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If Words Hurt, Can Tylenol Help? Testing for an embodied basis of pain-related meaning in words

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Abstract:
This study explores the relationship between physical pain sensitivity and word meaning perception, building on findings by Reuter et al. (2016) that individuals experiencing higher levels of pain associate words more strongly with pain. Grounded in the Body-Specificity Hypothesis (BSH; Casasanto, 2009), the research aims to elucidate the mechanisms by which physical pain influences cognitive interpretations of language. A pharmaceutical intervention utilizing an analgesic will be employed to investigate these effects.

Keywords: Pain Sensitivity, Body-Specificity Hypothesis, Embodied Cognition, Pharmaceutical Intervention

1. Introduction

The body-specificity hypothesis (Casasanto, 2009) proposes that people with different physical characteristics think differently, and therefore individuals' brains and minds may differ from each other. The way we store and retrieve information is closely related to the physical state that exists during learning. This means that the physical state of our body during encoding and retrieval can affect memory and cognition.

Most BSH findings have included handedness as a physical variable of interest. According to Willems et al. (2010), the stimulated hand area of the left premotor cortex responds more quickly to hand action verbs than the stimulated hand part of the right premotor cortex. Studies have shown body-specific differences in the brain activity of right-handed and left-handed people during motor imagination (Willems, Toni, Hagoort, & Casasanto,2009) and action verb understanding (Willems, Hagoort, & Casasanto, 2010). Furthermore, body-specific activation of the motor system plays a functional role in processing hand action verbs (Willems, Labruna, D 'Esposito, Ivry, & Casasanto, 2011).

Another set of studies found people with different handedness think about 'good' and 'bad' things differently, with left-handers more likely to show a "good is left" bias than right-handers, who are more likely to show a "good is right" bias than left-handers (Casasanto, 2011).

One study went beyond the experimental testbed of handedness to examine the role of individuals' sensitivity to pain in their evaluation of the meaning of

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words. Reuter and colleagues (2016) extended their work on the body-specificity hypothesis to examine whether there is a relationship between pain sensitivity and cognitive processing of words. The results showed that "pain sensitivity is an important predictor of people's pain relevance scores for words." That is, people with higher pain sensitivity rated words to be more strongly associated with pain compared to people with lower pain sensitivity.

Reuter et al. proposed two possible mechanisms to explain this effect. According to Reuter et al. (2016), the first possibility, which we call the Disembodied Account, is that highly pain-sensitive individuals may selectively store pain-related information in environments associated with pain experiences; this association led them to assign higher pain-related ratings to words that reactivated pain-related memories. Reuter and colleagues (2016) suggested that perhaps for people with high pain sensitivity, more frequent pain experiences would determine a memory bias, which in turn could explain the differences in ratings of pain-related words.

According to the second possibility, which we call the Embodied Account, pain sensitivity corresponds to a higher word pain-relatedness scores because feeling pain and processing the pain-related content of words rely on the same cognitive and neural mechanisms. On this account, semantic processing of the pain-related aspect of words' meanings reactivates brain regions that are active when people actually experience pain. Thus, the observed correlation between pain sensitivity and evaluation of words can be explained by individual differences in pain matrix activation during word processing. Recent studies have shown that differences in pain sensitivity are associated with stronger activation of the pain matrix (Coghill, McHaffie, & Yen, 2003). A recent study by Richter et al. (2010) showed that differences in activation reflected by differences in pain sensitivity also lead to differences in pain-related vocabulary processing.

The proposed study will seek to distinguish between the Dismbodied and Embodied accounts of the correlation between pain sensitivity and word meaning through the use of pharmacological interventions. Previous research has shown that painkillers such as acetaminophen affect cognitive states, reducing empathy and reducing emotional distress (Mischkowski et al. 2016). The present study will investigate whether painkillers affect individuals' cognitive processing of pain-related words.

The specific aims of this study are to distinguish the mechanisms by which individuals' pain sensitivity affects their judgments of word meanings and to determine if a pharmaceutical intervention with an analgesic can alter these meanings.

2. Method

2.1 Participants

We will recruit 300 healthy, native English-speaking undergraduate students weighing more than 50kg. For the pre-experimental screening, we will administer the Pain Sensitivity Questionnaire (PSQ; Ruscheweyh et al., 2009) in order to assess pain sensitivity among the recruited subjects. PSQ scores will be standardized, and participants who score below a z-score of -1 will be excluded from further stages of the study. Excluding subjects with low pain sensitivity is intended to prevent a 'floor effect' in the pharmaceutical manipulation. If fewer than 200 participants remain after the exclusion, we will continue to recruit new subjects until we reach a sample of 200 participants with moderate to high pain sensitivity (PSQ z-score > -1). Half of these participants will be randomly assigned to the Treatment condition, and the other half will be assigned to the Control condition for the pharmaceutical manipulation.

2.2 Procedure

Following the Pain Sensitivity Questionnaire (PSQ), only those participants who demonstrate moderate to high pain sensitivity will be eligible to participate in the follow-up experiment. Initially, participants will be requested to provide information about their age, and gender. Subsequently, the participants will be randomly allocated to either the treatment group or the control group.

The treatment group will orally receive 650 mg of acetaminophen, whereas the control group will be instructed to consume an identical quantity of placebo. Participants' subsequent task will be measured 40 minutes after they have taken the treatment or placebo, given that acetaminophen reaches peak plasma concentrations within approximately 40 minutes (Gerriets & Nappe, 2024).After receiving either acetaminophen or placebo, all participants will complete an English version of the Word rating task used by Reuter et al. (2016). In the word rating task, each participant will read a 100-word survey using an online survey platform.

After reading each word (x), participants will be prompted to answer the question, "How strongly do you associate the word 'x' with pain?" on a 5-point Likert scale, ranging from "1" meaning "not at all" to "5" meaning "very strongly."

2.3 Materials

The 600 German words used in the study by Reuter et al. (2016) will be translated into English using Google Translate and then checked by a native English speaker who is also fluent in German. This list of 600 words will be divided into six surveys, with each survey containing 100 words, categorized as follows: 55 pain-related nouns, 15 positive nouns, 15 neutral nouns, and 15 negative nouns, following Reuter et al. (2016). Each participant will be randomly assigned one of the six surveys to complete using an online survey platform.

3. Predictions

According to the Embodied Account, participants who took acetaminophen should rate words as less associated with pain than those who took a placebo (Figure 1a.) . That is, processing the pain-related aspects of words' semantics relies on the brain's pain matrix that enables people to feel physical pain, and therefore semantics are affected pain relievers. By contrast, according to the Disembodied Account, word ratings depend on participants' memories of previous experiences, and not on activation of the pain matrix, therefore word ratings are unaffected by analgesics (Figure 1b.)

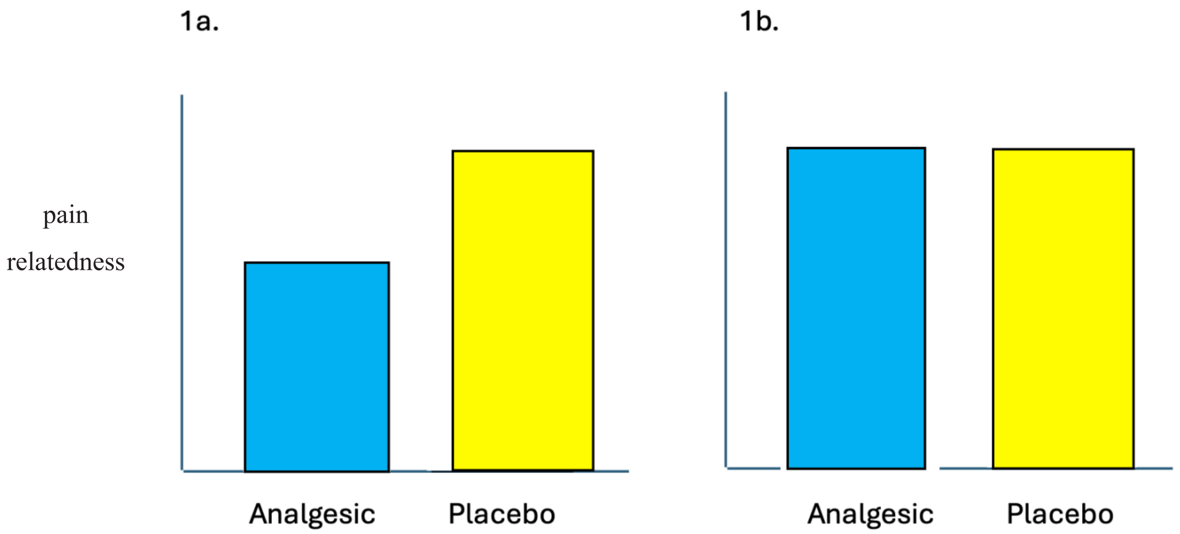

Fig.1 Predicted ratings of words' pain relatedness under the Embodied and Disembodied Accounts. Figure 1a. Predictions that follow from the Embodied Account. Figure 1b. Predictions that follow from the Disembodied account.

4. Implication and further study

Based on the results and discussions presented above, the conclusions are obtained as below:

(1) If results support the Embodied Account, this result would provide the first evidence that painkillers affect word meaning. This outcome would support the proposal that processing pain-related aspects of word meaning reuses the brain's network for experiencing physical pain, consistent with theories of embodied cognition.

(2) Alternatively, if pain relievers do not influence ratings of words' pain-relatedness, this result would be consistent with the Disembodied Account. This result would be consistent with Reuter et al's (2016) suggestion that the correlation between individual's pain sensitivity and their word ratings may be explained by remembering the experience of pain associated with those words -- but without re-experiencing that pain in the brain's pain network. One caveat in interpreting this outcome is that it relies on a null difference between the effects of the experimental treatment and the control; as such, a result consistent with the Disembodied Account is also consistent with the null hypothesis.

(3)If the results support the Disembodied Account, and allow the null hypothesis to be retained, this outcome would suggest that the experiment should be replicated with the following changes. First, the sample size could be increased to increase statistical power. Second, cultural and environmental factors should be examined to probe for any unintended effects. Lastly, a different type of pain medication could be considered, or an increased dosage of

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acetaminophen could be given to ensure the effectiveness of the pharmaceutical intervention.

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