 190 concrete words. We deliberately excluded all concepts that have both conrete and abstract features, e.g. tyrant, foul.

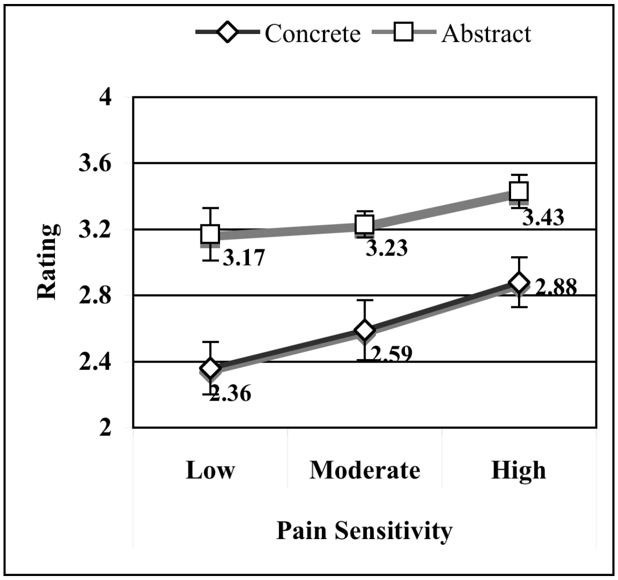

Figure 4: Abstract vs. Concrete Nouns

Discussion

The main purpose of this study was to determine whether pain sensitivity has an influence on the semantic processing of pain-related words. In order to test this hypothesis, we compared measures of subjects' self-reported pain sensitivity with their evaluation of the pain-relatedness of words. Our results confirmed that pain sensitivity has a significant impact on the rating of pain-related words. People who reported to be more sensitive to pain produced higher pain ratings to pain-related words compared to people who reported to be less sensitive.

This finding stimulates a series of interesting considerations. First of all, while the relation between the processing of pain-related information and other cognitive factors has been investigated, the notion of pain-related words has been generally operationalized using stimulus material that describes the sensory qualities of pain (e.g., words like ‘‘stabbing’’, ‘‘burning’’) or its affective component (e.g., words like ‘‘annoying’’, ‘‘terrifying’’). In our experiment we provide evidence, for the first time, of the relation between pain sensitivity and the processing of nouns which can be contextually related to painful situations but do not explicitly describe pain. This suggests that the individual variable pain-sensitivity might affect the processing of pain-related information to a much greater extent than previously thought. Given the widespread nature of this phenomenon, the exploration of the possible mechanisms by which this interaction takes place deserves special attention.

A potential interpretation of our results assumes a cognitive theory of pain. According to this account, the relation between pain sensitivity and the rating of pain-related words is explained by cognitive biases in retrieval and processing of pain-related information. For example, biases to orient the attention towards pain-related stimuli or to form implicit or explicit pain-related memories could play a relevant role. The underlying assumption is that people who are highly pain-sensitive show attentional or memory biases towards pain-related stimuli compared to low-sensitive people, and these biases mediate their processing of pain-related words. A classical paradigm to test attentional biases adopts a Stroop task, in which people are presented with colored words and instructed to name the color while ignoring the meaning of the words. Slower answers in naming the color of pain-related words are taken to reveal of an attentional bias towards pain related information (Pearce and Morley, 1989).

It has been recently shown that individuals who are attentionally more engaged with pain-related stimuli are also more pain-sensitive, as measured by experimental pain sensitivity (Baum et al., 2011). Thus, it could be argued that the results of our study are predicted by an attentional bias: people who are highly pain-sensitive would preferentially allocate their attention to pain-related words compared to people who are less sensitive, and would consequently produce higher ratings of pain-relatedness. It should be noted though that whereas attentional bias to pain stimuli has been extensively investigated, little is known about the emotional and behavioral correlates of attentional responses. It is not clear then that an attentional bias towards pain-related stimuli would predict evaluations of higher pain-relatedness of the presented words. Furthermore, a recent meta-analysis concluded that attentional bias towards pain-related information is not a robust phenomenon given that it proved difficult to generate or replicate (Crombez et al., 2013).

An alternative explanation of how cognitive factors mediate between pain sensitivity and the rating of pain related words could be that individual differences in pain sensitivity affect the way in which people form concepts. This view is consistent with prototype theory which, unlike the classical account, predicts that concepts vary from one person to the next, based on individual experiences with exemplars of a certain category (Rosch, 1999). People who are more sensitive to pain would, on this account, record more often the occurrence of the attribute “painful” for experienced exemplars of a certain concept. Thus, this attribute is more likely to be integrated into their concepts as compared to the concepts of people who are less sensitive to pain. For example, for high-pain-sensitive people, experiences with syringes will have in common the attribute of painfulness. It follows that the central tendency and the representation of this range of experiences will include their painfulness, that is, the property of being painful will become part of the prototypical representation of a syringe. Consequently, when high-pain-sensitive people are asked to evaluate the pain-relatedness of certain words, the average value of their evaluations is predicted to be higher compared to the average value produced by people who are less pain sensitive. Interestingly, prototype theory makes also an additional prediction concerning the ratings of concrete and abstract words. The theory predicts an influence of pain-sensitivity on word ratings also for abstract words given that also in this case the attribute “painful” is assumed to be more strongly integrated in the concepts of highly pain-sensitive people than in those of less sensitive people. This prediction, however, is at odds with our data, which confirmed a significant influence of pain sensitivity on word ratings only for concrete words. A supporter of prototype theory could object that in our experiment abstract words were on average rated to be more pain-related than concrete words. Thus, the saliency of the attribute “painful” for abstract words would obfuscate any difference due to f pain-sensitivity. If this reasoning were correct, we should expect to find a significant impact of pain-sensitivity on word ratings when considering only the sub-set of abstract words which were given low pain values. However, this additional analysis did not reveal any significant result between pain-sensitivity and abstract words, thus rejecting the prediction of prototype theory (see Results section). The latter then can only partially account for our results.

A third interpretation of the reported findings claims that pain sensitivity corresponds to higher ratings regarding the pain-relatedness of words, because both depend on the functioning of the same cognitive and neural mechanisms. Such an explanation is consistent with the embodied account of language, according to which the processing of linguistic meaning recruits areas of the brain dedicated to action, perception and emotion (Barsalou, 1999; Prinz, 2005; Werning, 2012; Werning et al., 2013). For example, understanding the meaning of a word like “syringe” is assumed to partially re-activate visual areas of the brain that are involved in perceiving syringes, motor areas that are relevant to the affordances of syringes, as well as emotional and pain-related circuits that encode affective states triggered by the interaction with syringes. More specifically, the semantic processing of pain-related words will re-activate the areas of the brain that are active when people actually experience pain (i.e., the pain matrix). On this account, the relation between pain sensitivity and the evaluation of pain-related words is explained by assuming that individual differences in the activation of the pain matrix determine individual differences in pain sensitivity and thus differences in the processing of pain-related words. The first part of this hypothesis (individual differences in pain sensitivity are associated with stronger activation of the pain matrix) has been indeed confirmed in an fMRI study in which highly sensitive individuals exhibited more frequent and more robust pain-induced activation of the primary somatosensory cortex, anterior cingulated cortex, and prefrontal cortex than did less sensitive individuals (Coghill et al., 2003). The second part of the hypothesis (individual differences in pain sensitivity determine differences in the processing of pain-related words) is an instance of the principle of body specificity (Casasanto, 2011), which claims that differences in bodily experiences will also lead to differences in the way in which concepts and word meanings are constructed. According to the body specificity hypothesis, if concepts and word meanings are in part constituted by implicit simulations of actual actions, perceptions and emotions, then systematic differences in the way in which people act, perceive and feel will also lead to differences in the way in which they construct concepts and word meanings. In this perspective, if the processing of pain-related words involves the re-activation of the brain regions that are active when people actually experience pain, then differences in activation as reflected by differences in pain sensititivity should also lead to differences in the processing of pain-related words.

The body specificity hypothesis can then directly account for our results given that it predicts that individual differences in the way in which people experience painful stimuli (i.e., differences in pain sensitivity) will also lead to differences in the processing of pain-related words.

Importantly, the difference between concrete and abstract words in terms of their relation with pain-sensitivity can also be readily explained assuming such a theoretical framework. Whereas concrete concepts are processed in brain regions devoted to action, perception and emotions, the encoding and processing of abstract concepts may rely more strongly on linguistic information, thus activating brain areas that are involved in language processing, e.g., the left perisylvian network (see Binder et al. (2009)). If so, we would in fact expect to find a correlation between pain sensitivity and the processing of concrete words given that they are assumed to depend on the activation of the same brain regions, while we do not have an apriori reason to expect a correlation also between pain sensitivity and the processing of abstract words given that the latter may depend on other brain areas. It is interesting to note that more radical versions of the embodied theories are currently rejecting such a picture suggesting that abstract words entail affective processing and activate brain regions associated with emotion (i.e., the rostral anterior cingulate cortex which modulates activity in the amygdala; Vigliocco et al., 2014). Our results, however, do not support this more radical version of the embodied account and suggest that a moderate version of it could better fit our findings.[3]

After having reviewed several theories that seem possible candidates to explain the results of this experiment, we can draw some final considerations. Both accounts of cognitive theories – processing biases and prototype theory - present some limitations. As for the first, in spite of the increasing number of studies that have been focusing on the processing of pain-related information, the solidity of the association between processing biases and pain sensitivity, as well as the direction of the effect, are still highly questionable. Prototype theory, on the other hand, has shown to be able to account only partially for the presented evidence. Although the embodied account cannot be unequivocally supported by our experiment, it does seem to be the most promising account to accommodate our results.

[3] Somewhere in-between the theories that we have considered – cognitive biases, prototype theory, and the embodied account – it could be argued that the correlation between pain sensitivity and ratings on the pain-relatedness of words, is due to the intermediate effect of imagination. Highly sensitive people may be more prone than less sensitive individuals at imagining scenarios that are potentially associated with, or elicited by pain-related words, leading to higher pain-association values for these words. Given the effect of pain-incompatible imagery as a distractor of pain, it seems at least plausible that pain-compatible imagery would have the opposite effect, enhancing the perceived pain-relatedness of words.

Conclusion

In this study we investigated whether and how people's pain sensitivity influences their associations of both abstract and concrete words with pain. Our results demonstrate that subjects with higher pain sensitivity are likely to associate words with greater amounts of pain than subjects with lower pain sensitivity. In order to adjudicate between alternative explanations, we have discussed three different accounts. While theories of cognitive bias have severe limitations in their application to this study, both, prototype theory and the embodied account of cognitive processing are well positioned to explicate the main results of our study. However, we have argued that differences in associations between abstract and concrete words are better accounted for by the embodied account. Future research will need to address a number of interesting and virtually unexplored open questions such as the relation between pain sensitivity and the cognitive representation of pain, and how motivational, emotional, attentional factors contribute, if they contribute at all, to determine people's sensitivity to pain. The urgency of these questions is not only determined by their scientific value, but also by their potential practical implications. Given preliminary evidence that heightened pain sensitivity increases risk for future chronic pain conditions, answering these questions could also help identifying novel routes for preliminary diagnosis and treatment of this complex condition.

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