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Can Pain Be Understood by Words?

– A Literature Review of Pain-Language Association

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Abstract: *This* review systematically explores the complicated interplay between pain and language, including nociceptive pain and empathic pain. While previous study focusing on physiological aspects of pain, this paper addressed how linguistics influence pain communication and perception. The finding reveals that language can influence bother subjective pain and the pain when we observe others. It is notable that the use of specific pain descriptors and metaphors significantly impacts individuals' pain perception and linguistic context can influence people's nociceptive pain experience. For empathic pain, there are similar brain activations when communicating with people who are suffering from pain. Besides, there is evidence that communication and interactions can benefit painful patients and reduce pain. To conclude, this paper empathizes the vital role language plays in individual's own pain experience and feeling others' pain. Future studies should aim to have standardized tools and frameworks for studying the linguistic aspect of pain, especially in the social inter-brain context, which is vital for understanding and communicating pain. Addressing the linguistic dimension of pain can help with pain assessment and management, leading to better patient care.

Keywords: Neurolinguistics, Multidimensional pain, Pain-related words, Empathic pain, Communication.

1. Introduction

Pain is not only a physical sensation but a multidimensional experience. More attention is being paid on the association between language and pain lately, highlighting the complicated ways in which language impacts nociceptive perception.

This paper aims to explore pain-language associations and build a fundamental understanding of how language impacts pain perception. The pain mentioned in this paper includes both nociceptive and empathic pain. Nociceptive pain is a subjective experience as a result of tissue impairment and empathic pain is the one caused by recognizing and understanding another person's pain. This research consists of two sections:

The first part is a review of language on nociceptive pain experience and the second part dives into the empathic pain. For the first part, the multidimensional nature of pain provides a basic framework for exploring existing studies. Based on this framework, investigations focus on current neurolinguistic studies of this subjective pain, exploring further language-pain influences.

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As for the second part, it will be the discussion about the empathic pain and the similarity of brain activation during empathic pain and nociceptive pain experience. Then the paper explores how language effect empathy which is the core of empathic pain. To study empathic pain, especially in social context, a new technique called hyperscanning is introduced. The exploration of hyperscanning in social context begins with face-face communication to how it is applied in the field of pain.

Knowing how language impacts on pain is helpful to enhance the effectiveness of communication across patients with various pain and enriches understanding of pain.

2. Multidimensional Nociceptive Pain Experience

The pain definition was refined by the IASP (International Association for the Study of Pain) Council in 2020. The most updated pain definition is “an adverse sensory and emotional experience associated with, existing or potential tissue injury”. The supplementary note “pain is impacted to different extents by biological, psychological, and social elements" emphasizes that it cannot be simplified to sensory pathways alone [1].

There are several theories of pain supporting the idea that pain is not only a bodily sensation but consisting of complex components. The "Gate Control Theory" put forward by Melzack and Wall indicates that the nociceptive system is not "hard-wired" but can undergo modulation [2]. In 1968, Melzack and Casey came up with a multidimensional model for the nervous system structures participating in pain. Apart from the neural networks engaged in processing the sensory and discriminative aspect of pain, there are also neural components for reticular formation in the brainstem and limbic system are part of emotional and motivational pain triggers. In sum, this concept states that pain contains sensory-discriminative, cognitive-evaluative, and motivational-affective units [3]. Besides, the neuromatrix theory of pain [4] [5] integrates Melzack and Casey’s model advocated that pain is a complicated experience generated by a unique neural pattern of an extensive neuronal system.

Furthermore, pain modulation also can be categorized to emotional and cognitive components. Feedback loops between pain, emotions, and cognition show that pain affects emotions and cognitive function, while emotional states influence pain intensity. Positive emotional states reduce pain, whereas negative states increase it. Cognitive modulation involves disengaging from the suffering component of pain [6] [7].

According to these theories, the research cases reviewed in the first part will follow the structure based on the components mentioned above: sensory-discriminative, motivational-affective and cognitive-evaluative modulations.

3. Impact of Language on Pain Perception

3.1. Sensory-discriminative Modulation

The use of language can impact on the sensory components such as the neural activation. Pain-related words activated neural circuits affiliated with bodily pain experiences [8]. A similar study clarified if the neural bases of nociceptive pain are shared by semantic pain and if so, to what degree of the portion is. Borelli et al. [9] compared the brain activations caused by noxious stimulation, pain-related words processing, and found evidence for partially shared neural substrates. There are two trials: nociceptive trial and semantic trial. In the first trial, participants received either painful or not mechanical stimulations. Compared to non-painful one, the painful stimuli revealed extensive brain activity in in primary somatosensory cortex, secondary somatosensory cortex, insula, cingulate cortex, thalamus, and dorsolateral prefrontal cortex. As for the second stage, pain-related descriptors, especially words related to social pain, revealed boosted activation in a large part of the brain locations mentioned above.

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3.2. Motivational-affective Modulation

The motivational-affective dimension plays an important role in pain experience. Language can influence the emotional and motivational dimensions of pain through the pain descriptor. Wilson, D et al. investigated the awareness on pain descriptors of persistent pain patients and found increased focus on pain descriptors was related to emotional condition and played an important role in prolonging enduring pain [10].

An interpretative analysis of Chinese pain language was conducted to explore how pain-describing words express people' experiences and perceptions of pain. Pain-describing words are ways to externalize pain expressions, whose lexical meaning of words is inter-subjective and varies based on as medical common sense, living environment, and culture [11]. Besides, the use of pain-related, negative, neutral descriptors has changed the discomfort level of participants. There were more elevated pain ratings of noxious when exposed to pain-related and negative stimulus than neutral primes. Thus, the motivational priming theory for semantic stimuli is convincingly validated by this study finding, showing that affectively negative semantic cues intensify subjective pain perception [12].

A similar study was conducted with the fMRI to detect the detailed brain activation. Ritter et al. [13] found that in contrast an, negative and pain-related words caused increased pain and stronger brain activation; compared to the negative words, pain-related words had a stronger effect. The result can be explained by motivational priming and neural networks theory [13] [14] [15]. Beyond that, the classification of social-pain and physical pain words is another case that language impact on motivational-affective pain components. Borelli et al. [9] found the words related to social pain were assessed as less positive, arousing, pain- associated, and expressing more severe and uncomfortable experiences compared with words expressing physical pain. They offered norms for words expressing bodily and social discomfort. To be more specific, social exclusion phrases can impact the pain perception when it comes to vicarious experience of others' pain. It shows that by affecting the motivation and affection, semantic pain shares some neural substrates with nociceptive pain [16].

3.3. Cognitive-evaluative Modulation

The pain experience also involves cognitive progress, such as defining, assessing, interpreting and evaluating of the pain. To define pain from linguistic perspective, a study suggests a pluralistic view best captures pain semantics, incorporating feelings and bodily states. There are three identified perspectives: the feeling view (semantic content pertains to feelings), the bodily view (semantic content pertains to bodily states), and the pluralist view (semantic content includes both feelings and bodily information) [17]. The study emphasizes the significance of weighing both affective and physical components in the neurolinguistic and psycholinguistic study of pain.

In addition, the language-pain association can be studied in a bilingual context. Gianola et al. [18] explored how linguistic context and cultural orientation influence pain perception among Spanish-English bilingual adults. The Whorfian hypothesis, or linguistic relativity, examines whether language influences thought and provides a framework of language-pain effects. Implementing Wolff and Holmes's [19] Model, Gianola, M et al. [18] further developed the three systems about how language influence pain. The language can serve as attention spotlight, a somatosensory inducer and a sematic processing meddler. The study found that participants rated higher pain intensity while experiencing painful heat in their culturally preferred language, in detail, the Spanish participates reported greater intensity scores in Spanish compared to English.

These findings reveal pain-related words impact people's nociceptive perception by emotion and cognition. With the modern brain imaging techniques such as fMRI, those studies provided evidence

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of neural substrates of semantic pain and nociceptive pain, highlighting the critical role of language in pain perception.

4. Empathic Pain Experience

Language can affect individual's nociceptive pain perception from sensory-analytical, motivational-emotional and cognitive-assessment aspects, the next session is about how language influence people perceiving others' pain.

Empathy refers to a set of psychological capacities which are crucial for humans' social activities. It allows people to comprehend others' thought and feeling, to build emotional connections with them, to convey their emotions and ideas, and to take care of their health [20]. Empathy is the key quality to feel other's pain. Empathic pain is the pain arising from observing or understanding other's pain.

The first half the paper focuses on the pain which is viewed as a personal experience activated by a mental representation of current or possible tissue impairment. The concept of a mental representation is the basis of empathic pain, specifically, with the mental presentation of nociceptive pain, people can associate the subjective pain with the pain perception of others. Based on that, a study found people can also feel pain without a nociceptive stimulus and the associated brain network can also be established.

There are the functional neuroimaging studies supporting the hypothesis that the perception of empathic pain partially activated a mental representation of nociceptive pain, sharing common neural systems [21].

There is also another evidence for neural intersect between empathic pain and pain in the oneself, indicating fundamental mental models [22].

Another research also reveals some insights for the comprehension of the interpersonal and empathic neurological mechanisms. Jackson et al. [23] suggested that there is a brain overlapping between perceived pain and observed pain. They found that observing and evaluating another individual's pain activated some cerebral regions including the anterior cingulate, the anterior insula, the cerebellum, and small part of the thalamus, recognized the vital role in pain processing. Notably, when assessing other's pain, the activation in the anterior cingulate had a strong correlation with this activity, indicating that the activity of this brain region is regulated based on individuals' sensitivity to others' suffering.

Furthermore, Bufalari et al. [24] observed primary somatosensory cortex (S1) activation dependent on assessment of other people's pain and touch, implying that the S1 is involved in feeling one's actual pain along with identifying physical attributes by interacting with other people.

While most neuroimaging studies conducted during empathy for pain focus only on affective aspect of the pain matrix, the studies above provided a new perspective. Empathy is a multifaceted concept made up of emotional, cognitive and somatomotor elements [25]. Therefore, the studies demonstrated that empathy may utilize fundamental mechanisms that enable to align others' sensation individuals' experiences with their sensorimotor framework.

5. Linguistic and Empathy

A study defined the empathy as a multidimensional experience: empathic process involves not only the emotional components but also the cognitive dimensions of empathy are all vital to the empathic process. Empathy itself also should be investigated more on an interdisciplinary basis. Researchers studied how the participants focus on the various facets of empathy and concluded that linguistic analysis can be used to understand the way empathy works in real-world experience. [26].

Linguistic Empathy is the alternative perspective to study empathy from a linguistic view and it is defined as a linguistic representation of the perspective speaker takes regarding the details of the

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utterance, and of the speaker's viewpoint toward people, objects, or concepts they are referring to in their speech. It show that preliminary measure of linguistic empathy is correlated with psychological empathy. They may share information processing algorithms and correlate electro-physiologically [27].

Linguistic, especially the communication and interaction between speakers and listeners, serves as an important element for studying the empathic pain.

6. Hperscanning- A New Technique to Study Joint Action

Hyperscanning has become a popular method to study simultaneous cerebral activation from different people in social context since the first study by Montague et al. [28]. They used two connected fMRI scanners with two participates playing a modified version of the kid's guessing game, which is called "handy dandy." It is used when two or more people participate joint action and researchers can capture the fundamental interconnectivity between two people's cognitive and neural processes during the interaction.

The emerging trend from an intra-brain method to an inter-brain moethod highlights the promising future of Hyperscanning. The stimulus-brain approach is based on the experimental setup and focus works on the neural activities after the stimulation. Brain-brain approach provides a way to study Interactional dynamics among coupled people in social context. In another word, it allows researchers to study the brain activities during joint action when participants take a second perspective [29].

A more concise way to summarise the inter-brain synchronisation measures, we can quantify the similar level of their phase, power or both. More specifically, Ayrolles et al. [30] arranged inter-brain measures into five general classifications, they are: phase synchrony, amplitude/envelope correlation, coherency-based, causality measures and other. It offers an extensive overview for researchers.

Hyperscanning provides the basic technique and the possibility to study the empathic pain.

6.1. Inter-brain Sychronization during Communication

Communication is one kind of joint action that can be examined by hyperscanning. Jiang, J et al. [31]. found that in-person communication has unique neural characteristics which is different with other forms of communication: the alignment of neural processes may be crucial for the effective in-person communication between participates.

According to the type of interaction specified in each study, a review classified spoken communication studies into four categories: knowledge sharing; turn-taking speech co-ordination; cooperation, problem-solving and creativity; and naturalistic discussion paradigms. And the result shows that emerging synchrony has been identified in verbal communication hyperscanning studies. Also, the research defines knowledge exchange, turn-taking, and natural conversation models. The frontal and temporo-parietal areas are the locations where the alignment happened. Finally, paired neuroscience enhances our comprehension of person-to-person communication [32].

6.2. Inter-brain Sychronization for Empathic Pain

Based on the findings in communication brain sychronization, Hyperscanning provides the possibility to study the empathic pain during interpersonal communication and interaction. There are increasing number of research focusing on the interaction of people who suffering from pain and people who listening.

The study conducted by Anzolin et al. [33] investigated brain connectivity between painful patients and health providers during an experiment. Researchers compared a controlled improved context with limited clinical condition. More precisely, the first condition is empathic and the second is business-like. Patients in the empathic condition gave higher scores when it comes to the questions how warm and allied are clinicians. The preceding EEG studies showed that Theta band was associated with pain empathy. By analyzing EEG data in this study, it is found that in Theta band, brain-to-brain connectivity volume inside social mirroring and pain/sensorimotor cerebral areas was varied over the provoked pain treatment.

Another research's result suggests that handholding when suffering pain amplifies the interbrain synchronization that shows a correlation with the level of the analgesia and the accurate level observer's empathy [34].

Ellingsen et al. [35] tracked synchronous inter brain connectivity in the health providers and people who suffering chronic pain. There were interactions between the clinicians and patients when the latter group obtained triggered pain. Patients reported less severe pain when engaging with a health provider compared to being by oneself. The findings indicate a paired-brain system supporting pain empathy and caring support.

7. Conclusion

This literature review looks into the language-pain effect for both nociceptive and empathic pain. For nociceptive pain, a sensory-discriminative, motivational-affective and cognitive-evaluative structure is used to summarise how language effects pain, especially the pain descriptors. For empathic pain, hyperscanning technique which is used to study inter-brain connectivity during joint action is introduced. Communication and pain related brain synchronization is the focus in this review. It demonstrates that the language has influence the pain experience deeply.

While there is an increasing number of studies and insights gathered on the relationship between language and, there are still limitations, such as the limited sample size and diversity, the inconsistent language used in different research and self-report evaluation methods for the subjective pain experience.

There are also research gaps that remain in empathic pain. Few studies focus on the language used during the pain-related interaction. There are studies about brain sychronization during communication but when it comes to pain-related experience, there are few studies focusing on linguistic viewpoint and diving into the language to describe the pain and how it influences the empathic pain of others.

To summarize, significant advancements have been made in understanding the language-pain association; however, further exploration is required to address existing knowledge gaps. Investigating the interplay between language and pain not only contributes to the theoretical development of neuroscience and neurolinguistics but also holds practical implications for enhancing communication between patients and healthcare providers, ultimately improving patient care and outcomes.

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