__**Draft version. For the final version see *Sensory Individuals: Unimodal and Multimodal Perspectives*, A. Mroczko-Wąsowicz & R. Grush (Eds.), Oxford University Press.**__

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Multimodal structure of painful experiences

It is common to characterize pain with touch-related terms, like 'cutting', 'pressing', 'sharp', and 'pulsing', or temperature-related terms, like 'hot' or 'burning'. This suggests that many pains are phenomenally multimodal because they are experienced as having some tactile-like or thermal-like character. The goal of this chapter is to investigate the structure of phenomenally multimodal pain experiences. It is argued that the usual accounts of multimodal structure proposed in investigations regarding exteroceptive experiences cannot be plausibly applied to multimodal experiences of pain. Instead, an alternative framework is proposed which characterizes the structure of tactile-like and thermal-like pains by referring to the notion of crossmodal correspondences.

Authors working on the topic of pain often claim that experiences of pain have two aspects: a sensory aspect, which determines descriptive, non-evaluative aspects of pain, for instance that it is 'pinching' or 'cramping,' and an evaluative aspect, which determines that pain feels bad (e.g., Aydede and Güzeldere 2002; Bain 2014; Corns 2018). An important problem in analyzing the sensory aspects of pains is that they are characterized by such a great variety that it is difficult to find any experiential quality shared by all painful experiences. Nevertheless, while sensory aspects of pains do not constitute a uniform set, they are also not completely random. For instance, the widely used McGill Pain Questionnaire distinguishes ten groups of descriptors used by people in characterizing the sensory character of pains. Many such descriptors characterize pains in touch-related terms, like ‘cutting’, ‘pressing’, ‘sharp’, and ‘pulsing’, or temperature-related terms, like ‘hot’ or ‘burning’.

This suggests that at least some pains, in addition to pain-specific terms, like ‘aching’ or ‘hurting,’ are characterized by terms strongly related to tactile or thermal modality. Because application of such terms is likely to happen due to the specific phenomenal character of painful experiences, it is plausible to assume that there are pains which are experienced as having some tactile-like or thermal-like character. Hence, pain experiences are not only ‘physiologically multimodal’ as mechanisms involved in producing painful sensations process various types of sensory inputs (see Julius and Basbaum, 2001 for review), but some of them are also ‘phenomenally multimodal.’ The goal of this paper is to investigate the structure of such phenomenally multimodal pain experiences—and by structure, I mean the way in which various elements presented in an experience of pain, like its unpleasantness, intensity, or tactile-like character, are experientially organized.

In recent years, philosophers of perception have become increasingly interested in analyzing structures of multimodal experiences (e.g., Briscoe 2016; Green 2019b; O’Callaghan 2015; Richardson 2014; Skrzypulec 2021). In particular, it has been recognized that the perceived elements of multimodal experiences are not presented as simply co-occurring but as organized into complex wholes. For instance, when having an audio-visual experience of a barking dog, one does not merely experience that something has a dog-like appearance and that something is barking, but that both visual and auditory elements somehow characterize the same object. In consequence, a question arises of how to characterize the way in which the content of multimodal experiences is organized.

These investigations have given rise to two main ideas regarding the structure of multimodal experiences. According to the first, the structure of multimodal experiences should be characterized in terms of property instantiation (see O'Callaghan 2014; 2015; Macpherson 2011). In this case, when one perceives a multimodal object, what is presented is that a single object instantiates properties related to distinct modalities—for instance, visual and auditory properties. The second, alternative proposal is to analyze the multimodal experiential structure in mereological terms (see Matthen 2010; O'Callaghan 2016), which holds that the structure of multimodal experiences should be characterized in terms of parts and wholes. For instance, when a multimodal, audio-visual object is perceived, the experience presents it as a whole composed of a visual proper part and an auditory proper part.

However, I argue that these two accounts of multimodal structure cannot be plausibly applied to multimodal, tactile-like and thermal-like experiences of pain. I set forth two major reasons: First, the mechanisms underlying pain experiences are unlike those which underline multimodal experiences, whose structure can be characterized in terms of instantiation and parthood. Second, the considered accounts entail that many adaptive tactile-like and thermal-like pain experiences are illusory. Instead, I propose to characterize the structure of tactile-like and thermal-like experiences of pain by referring to the notion of crossmodal correspondences. Crossmodal correspondences are associations which people experience between elements belonging to distinct modalities (e.g., Parise 2016; Spence 2011; Spence and Deroy 2013). For instance, ascending visual movement is judged as corresponding to transition from lower to higher pitch and brighter colours are experienced as corresponding to louder sounds (see Deroy and Spence 2016).

In the subsequent investigations, I do not rely on any specific theory of painful, tactile, and thermal experiences. However, I assume that such experiences have some intentional content which concerns bodily states. This content does not necessarily have to be merely indicative content characterizing a bodily state in some way. In particular, it has been proposed that evaluative aspects of pains may be grasped by the notion of imperative, command-like content (e.g., Klein 2007). Furthermore, while I do not endorse any particular view on individuation of experiences, I assume that a thermal-like or a tactile-like painful experience is a single experience and not some combination of two experiences: one thermal or tactile and the second a 'pure' painful experience. While arguing for this thesis goes beyond the scope of the paper, I believe that it is intuitive that while having, for instance, a burning pain in one's foot we recognize it as a single, and not two distinct experiences.

More specifically, to account for the multimodal pains by using the notion of crossmodal correspondences, I argue that tactile-like and thermal-like painful experiences have such content that they present painful bodily states as corresponding to tactile or thermal bodily states of certain types. My proposed analysis can avoid problems of instantiation and parthood because the mechanisms underlying experiences of pain are able to sustain crossmodal correspondences, and analyses in terms of crossmodal correspondences do not entail the illusory character of many adaptive multimodal pains.

The paper starts by presenting the major mechanisms responsible for pain perception (section 1). Subsequently, in sections 2 and 3, I argue that the mechanisms of pain perception are of a distinct type than those underlying experiences with structure organized by relations of instantiation and parthood. Furthermore, I show that analyses in terms of instantiation and parthood lead to an implausible conclusion that many adaptive multimodal pains are illusory (section 4). Finally, in section 5, I analyze the experiential structure of tactile-like and thermal-like pains in terms of crossmodal correspondences and show that such an analysis avoids the problems of other theories.

1. Mechanisms of pain perception

The modern paradigm in scientific investigations regarding pain has emerged due to formulation of the gate control theory of pain by Melzack and Wall (see Melzack and Wall 1965 for their seminal paper and Mendell 2014; Moayedi and Davies 2013 for contemporary reviews). This theory postulates pain gates, implemented in the spinal cord, which receive input from various afferent fibres. The activities of some of these fibres ‘open’ a gate, while those of other fibres ‘close’ a gate. The opening of a gate leads to the occurrence of a conscious painful sensation. In consequence, an experience of pain happens when there is a certain combination of activities of various afferent nerve fibres such that ‘closing’ activities are weaker than ‘opening’ activities.

The gate control theory has been developed in opposition to two earlier major theories: specific system theory and intensity theory (see Moayedi and Davies 2013). The specific system theory claimed that there is a specialized system for processing noxious stimuli whose activities lead to experiences of pain. On the other hand, proponents of intensity theory believe that painful sensations arise not due to activities of a specialized system but rather as a result of a detection of intense stimulation made by any sensory system. The success of gate theory has demonstrated the shortcomings of these two approaches.

First, while there are fibers such as Aδ and C fibers, which are specialized in transferring noxious stimuli, pain, contrary to the specific system theory, is experienced not merely due to the functioning of a separate system, but in virtue of certain (gate-opening) combinations of activities of afferent fibers related to various sensory systems. Second, in contrast to intensity theory, intense stimulation is neither necessary nor sufficient for the occurrence of pain. In some circumstances, even intense stimulation may be countered by certain gate-closing activities and thus does not lead to pain. Similarly, pain may occur even without intense stimulation due to a lack of usual gate-closing inputs. Nevertheless, gate control theory preserves some insights of earlier theories. In particular, as observed above, while there is no specialized pain-system, there are certain nociceptive receptors and related afferent fibres whose activities contribute to opening of pain-gates. Furthermore, while there is no strict relationship between intense stimulation and experiences of pain, in a typical situation, an intense stimulus is likely to cause pain-gate opening.

Over the years, gate control theory has undergone various modifications and extensions (see Wall 1996). For instance, while in their initial model Melzack and Wall strictly differentiated between gate-closing large-fibre activities and gate-opening small-fibre activities, the actual interactions between activities of afferent fibres are more complex (see Peláez and Taniguchi 2016). Furthermore, while gate control theory mainly concerns bottom-up processing, nowadays it is well-recognized that there are important top-down contributions that determine the occurrence of sensations of pain (e.g., Tsao et al. 2011). Melzack himself has proposed a more general theory of pain by introducing the concept of the 'neuromatrix' (Melzack 1993). The neuromatrix is a distributed neural network, shaped both by genetic and developmental factors, which processes information about the state of the body provided by various bottom-up and top-down systems (e.g., the neuromatrix processes sensory data, information about emotional states, and inputs from stress-regulation system, see Melzack 1999). When a particular combination of activities within the neuromatrix occurs, known as a pain 'neurosignature', conscious pain is experienced.

Though gate control theory does not explain all pain-related phenomena, and the original model proposed by Melzack and Wall is not considered fully accurate, it provides a general idea concerning mechanisms underlying pain perception that is crucial in contemporary investigations of pain. This idea is that mechanisms of pain perception are, to an important extent, mechanisms that detect particular combinations of inputs. A pain-gate itself is such a detector, which, by virtue of having 'open' and 'closed' states, differentiates combinations of various types of inputs which lead to experiences of pain from combinations which do not lead to such a sensation. Similarly, the neuromatrix is a mechanism which processes combinations of bottom-up and top-down inputs, and as an output recognizes whether the input satisfies a pain or non-pain neurosignature. Such mechanisms can be called ‘pattern classification mechanisms’: as an input they take a pattern of elements, such as a certain combination of sensory stimulations, and as an output they classify this pattern as being of a certain type.

In the next two sections, I argue that experiential structures which can be characterized in terms of instantiation or parthood arise as a result of mechanism types that differ from pattern classification mechanisms. Hence, experiences of pain, including tactile-like and thermal-like pains, are not likely to have content organized by instantiation and parthood relations.

2. Mechanisms of experiential instantiation

An influential idea in investigations concerning the structure of multimodal experiences is to characterize their structure in terms of an instantiation relation between a property and a subject possessing this property (see O’Callaghan 2014; 2015; Macpherson 2011). For example, in case of an audio-visual experience presenting a barking dog, the structure of an experience consists of a common subject which instantiates both vision-related properties (concerning how the dog looks) and audition-related properties (concerning how the dog sounds). Due to this structure, an audio-visual experience not only presents that there is something that looks a certain way and something that sounds in a certain way, but that there is a single entity which instantiates both of these visual and auditory characteristics. If the analogous idea were applied to the multimodal tactile-like and thermal-like experience of pain, it would mean that such experiences present a common subject, like a bodily state, as possessing various properties, including those related to activities of the tactile and thermal sensory systems.

The mechanisms underlying the experiential attribution of properties to a common subject are often characterized by referring to the notion of 'object-files' (e.g., Green and Quilty-Dunn 2017; Mitroff et al. 2005). According to object-file theories, a perceptual system organizes information about perceived objects by storing them in 'files' such that a single file contains information about exactly one object. The content of an object-file can be updated over time, which allows representation of the diachronic sameness of the perceived entities. For instance, an object may change colour from red to green but still be visually represented as numerically the same entity due to being represented using the same object-file. In the case of multimodal experiences, an object-file combines information provided by different modalities, and serves as a basis for an experiential structure in which an entity is presented as instantiating multimodal properties (Green 2019b).

The object-files framework is not the only one used to characterize mechanisms underlying experiential presentations of individual entities as subjects simultaneously possessing a variety of properties. For instance, Pylyshyn (2007) famously proposed a notion of preattentive 'visual indices', by virtue of which the visual system is able to simultaneously refer to several objects, treat them as distinct, and track them through time. A visual index functions like a demonstrative term, such as 'this' or 'that' which refers to an entity without attributing any properties to it. As a result of combining indices with qualitative information, perceived entities can be presented as instantiating properties. Another classic approach, Feature Integration Theory (Treisman 1998), proposes an attentional mechanism in virtue of which focusing attention on an element of a visual scene allows the integration of information from distinct feature-maps and representation of the attended entity as possessing various properties. Similarly, according to Rensink's coherence theory of attention (Rensink 2000), attentional mechanisms combine short-lived representations of properties into a stable 'nexus' which represents a persisting object instantiating properties. In terms closer to the neural implementation level, a neural synchronization mechanism has been proposed which allows representation of a single entity as having many properties and differentiating between properties instantiated by distinct entities because the neurons coding properties of a single entities fire in synchrony (e.g., O'Reilly et al. 2003).

These theories describing mechanisms which are likely to be responsible for perception of individuals as subjects instantiating properties differ in many respects and they describe the relevant mechanisms using terminology from distinct levels of description, sometimes closer to a specific neural implementation, and sometimes postulating abstract structures which could be implemented in many ways. Nevertheless, despite these differences, all of them characterize mechanisms of the same type. These mechanisms are 'unification mechanisms' in virtue of which initial, separate input elements become constituents of some higher-order whole. For instance, in object-files accounts, separate pieces of information about perceived features are gathered within a single object-file; similarly, in visual indices theory, a complex representation is formed that combines a visual index with representations of properties. The same general pattern can be identified in other theories, as in the coherence theory of attention, feature-representations are unified within a nexus; in Feature Integration Theory, an attentional mechanism combines information from separate feature-maps; and in neural synchronization accounts, separate neural representations start to form a synchronized whole.

However, the fact that experiential instantiation structures arise from the function of unification mechanisms poses a problem for interpreting tactile-like and thermal-like pains in terms of instantiation. As described in section one, the mechanisms underlying painful sensation are pattern classification mechanisms and not unification mechanisms. In particular, pattern classification mechanisms do not add any new element to the input elements but merely recognize that the arrangement of input elements satisfies a certain pattern. For instance, pain-related mechanisms recognize whether pattern of inputs is ‘gate-opening’ or satisfies a certain neurosignature. On the other hand, unification mechanisms modify the input by adding a new element, such as an object-file, an index, or a nexus, in virtue of which other input elements are unified into a higher-order whole. In contrary, mechanisms such as pain-gates and neuromatrix do not create any such higher-order structures by adding new elements to the input elements. As a result, it is not plausible to characterize the structure of multimodal pains in terms of property instantiation, as the major mechanisms of pain are distinct from those usually associated with experiential instantiation structures. This is not to deny that mechanisms responsible for creating structures such as object-files can also be described in terms of pattern recognition, especially when characterized using low-level terms concerning their neural implementation. However, they are some specific types of pattern recognition mechanisms which can serve a unificatory function associated with object-files. On the other hand, the mainstream description of pain mechanisms do not provide grounds for believing that such unificatory functioning is also present in the case of pattern classification mechanisms that underlie pain perception.

3. Mechanisms of experiential parthood

Structures of multimodal experiences are characterized not only in terms of instantiation but also in terms of parthood. In particular, O’Callaghan has argued that in the case of audio-visual experiences it is implausible to describe experiential structure of multimodal objects by referring solely to the notion of instantiation as sounds are not experienced as properties of objects but themselves are experienced as individuals instantiating properties (O'Callaghan 2016, see also Green 2019a). Instead, he has proposed that an audio-visual object is presented as a mereological whole with visual and auditory proper parts, each instantiating separate visual and auditory properties. In the case of multimodal tactile-like and thermal-like pains, a mereological account entails that such experiences of pain present a bodily state divided into proper parts, some of which are tactile or thermal. For instance, it may be that when a tactile-like pain is felt, what is presented are two proper parts: a tactile state of a body (e.g., that a pressure is inflicted on the skin) and a purely painful state of the body (e.g., that a bodily disorder is present), which jointly constitute a mereological whole (i.e., a tactile-like painful bodily state). Nevertheless, I believe that such a solution faces an analogous problem to characterization in terms of instantiation, as the mechanisms responsible for part perception are of a distinct type from those underlying painful sensations.

Studies on part perception are most extensively developed in regard to the visual modality, which usually present objects as composed of spatial parts. Mechanisms of visual part perception are mainly concerned with detecting qualitative discontinuities and analyzing the structure of edges to identify specific arrangements, like concavity, which serve as a cue for determining where one parts ends and another starts (e.g., Hoffman and Richards 1984; Palmer and Rock 1994; Xu and Singh 2002). For instance, an hourglass shape will be perceptually divided into two parts due to an arrangement of edges creating a concavity. While vision was the primary target of part perception studies, it is likely that analogous mechanisms also operate in other modalities. In particular, it has been proposed that sounds are perceived as having temporal parts designated by detecting discontinuities in pitch (see O'Callaghan 2008).

While there are significant differences between mechanisms of part perception in various modalities, the relevant mechanisms are of the same type. Such mechanisms, which may be called ‘differentiation mechanisms’, detect differences and similarities between input elements and as an output arrange them so similar elements are combined with each other and separated from dissimilar elements. For instance, in the case of visual part perception, the relevant mechanisms arrange perceived elements into spatially and qualitatively coherent fragments separated from each other by qualitative discontinuities and specific arrangements of edges. Similarly, in the auditory modality, part perception mechanisms divide the stream of auditory information into fragments relying on temporal and qualitative properties such as pitch.

This observation leads to an analogous problem for applying the mereological notions in analyzing the structure of tactile-like and thermal-like pains as in the case of analysis in terms of instantiation. While, at the neural level of description, mechanisms of part perception may also be characterized as engaged in pattern recognition, their specific function is to serve as differentiation mechanisms. On the other hand, it does not seem to be true in the case of major mechanisms of pain perception. In particular, there is nothing in the way in which pain-gates and the pain neuromatrix function that suggests they detect and process qualitative differences between input elements to divide them into some coherent arrangements. In consequence, it is not plausible to characterize the experiential structure of multimodal pains in terms of parthood, as the mechanisms responsible for part perception are significantly distinct from those underlying pain perception.

4. Illusory pains

The previous sections demonstrated that characterizing the structure of multimodal tactile-like and thermal-like pains in terms of instantiation or parthood is implausible given the type of mechanisms that are responsible for pain perception. Below, I argue that there is an additional problem in applying these accounts to multimodal experiences of pains. Accepting them entails that various adaptive multimodal experiences of pain are in fact illusory. Both considered frameworks are representational frameworks, as they assume that multimodal experiences present perceived entities as having certain characteristics, and in doing so they may be accurate or inaccurate, leading to a veridical or an illusory experience. In particular, when applied to a tactile-like pain experience, an analysis in terms of instantiation states that the bodily state is represented as having some touch-related properties. For instance, it may be presented that the concerned state instantiates properties associated with being under pressure or being in contact with an external entity. Similarly, in an analysis in mereological terms, a bodily state is represented as having a tactile proper part. For example, such a theory may postulate that in a mereological structure of the whole bodily event there is a tactile proper part concerning being under external pressure.

Such a representational approach to multimodal pains is problematic as there are types of tactile-like and thermal-like painful experiences which do not intuitively seem illusory but are illusory from the perspective of instantiation and parthood frameworks. One such example can be presented by referring to the distinction between so-called ‘first pain’ and ‘second pain’ (Price and Aydede 2005). When one cuts one’s finger, at the first moment a sharp, short lasting first pain is felt, which in an important way is due to information carried by Aδ fibres. However, after a moment, due to information carried by C fibres, a second pain occurs which is longer lasting and more spatially diffuse. Such second pains are commonly described in thermal-like terms (specifically, as ‘burning’), despite the fact they happen without any actual thermal stimulation or significant change in body temperature. Because of that they are illusory from the perspective of an instantiation framework; according to this framework, the considered painful bodily state is inaccurately represented as having some thermal-related properties. Similarly, experiences of second pains are inaccurate from the perspective of a mereological framework, as the represented bodily states do not have any actual thermal component that can serve as a thermal proper part. Nevertheless, treating second pains as illusory is problematic because they have adaptive value as they facilitate prolonged protection of injured area and do not involve any malfunction of pain mechanisms. In fact, they are one of the most common responses for typical noxious stimuli. What is particularly important is that the adaptiveness of second pains is not independent from the presence of thermal-like aspects. Quite the opposite; second pains are in an important way adaptive precisely due to their thermal-like character: a second pain has a qualitative character which is plausibly described as ‘burning’ and the presence of this thermal-like character determines that a proper behaviour consist in a prolonged care and not, for instance, a rapid withdrawal movement. In consequence, instantiation and parthood accounts that treat the thermal-like character of second pains as illusory face problems in explaining the adaptiveness of such experiences of pain.

Another example, this time concerning tactile-like pains, comes from experimental studies in which painful sensations are evoked by applying laser stimuli (Haggard et al. 2013). As a result, the occurring pain is described in tactile terms as a ‘pinprick pain’ even though the laser stimuli are used specifically to avoid activation of tactile Aβ fibres. Similar to the case of second pain, the pinprick sensation is inaccurate from the perspective of instantiation and parthood frameworks, as the ‘pinprick’ description suggest the presence of a bodily state which has properties, or a proper part, concerning the occurrence of a sudden increase in pressure inflicted on a small skin fragment, though no such event happens after laser stimulation. However, also in this case it is far from obvious that the pain experience is illusory. Again, the painful sensation does not happen because of some malfunction of pain mechanisms and is adaptive because its tactile-like, ‘pinprick’ character motivates a proper behaviour. In the case of ‘pinprick’ pain, such a behaviour is a swift withdrawal of a bodily part, which is likely to break contact with a noxious stimulus.

It should be noted that it is not inconsistent to interpret each case as a form of pain illusion. In particular, it may be the case that some experiences are both illusory and adaptive. However, it is a disadvantage of a representational approach which holds that a significant number of common experiences is inaccurate, so such an approach should not be adopted unless there is no other viable theory. In the subsequent sections, I argue that such an alternative theory can be formulated using the notion of crossmodal correspondences.

5. Crossmodal correspondences

Crossmodal correspondences are associations experienced between elements presented by distinct modalities (Parise 2016; Spence 2011; Spence and Deroy 2013). Some elements are phenomenally presented in such a way that people judge them as matching some other elements, presented by a distinct sensory system. For instance, transition from lower to higher pitch is experienced as matching ascending visual movement, and various vivid correspondences occur between olfactory and taste perception (e.g., odours are often characterized as ‘sweet’). One of the most famous demonstrations is the kiki/bouba effect, showing that people feel that the sound of the name ‘kiki’ is more appropriate for angular shapes, while the ‘bouba’ sound is associated with shapes without sharp corners (see Köhler 1947 for the classic study). The presence of crossmodal correspondences has been demonstrated between virtually all modalities, including associations between sounds and tastes, shapes and tactile hardness, or colours and temperatures (Deroy and Spence 2016). Studies on crossmodal correspondences constitute a fruitful area of investigations in which psychologists consider, *inter alia*, the influence of correspondences on behavioural performance (Brunetti et al. 2017), cultural differences in experienced correspondences (Wan et al. 2014), and the emergence of correspondences in ontogenetic development (Asano et al. 2015). It is believed that crossmodal correspondences occur mainly due to similarities in the way corresponding elements are represented, the learned statistical associations between corresponding elements, and possession of common semantic labels, as in the case of 'high' sounds and 'high' visual elements (Deroy and Spence 2016; Parise 2016; Spence 2011).

I propose that multimodal tactile-like and thermal-like pains should be understood as cases of crossmodal correspondences. More specifically, I claim that tactile-like pain consists in experiencing that a painful bodily state corresponds to a tactile bodily state of a certain type, and that having a thermal-like pain consists in experiencing that a painful bodily state corresponds to a thermal bodily state of a certain type. This correspondence is a relation in virtue of which an element is experienced as associated with another element, such that they tend to be described in similar terms. For instance, a visual stimulus and a sound may be characterized as being 'high' and some painful bodily states may be described as 'pressing' or 'pulsing' in analogy to certain tactile states.

As observed above, there are several types of correspondences, and so the specific character of the correspondence relation may vary depending on a particular type of crossmodal correspondence. For instance, experiencing element *A* as corresponding to *B* may consist in experiencing *A* as likely co-occurring with *B*, as being associated with the same external entity as *B*, as motivating similar actions as *B*, or as having a similar significance for the organism as *B*. The correspondence occurs between a bodily state and a bodily state of a certain type because one element typically corresponds to many elements with a common characteristic. For instance, the sound 'kiki' is not experienced as corresponding to a particular angular shape, but to many shapes with a property of being angular.

The approach described above does not require postulating that bodily states presented by multimodal experiences of pain are experienced as having any internal structure organized by instantiation or parthood relations. The tactile-like or thermal-like character of pain does not consist in presenting some combination of a subject and properties or in presenting proper parts composing a mereological whole. Instead, tactile-like and thermal-like pains occur when a presented painful bodily state, which may be atomic in respect of experiential internal structure, is experienced as standing in a correspondence relation to a tactile or a thermal state of a certain type. It should be noted that this position is coherent even if one believes that correspondence is a form of similarity, and that similarity between any entities *A* and *B* entails the presence of a property *F* instantiated both by *A* and *B*. This is because representing introduces an intensional context, i.e., even if similarity between *A* and *B* entails that a property *F* is instantiated both by *A* and by *B*, it may still be the case that *A* and *B* are *represented* as similar without being *represented* as instantiating the property *F*. Hence, it can be maintained that a painful bodily state is represented as similar to a tactile or thermal bodily state without representing that this state has the structure of a subject instantiating properties.

Further, I argue that the approach formulated in terms of crossmodal correspondences is free from difficulties that threaten the instantiation and parthood theories. First, I show that mechanisms of pain perception are such that they can sustain crossmodal correspondences between painful, tactile, and thermal bodily states. Second, I show how interpreting multimodal pains as cases of crossmodal correspondences allow us to avoid interpreting various adaptive multimodal pains as inaccurate representations.

5.1 Mechanisms of crossmodal correspondences

The huge variety of crossmodal correspondences makes it unlikely that there is a single mechanism responsible for all of them. Nevertheless, scientists investigating crossmodal correspondences have proposed three, nonexclusive types of correspondences which are likely to happen due to distinct relations between mechanisms responsible for experiencing corresponding elements (Deroy and Spence 2016; Parise 2016; Spence 2011). The first type are structural correspondences in which an element *A* is experienced as corresponding to an element *B* because a mechanism in virtue of which *A* is experienced is similar to a mechanism in virtue of which *B* is experienced. For instance, the correspondence between bright and loud stimuli is likely to be structural, as both higher levels of brightness and loudness are coded by an increase in neuron firing. The second type is statistical correspondences arising from learning that some elements are likely to occur together in the environment. In this case, an element *A* is experienced as corresponding to an element *B* because it has been learned that activities of mechanisms in virtue of which an element *A* is experienced frequently co-occur with activities of mechanisms in virtue of which an element *B* is experienced. It has been proposed that the correspondence between smaller visual size and higher pitch is a statistical correspondence, as smaller objects are more likely to emit higher pitched noises. Finally, there are semantic correspondences, which occur due to common, higher-order (e.g., linguistic) classification of experienced elements. In this case, the correspondence between an element *A* and an element *B* is likely to be due to a common top-down influence on the outputs or functioning of mechanisms in virtue of which *A* and *B* are experienced. It is believed that correspondence between higher pitch and higher visual elevation is at least partially a result of the use of the same predicates (‘high’ and ‘low’) in both cases.

In sections two and three, I argued that multimodal tactile-like and thermal-like pains should not be analyzed in terms of instantiation or parthood, as such phenomenal structures occur due to the function of unification and differentiation mechanisms, not pattern classification mechanisms which underline experiences of pain. Now, it can be asked whether such pattern classification mechanisms are suitable for sustaining experiences which present an element as corresponding to a distinct element. I believe that the answer is positive no matter which type of correspondences is considered.

The structural correspondence occurs when an element *A* is experienced as corresponding to an element *B* because the experience of *A* and the experience of *B* happen in virtue of similar mechanisms. The question is whether pattern classification mechanisms responsible for pain experiences are such that structural correspondences can happen in virtue of them. I believe that it is so because pain mechanisms, such as pain-gates, process input from various types of afferent fibers. Some of these fibers are specialized in providing information concerning noxious stimuli, but others are specialized in transferring information concerning tactile or thermal stimulation. In consequence, input elements, in virtue of which pain experiences arise, may be, in some instances, partially similar to input elements which lead to tactile or thermal experiences. Thus, the functioning of pain mechanisms in cases of some tactile-like and thermal-likes pains is likely to be similar to the functioning of mechanisms processing non-painful tactile or thermal stimulation, which may lead to structural correspondences.

Similarly, statistical correspondences can be sustained by pattern classification mechanisms because frequent co-occurrence, and so co-computing, of certain stimuli may shape the function of such mechanisms in a process we may broadly label as ‘learning’. For instance, it may be the case that due to frequent co-occurrence of certain nociceptive and tactile inputs, the neurosignatures provided by the neuromatrix undergo modifications. Then, even when a pinprick pain is caused by laser stimulation without activating the fibres that usually transfer tactile information, the correspondence occurs because, in virtue of the usual co-occurrence, the neuromatrix provides a neurosignature typically produced by processing both nociceptive and tactile information.

Semantic correspondences can also arise from interactions between pattern classification mechanisms and some higher-order mechanisms—for instance, those responsible for the application of linguistic categories. In this case, a correspondence between an element *A* and an element *B* may occur because the output of pain mechanisms processing *A* and the output of tactile or thermal mechanisms processing *B* are further classified in the same way by a higher-order system. For example, the second pain that persists after injury may correspond to some thermal sensations partially because both sensations are linguistically categorized as ‘hot’ or ‘burning’.

The above considerations demonstrate that while experiential structures organized by instantiation and parthood relations are unlikely to be sustained by pattern classification mechanisms, such problems do not occur in the case of crossmodal correspondences. In consequence, the framework of crossmodal correspondences is suitable for analyzing tactile-like and thermal-like multimodal pains. It should be noted that due to the variety of crossmodal correspondences, I do not postulate that all tactile-like and thermal-like pains are purely sensory experiences. While a purely sensory character is plausible in the case of structural correspondences, it is likely that statistical and semantic correspondences also occur in virtue of input provided by mechanisms responsible for memory, imagery, and language.

5.2 Content of crossmodal correspondences

Proponents of instantiation theories and parthood theories of multimodal experiences adopt representationalist positions which lead to the conclusion that many multimodal pains, despite being adaptive and resulting from the normal function of pain mechanisms, are inaccurate. In consequence, it should be asked whether characterization in terms of crossmodal correspondences can provide an approach to multimodal pains that does not render adaptive pains illusory.

When a crossmodal correspondence is experienced, an element *A* is presented as corresponding to an element *B* of a certain type. In virtue of the occurrence of correspondence relations, elements are associated with each other and are likely to be described in similar terms. As stated earlier, the specific character of the correspondence relation may vary depending on the particular type of crossmodal correspondence. For instance, small visual stimuli may be experienced as corresponding, in the sense of likely co-occurrence, to a high-pitched but not to a low-pitched sound. Similarly, sudden, bright visual stimuli may be experienced as corresponding, in the sense of leading to a similar defensive reaction, to a sudden loud sound. From the perspective of the current investigation, the crucial characteristic of such experiences is that when *A* is experienced as corresponding to *B*, it is not the case that properties of *B* are attributed to *A* or that parts of *B* are presented as parts of *A*. Instead, *A* stands in a correspondence relation to *B*. For example, when a bright visual stimulus is experienced as corresponding to a loud noise, it is not represented as having certain loudness or pitch, but as standing in a correspondence relation to a noise of a certain type.

When applied to multimodal pain experiences, this position states that in the case of tactile-like or thermal-like pains, a bodily state is represented as corresponding to a tactile or thermal experience of a certain type. From this perspective, a painful sensation is described as ‘pressing’ because the represented bodily state is experienced as corresponding to a tactile state of a type which is likely to be described in such terms. However, in the case of crossmodal correspondence, the painful bodily state is not represented as instantiating some tactile properties or having some tactile parts. In consequence, even when a multimodal experience of pain happens without co-occurring tactile or thermal stimulation such an experience of pain can still be accurate. It is so because what is represented is merely that a bodily state corresponds (e.g., in the sense of frequently co-occurring) to some tactile or thermal state of a certain type. It should be noted that a painful bodily state can be accurately represented as corresponding to a different bodily state even if the corresponding element is not currently present. This can happen because the information concerning the corresponding tactile of thermal states of the relevant types can be available to the cognitive system due to the functioning of memory, imagery, and semantic knowledge, without the actual occurrence of a given bodily state. Thus, it may be accurately represented that a pinprick pain corresponds to of a tactile state of a certain type, even if no such tactile state is currently occurring.

On the other hand, painful experiences are often preceded by a tactile or thermal stimulation that increases in intensity and finally causes a painful sensation. Relying on this common pattern one may doubt whether there is a strong analogy between phenomenally multimodal pains and other cases of crossmodal correspondences. In usual cases of crossmodal correspondences, the correspondence concerns elements presented by two experiences belonging to distinct modalities. However, when a painful experience is the result of a tactile or thermal stimulation, it may seem that there is a sequence of experiences belonging to the same modality, for instance at first a non-painful tactile experience and then a painful tactile experience, as each experience is caused by the same type of stimulus. Nevertheless, even if such analysis is correct it is not inconsistent with my main proposal (even if it is no longer strictly a *crossmodal* correspondence). I argue that phenomenally multimodal pains present painful bodily states as corresponding to tactile or thermal bodily states of certain types. It may be the case that an experience, at first, presents a non-painful, tactile or thermal bodily state *S* and subsequently starts to present a painful bodily state *P* as corresponding to the earlier state *S*. Furthermore, while there is no philosophical agreement regarding the individuation of sensory modalities, there are reasons to believe that when a painful sensation is caused by a tactile or thermal stimulation, experiences from two modalities are present. This is because when an earlier non-painful experience leads to a subsequent painful experience, the underlying combinations of inputs change what causes a difference in sensory processing: Only the later combination of inputs opens a pain-gate and leads to a recognition of a pain neurosignature.

Furthermore, characterization in terms of crossmodal correspondences can easily account for the fact that tactile-like and thermal-like pains often lead to adaptive reactions, even when no actual tactile or thermal stimulus is present. It is so because in virtue of representing a painful bodily state as corresponding to some type of tactile or thermal bodily state, a multimodal painful sensation may motivate behaviours that are suitable given the content of occurring correspondence. For instance, a laser-induced pinprick pain represents a bodily state as corresponding to a bodily state evoked by a rapid, finely localized tactile stimulation and so evokes a swift withdrawal reaction. On the other hand, a thermal-like second pain represents a bodily state as corresponding to a longer lasting bodily state caused by thermal stimulation and so leads to actions aimed towards prolonged care concerning the bodily fragment.

6. Conclusions

I have argued that in case of phenomenally multimodal tactile-like and thermal-like pains, the usual frameworks referring to the notion of instantiation and parthood, are not plausible. A more promising approach is to characterize multimodal pains in terms of crossmodal correspondences. According to this proposal, tactile-like pain consists in experiencing that a painful bodily state corresponds to a tactile bodily state of a certain type, and thermal-like pain consists in experiencing that a painful bodily state corresponds to a thermal bodily state of a certain type.

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