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An enactive approach to pain: beyond the biopsychosocial model

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Abstract

We propose a new conceptualization of pain by incorporating advancements made by phenomenologists and cognitive scientists. The biomedical understanding of pain is problematic as it inaccurately endorses a linear relationship between noxious stimuli and pain, and is often dualist or reductionist. From a Cartesian dualist perspective, pain occurs in an immaterial mind. From a reductionist perspective, pain is often considered to be "in the brain." The biopsychosocial conceptualization of pain has been adopted to combat these problematic views. However, when considering pain research advancements, paired with the work of phenomenologists' and cognitive scientists' advanced understanding of perception, the biopsychosocial model is inadequate in many ways. The boundaries between the biological, psychological, and social are artificial, and the model is often applied in a fragmented manner. The model has a limited theoretical foundation, resulting in the perpetuation of dualistic and reductionist beliefs. A new framework may serve to better understand and treat pain. In this paper, we conceptualize pain as a 5E process, arguing that it is: *Embodied*, *Embedded*, *Enacted*, *Emotive*, and *Extended*. This perspective is applied using back pain as an exemplar and we explore potential clinical applications. With enactivism at the core of this approach, pain does not reside in a mysterious immaterial mind, nor is it an entity to be found in the blood, brain, or other bodily tissues. Instead, pain is a relational and emergent process of sense-making through a lived body that is inseparable from the world that we shape and that shapes us.

Keywords Biopsychosocial · Phenomenology · Pain · Cognition · Embodied · Enactivism

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1 Introduction

Persistent pain is a global burden, with back pain identified as the leading cause of disability worldwide (GBD 2016 DALYs and HALE Collaborators 2017). Most often there is no readily identifiable pathoanatomic driver of persistent pain; approximately 90–99% of back pain is considered to be non-specific, in that there is no definitive underlying pathology, such as a fracture, tumor, infection, or significant structural change to explain the pain experience (Maher et al. 2017). This creates a communication problem for clinicians that are trying to explain persistent pain and for patients trying to understand their experience.

While recently there has been debate over the definition of pain (Williams and Craig 2016), at this point in time the most widely accepted definition comes from the International Association for the Study of Pain (IASP); "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" and this experience is "always subjective" (IASP 1994). In discussing the complex manner in which pain is experienced, IASP publications note that neural activity induced by noxious stimuli (i.e., nociception) is not pain, and that many people report pain in the absence of tissue damage or any clear pathophysiological mechanisms. They suggest that "… usually this happens for psychological reasons" (IASP 1994). There is a growing number of calls for an update of the IASP definition, as it is dualistic and does not represent our current understanding of pain (Cohen et al. 2018).

While the IASP definition recognizes pain as a subjective experience, many in the medical community continue to look for objective measures of pain and seek technological solutions or fixes for persistent pain. Unfortunately, this approach is not accompanied with clinical success; advanced imaging, surgical interventions, and the widespread use of pharmaceuticals have not made an impressive impact on the burden of persistent non-specific pain, including most forms of back pain (Deyo et al. 2009). Paradoxically, the medicalization of back pain has contributed to further pain and disability (Buchbinder et al. 2018), and perpetuated the quest for a *root cause,* or what has been described as the "pathoanatomical Holy Grail of pain" (Jevne 2016, p. 198). On this quest, many scientists have attempted to reduce the experience of pain to objectively measured structures or functions in the body (e.g., intervertebral disk pathology) or a neural substrate in the brain through the use of imaging techniques (e.g., pain centers revealed by fMRI) and, medicine and research funding bodies reinforce these perspectives. For example, in an effort to combat the opioid crisis in North America, the National Institutes of Health (NIH) recently allocated millions of dollars in grant funding to develop a tool to objectively measure pain (NIH 2017).

In opposition to these dualist and reductionist approaches to pain, many have advocated for a biopsychosocial conceptualization of pain (Gatchel et al. 2007). Although appealing, this paper argues that the biopsychosocial model is inadequate, as it is often applied in a fragmented manner, and through that, although unintentionally, perpetuates dualistic and reductionist beliefs. What follows is a brief overview of the development of influential pain theories leading up to increased acceptance of the biopsychosocial model. Next, we address some of the shortcomings of the biopsychosocial model and common conceptualizations of pain, and propose a new umbrella or *big picture* approach. Inspired by connected E-based approaches to cognition (Gallagher 2017; Newen et al. 2018; Varela et al. 1991) we propose pain as a '5E' process, in that it is: (1) *Embodied*, (2) *Embedded*, (3) *Enacted*, (4) *Emotive*,

and (5) *Extended*. We take the perspective that enactivism is a unifying core of this 5E-movement. Several fields are now converging under the umbrella of enactivism to study human experience; we are now pulling the complex experience of pain into this conversation. We present our enactivist interpretation of the 5Es, with application to pain. We refer to this as an *enactive approach to pain*; we use back pain as an exemplar and explore how this novel conceptualization of pain may influence current practice.

2 Pain theories

2.1 From animal spirits to neural patterns

In the seventeenth century, Descartes set the stage for the development of pain theories beyond the accepted mystical explanations. Descartes' theory on the dualism of mind and body argued that the two were distinct; that people have an immaterial mind and a material body. When exploring the experience of pain, he explained that when a person was sufficiently stimulated (e.g., burned by a fire), physical tubes that traveled up to the brain were tugged, resulting in the release of animal spirits that caused pain and a motor response of withdrawing from the pain source (Descartes 1633/1972). Further, he suggested that tissue damage was directly related and proportional to pain, "… just as, pulling on one end of a cord, one simultaneously rings a bell which hangs at the opposite end" (ibid, p. 34). Despite the many advances in science, this mechanical and dualist view of pain persists today.

By the nineteenth century the concept of animal spirits had faded, but the separation of body and mind continued along with the endorsement of a linear relationship between noxious stimuli and pain. This was reflected in the pain theories of the day, including: *specificity theory, intensity theory,* and *pattern theory* (Moayedi and Davis 2013). Although these pain theories enriched Descartes' original descriptions, the simple, mechanical explanations were unable to account for complex presentations such as phantom pain. Even into the 1950s, pain was considered a response proportional to the level of tissue damage, a view that has since been soundly defeated through research (Melzack and Katz 2013). Patients with persistent pain who did not have ongoing identifiable physical sources of pain were stigmatized, labeled as psychologically disturbed, and either did not have access to treatment or were sent to psychiatrists. The nervous system was generally viewed as hard-wired; peripheral stimuli were relayed to the brain and the brain was believed to provide a printout of the stimuli, without influence or interpretation. Until the 1960s, there was no "role for the brain other than as a passive receiver of messages" (ibid., p. 2).

2.2 The brain beyond a ringing bell

Beginning in the 1960s, the scientific community started discussing the active role the brain played in pain modulation and this resulted in considerable clinical implications. In 1965, Melzack and Wall presented the *gate control* theory of pain (Melzack and Wall 1965). They proposed that non-noxious input could close a "gate" in the spinal cord that inhibited ascending nociceptive inputs. Further, they proposed that the brain/central nervous system could exert anti-nociceptive effects through descending inhibition. This

active involvement of the nervous system was a breakthrough in understanding the many ways humans experience pain. The gate control theory was highly influential, stimulating an increase in pain research and informing key concepts such as the IASP definition of pain that is most often used today. Although the original details of the gate control theory are now understood to be incorrect, the general concept has endured; it is central to pain education scripts and researchers continue to build on the Melzack and Wall foundation (Mendell 2014).

In the 1980s and 90s, as neurobiologic research techniques advanced, neuro- and brain-centric perspectives of pain emerged. Physicalist/materialist theories surrounding the neural correlates of consciousness/perception were proposed and prominent scientists, such as Nobel Prize winner Francis Crick, declared that human experiences were no more than the actions of neurons and their associated molecules (Crick 1995). Specifically, he wrote that we are "… nothing but a pack of neurons" (ibid., p. 3). Around this time, Melzack proposed what is arguably the most influential brain-centric theory of pain; the *neuromatrix theory* (Melzack 1990). This theory holds that pain is a multidimensional experience produced by a widely distributed neural network in the brain, the *body-self neuromatrix* (Melzack 1999, 2001; Melzack and Katz 2013). Sensory, affective, and cognitive-related brain areas provide inputs to the body-self neuromatrix that result in outputs to brain areas that then produce the perception of pain (sensory, affective, and cognitive dimensions), action programs (e.g., involuntary or voluntary behaviours), and stress-regulation programs (e.g., immune response). This attractive, neurocentric theory was broadly accepted, and as a result, this conceptualization of pain has also become the way that health care professionals describe the experience of pain to their patients.

2.3 Challenging Neurocentrism

Some have challenged the notion that pain is *in the brain*, arguing that pain is emergent and that the brain is necessary, but not sufficient for pain (Thacker 2015). If this view of pain is correct (the perspective taken in this paper) then its properties cannot be explained or produced only by the brain. As Manzotti explained "… there is no definitive proof that neural activity is sufficient to generate pain. In all known cases, neural structures are involved, but so are bodies, the environment, stimuli, tissue damage, past and future behavior, and social interactions. We have no reason to discard all of that in favor of the neural underpinnings alone" (Manzotti 2016, p. 2). In support of the idea that a body is not necessary for pain, many scientists claim that neural processes are conscious. However, *brain-in-a-vat* thought experiments emphasize the necessity of a body and environment (see Thompson and Cosmelli 2011).

What Manzotti was referring to is the so-called mereological fallacy (Bennett and Hacker 2003). Someone commits the mereological fallacy when they attribute properties of the whole to a part. We see this with fMRI studies, where the activation of brain *pain centers* or *signatures* associated with noxious stimulation are considered (through reverse inference) to be the cause or essence of a pain experience. The conclusion that the brain has pain-specific centers or signatures was brought into question when an fMRI study (published in *JAMA Neurology*) revealed that the activation of pain signatures associated with noxious stimulation occurred in the brains of study participants who had congenital insensitivity to pain (Salomons et al. 2016). Still, in current

pain research and practice, it is common to find studies and reports that disembody and decontextualize the brain and conflate neural activation with subjective experience. Many hold the idea that the experience of pain can be found objectively, through third-person approaches, in the brain's structures and connections. For example, it has been stated that the subjective experience of pain is: "… in the brain and this can be detected with fMRI every time it occurs" (Apkarian 2011, p. 579). Considerations of the biopsychosocial model (described in the next section) offer an alternative, less reductionist approach to understanding pain.

2.4 Biopsychosocial model

Since the 1980s, many psychologically and sociologically-informed pain theories and models have been proposed, including the: *onion model* (Loeser 1980, 2006), *mature organism model* (Gifford 1998), *fear-avoidance model* (Vlaeyen and Linton 2000), *biopsychomotor* conceptualization of pain (Sullivan 2008), and the *social communication model of pain* (Craig 2009). Approaches such as these have fostered a growing appreciation that the biopsychosocial model provides an umbrella framework for pain, and currently it is considered the clinical standard of care (Gatchel et al. 2007).

The biopsychosocial model was a response to the reductionist and dehumanizing application of the biomedical model in clinical practice. In the 1960s and '70s, Engel argued that the biomedical model could not explain the complex nature of health conditions (Engel 1960, 1977). He expressed frustration with the medical profession's persistent mind-body dualism and its flaw of focusing on perceived *real* problems by measuring biological/somatic variables while excluding or minimizing psychosocial aspects of health. He described how the biomedical model "… encourages bypassing the patient's verbal account by placing greater reliance on technical procedures and laboratory measurements" (Engel 1977, p. 132). Engel created the biopsychosocial model (ibid.) by applying the tenets of general systems theory, considering the interplay of the patient and their social/healthcare context. The model attempts to unite all the biological, psychological, and social aspects of health under one umbrella.

The biopsychosocial model is meant to facilitate a better understanding of the psychosocial and sociocultural aspects of pain, along with a continued focus on biology. Since its introduction, there have been significant pain science advancements, such as the understanding of neuroplasticity, central sensitization (Latremoliere and Woolf 2010) and an increased understanding of the role of anxiety, depression, anger, fear, and catastrophizing in the pain experience (Gatchel et al. 2007). Given the obvious observation that brains coexist with bodies in a sociocultural context, the biopsychosocial model has appeal over neuro- or brain-centric, biomedical models of pain. However, the biopsychosocial model has several limitations, the focus of the next section.

3 Biopsychosocial model limitations

3.1 Bio-psycho-social fragmentation

The biopsychosocial model is vaguely defined and researchers, clinicians, and educators struggle when teaching and applying the model in a holistic manner.

Often a Venn diagram with three, separate, but slightly overlapping circles is used to represent the biopsychosocial model, suggesting that each domain has some shared features. Some even depict how the circles may be of different sizes (Jull 2017). Yet, these representations, and common interpretations, do not offer the dynamic integration of the three domains and situate first-person experiences such as pain. When applying the biopsychosocial model, there is a tendency to separate patients' pain into two (biological or psychosocial) or three (biological, psychological, or social) domains. In educational and clinical settings, once the domains are separated, the focus tends to be on the biological (Carr and Bradshaw 2014). As de Haan (2017) has pointed out, there is room for improvement when it comes to integration of the three domains and acknowledging the phenomenology of experience. Similarly, Wideman et al. (2019) argue that the biopsychosocial model does not clearly delineate how different forms of assessment relate to the subjective experience of pain. Others have gone as far as saying that the biopsychosocial model is insensitive to patients' subjective experiences (Benning 2015) and that it conflicts with patient-centered approaches to communication even when a clinician has a "sophisticated understanding of biopsychosocial theory" (Bartz 1999). This lack of integration and incorporation of phenomenological elements may be traced back to the fact that there is not a strong theoretical foundation for the biopsychosocial model and without it, teaching, research, and clinical application does not have clear direction. Despite some of the challenges pointed out, only a few have openly criticized the model and its practical utility.

The field of psychiatry is one of the few areas in health that has offered a critical analysis of the biopsychosocial model. Cabaniss et al. (2015) described how the biopsychosocial model "… chops the patient into three neat packages…" (Cabaniss et al. 2015, p. 579). They go on to state that when students are prompted to consider the patient from three perspectives, they commonly propose treatment plans with superficial psychological and social interventions with no connection to the patient's biology. Likewise, Benning (2015) discussed how the biopsychosocial model lacks philosophical coherence and that there are "… no safeguards against either the dominance or the under-representation of any one of the three domains of bio, psycho, or social" (p. 347). These criticisms align with what we see in musculoskeletal education and practice, where there is a focus on pathoanatomical (biological) *causes* of pain, while psychosocial factors are neglected, ignored (or referred away to other healthcare professionals), or the patient is stigmatized through the attribution of pain for psychological causes (Breen et al. 2007; Synnott et al. 2015). This is reinforced by the current IASP definition of pain as physical/biological, and when other elements are presented, they are dismissed as psychological (IASP 1994). Fragmenting a patient's pain into components inappropriately considers humans as linear and dissociable (i.e., able to mechanistically separate into distinct parts) and is contrary to the intent of Engel's proposition. Further, the social aspects of pain are often left out of the clinical picture when the patient's problem is believed to be "mechanical" (biological) or related to underlying pathology. Yet, as described in detail later, pain is always socially and ecologically grounded. Some have recognized this and have proposed a reformulation of the biopsychosocial model to frontload or emphasize the social domain. For example, Sommers-Flanagan and Campbell (2009) proposed the *social-psycho-bio* model, but it was not widely supported. Still, this is not a solution as it continues to

draw artificial lines and ignore the person as a dynamic whole that is always *in and of the world*.[1]

3.2 Dualist and physicalist tendencies

Despite the desire to expand the clinical understanding of pain with the biopsychosocial model, clinical application has been reported to be dualistic from both the clinician's and the patient's point of view (Arnaudo 2017; Duncan 2000). According to Arnaudo: "… pain has to be either in the body or in the mind. If the patient's experience of suffering does not fit within the physician's model of knowledge, i.e., if there is no objective evidence that the source of the suffering is in the patient's body, the conclusion is that the origin of that pain experience has to be in the patient's mind" (Arnaudo 2017, p.3). Using the IASP definition and in the absence of physical findings, patients are labeled as having pain that is psychogenic (IASP 1994). Unfortunately, pain without demonstrable physical cause is viewed by clinicians with suspicion and patients are often stigmatized as a result (Arnaudo 2017; Slade et al. 2009; Synnott et al. 2015). If a patient is told they have psychogenic pain, Morris explained: "Quite naturally, patients resist the bizarre idea that they are somehow the cause of their own suffering. How could it be that a pain spreading across the lower back like a firestorm does not reveal a steady stream of nociceptive impulses flowing from an injury to the lower back?" (Morris 1993, p. 157). Qualitative studies exploring patients' experiences confirm how they are often not responsive to explanations involving the idea that their brain is creating their pain or that their pain is psychogenic in nature. Versions of the following patient response are not uncommon: "I felt stupid – the pain isn't in my head it's in my back" (Holloway et al. 2007, p. 1459).

To avoid negative patient responses to pain explanations, biopsychosocial model proponents have suggested that deep learning through intensive pain neuroscience education is needed to better understand the role of the brain and how it can be retrained – otherwise "… patients often misunderstand the neuroscience education message and believe that they are being told 'the pain is all in your head', which is a common pitfall of this approach" (Nijs et al. 2015b, p. 217). However, with "deep learning" it is no wonder that patients become upset and confused, as the content of the pain education strongly emphasizes biology with the additional explanation that the brain creates pain and that patients need to re-train their brain, perpetuating Cartesian dualistic thinking. As Ryle (2009) has pointed out, this type of approach promotes the idea that there is a "ghost in the machine" that can control the brain (body). With this ghost in the machine perspective, people possess something immaterial that can interact with their body and retrain their brain. With this, we are back to a version of Descartes' concept of pain; the same concept that the scientific community criticized yet has struggled to shed. As described by Duncan (2000) "… the biopsychosocial theory starts by trying to avoid dualism, and then, in practice, becomes dualistic …" (p. 502). Further, when we look closely, biopsychosocial proponents take a brain-centric approach and suggest that pain is ultimately *in the brain* (Moseley and Butler 2017). Even

[1] Extending Merleau-Ponty's work, Noë (2009) has argued that perception/consciousness is not something that happens inside us. Instead, it is something that we achieve through action *in* the world that we are always a part *of*.

recent guidelines for back pain from strong promoters of the biopsychosocial approach state that it is a "… fact that all pain is in the brain" (Nijs et al. 2015a, p. 340). This is problematic as pain education delivered in this way more closely resembles the reductive and physicalist view of pain previously discussed.

Although many have looked to the biopsychosocial model to conceptualize, assess, and explain pain, it provides little guidance and is rarely applied in the manner that Engel intended, where biological, psychological, and social factors are considered dynamic and interdependent. While the biopsychosocial model created and continues to create discussion about the problematic biomedical model, to better understand pain, a more holistic conceptualization of pain is currently warranted. Next, we introduce the 5E-movement and enactivism. The common thread of enactivism across the 5Es will become more apparent as the paper progresses.

4 An enactive approach to pain

The term '4E' has been attributed to Gallagher, who coined the phrase in reference to a new way of thinking about the mind (Rowlands 2010). Gallagher proposed that cognition is (1) embodied, (2) embedded, (3) enacted, and (4) extended. 4E cognition has its foundation in phenomenology and the cognitive sciences, and diverse E-based research programs have emerged, not specifically applied to pain (Menary 2010). For example, work has been published in domains such as mathematics education (Reid 1996), architecture (Jelic et al. 2016), pretend play (Rucinska and Reijmers 2015), and autism (De Jaegher 2013). Some rehabilitation-based work has been conducted in the areas of brain injury (Martínez-Pernía et al. 2016), schizophrenia (Kyselo 2016), and cerebral palsy (Martiny 2016). Øberg et al. (2015) made theoretical progress with their paper on clinical reasoning in physiotherapy, but few have explicitly used an E-based framework to understand the etiology and treatment of pain.

In this paper we present our enactivist interpretation of the 5Es (adding 'emotive' to Gallagher's 4Es), arguing that it is a promising avenue to understand pain as it does not commit the mereological fallacy, is not dualistic, appreciates the first-person experience of pain, and avoids the trichotomization or dichotomization of pain that is common when clinicians apply the biopsychosocial model. Further, the enactive approach to pain has a strong theoretical foundation with important elements not found in other pain theories such as recently converging theories of perception (i.e., embodied cognition and predictive processing). These elements of the enactive approach are interconnected and dependent on each other, in contrast to the biopsychosocial approach that does not have this explicit interconnectivity. It is important to note that E-based approaches to cognition are currently stimulating rich debate stemming from internal inconsistencies (Gallagher 2018). As optimistically described by Kiverstein and Clark (2009, p.2), there are "… many straws in this otherwise quite refreshing wind." In an attempt to maintain conceptual consistency, here and throughout the paper we declare the E-based considerations that best align with a cohesive (we hope) account of pain.

Enactivism stems from the work of Maturana and Varela (1987/1992) and the aligned content of Varela et al. (1991) which has strong biological and phenomenological roots. We appreciate that there are now many strands of enactivism and align ourselves with the grouping that rejects traditional computational and representational (often referred to as

cognitivist) cognitive science. We make deliberate attempts to provide consistency by aligning our terminology with this strand of enactivism, using concepts and terminology from Maturana and Varela (1987/1992) and later E-based work that has built on original concepts such as *autopoiesis* and *structural coupling*. This includes the work of Varela et al. (1991) that rejects the idea that people (and other organisms) internally represent an external world in a Cartesian sense. The sections that follow explain the 5Es as they apply to the experience of pain, considering each individually and in combination to provide a robust enactive explanation of the human experience of pain.

4.1 Embodied

Embodiment means "… not just having, and acting through, some physical instantiation, but recognizing that the particular shape and nature of one's physical, temporal and social immersion is what makes meaningful experience possible" (Anderson 2003, p. 124). Husserl and Merleau-Ponty's work are the foundation of the current concept of embodiment. Husserl emphasized the important role of the body as a core part of phenomenology. As described by Moya, Husserl appreciated that "… perception is not a passive reception of information, but instead implies activity, specifically, the movement of our body" (Moya 2014, p. 2). Merleau-Ponty also emphasized the role of the body in everyday experiences and argued that we are directed to the world through *motor intentionality*, a matter of bodily skills and habits from the first-person perspective (Käufer and Chemero 2015). Further, Merleau-Ponty described how the lived body inhabits space and time, and that, in relation to Heideggarian terms, the living body is the vehicle of being-in-the-world (ibid.).

Proponents of embodied cognition entertain differing views as to what embodiment is. We do not ascribe to what Alsmith and de Vignemont (2012) have conceptualized as *weak* embodiment, involving body-formatted neural representations in the brain and the trivialization of non-brain related factors (i.e., the environment). Instead, we align with Gallagher's (2017) phenomenological, *strong* conceptualization that appreciates the central nervous system *and* the non-neural body, bodily activity, autonomic and peripheral systems, and relations with the environment. We do not view cognition as happening *in the brain* - instead, we appreciate that brain activity influences, "… but is in turn influenced by, physical activity taking place in other parts of the organism (such as the endocrine and immune systems)" (Colombetti 2017, p. 1). This includes the way the body is felt, visualized, and positioned; for example, studies have reported that when participants hold their arms out to the side, doorways look narrower (Stefanucci and Geuss 2009) and hills appear steeper when carrying a heavy backpack (Bhalla and Proffitt 1999). According to Thompson (2005), there is an inseparable relationship between sensation, action, and the environment. Cognizing systems (e.g., people and other organisms navigating their environment) "… embody a dynamic sensorimotor loop: the way they move depends on what they sense, and what they sense depends on how they move" (Thompson 2005., p. 418). It is not just the body's (or brain's) internal processes that shape perception; bodily action and capacity to act based on our social environment are also vital. At this point, it is important to note that while embodied consideration of cognitive science involves the close relationship between cognition and behavior, embodied cognition is not a return to behaviorism (see Martiny and Aggerholm 2016).

The concept of embodiment is not novel when considering the historical foundations of phenomenology, and qualitative researchers have long advocated the importance of embodiment in research (Sandelowski 2002). However, in the study of pain, the examination of the body and the nervous system has been focused on the body as an object, which is only one aspect of embodiment. While this has led to many scientific advancements related to physiology (e.g., nociception), serious consideration of embodied first-person experiences (i.e., the lived body or body-as-subject; see Øberg et al. 2015) is not often employed. But this is slowly changing, as there is growing appreciation of how body orientation and movement contribute to the pain experience and how an individual's evaluation of the function and action of their body intertwines with their experiences of space, time, and ultimately, their pain and future action. More specifically, pain can dilate subjective time perception (Rey et al. 2017), alter subjective space, including less "room" - restricting bodily motion (Honkasalo 1998), and can increase the perception of distances compared to pain-free controls (Witt et al. 2009). In pilot work using real-time footage of modified versions of participants' own backs during a lifting task, a participant with negative back beliefs was able to embody the illusion of a strong, muscular back – resulting in less pain and fear during the lifting task and increased strength and confidence, as compared to the same task when visualizing their back as normal or reshaped (non-strong) (Nishigami et al. 2018). These findings are consistent with illusion embodiment research with people experiencing knee pain (Stanton et al. 2018).

Embodiment and pain described in this section aligns with phenomenological models of illness, where the focus is on how disease (physiological dysfunction) is experienced (Carel 2016; Svenaeus 2001; Toombs 1990). Yet, as Carel (2016) pointed out, illness (the "what it is like" qualitative/phenomenological dimension) cannot be reduced to disease, and illness can develop without clear underlying physiological dysfunction. Svenaeus (2001) emphasized the importance of individuals' interpretation and evaluation of their situation, not just the biological investigation of their body; yet, they noted that their phenomenological model of illness was not meant to replace biomedical research or negate the body-as-object. Instead, it was appreciated that "the physiology of the body, however, certainly affects and sets limits to the different ways we are able to experience and interpret our being-in-the-world" (Svenaeus 2001, p. 87). In summary, the physical body (including nociception, sensitization, neuroplasticity, bodily movement and orientation) and the subjectively lived body must both be simultaneously considered when exploring embodiment and pain in a comprehensive manner. Further, embodiment is shaped by and shapes culture and society – the focus of the next section.

4.2 Embedded

By virtue of being embodied, people are also automatically embedded or situated in an environment, and perceptual changes can be viewed in relation to potential for action, based on what the environment affords. An embedded approach can be seen in Heidegger's philosophy where he described how every situation is an interpretation based on our background and the current context (Benner 1994), along with Gibson's theory of affordances (Gibson 1977). The theory of affordances aligned with Merleau-Ponty's work, of which Gibson was well aware (Käufer and Chemero 2015). Merleau-

Ponty espoused that the world we experience is a field of possibilities for skilled action which closely resembles the theory of affordances (Baggs and Chemero 2018). Contemporary research on perception has consistently supported the importance of context and participants' relation to their environment. For example, in a study by Stefanucci et al. (2008) research participants stood at the top of a hill on either a skateboard or a wooden box. Participants that were afraid (standing on the skateboard) judged the hill to be steeper relative to participants who were unafraid (standing on a wooden box). This can be explained by what the environment subjectively (spatially and relationally) afforded the individual. Participants on the skateboard were afforded potentially dangerous action (i.e., falling, getting hurt), which shaped their perception.

While Heidegger rarely made reference directly to pain, he did not see it as an internal sensation; instead, he described it as relational and simply our contact with the world and our "openness" to it (Mitchell 2010). Ratcliffe's (2008) work built on this idea and is relevant to our considerations of pain. He incorporated various components from Husserl, Heidegger, and Merleau-Ponty to create a coherent phenomenological story of experience that is inseparable from the environment. He stated that "even in cases where *either* the body *or* some other part of the world appears to be the sole content of an experience, that experience retains an underlying structure where body and world are inseparable - to experience one is to experience the other" (ibid, p. 1). He considers how pathological experiences (e.g., schizophrenia) can change our appreciation of the nature and variety of feelings, and that many bodily feelings are not experiences of bodily states but ways of experiencing the relationship between the body and the world. He argues that this unity is overlooked as many interpret experience dualistically – as experience of bodily states *or* experience of everything else (ibid).

There is now a growing body of pain literature aligning with the ideas of phenomenologists, emphasizing the importance of environmental/social contexts (Arntz and Claassens 2004; Harvie et al. 2015; Hechler et al. 2016; Valentini et al. 2014). The literature as a whole recognizes that situations can embed a sense of threat or safety, worsening or dampening pain - depending on the scenario and an individual's embodied perspective. As described by Ongaro and Ward (2017, p. 535): "A situation or object that someone else experiences as affectively neutral might be highly salient for me in virtue of my history of embodied interactions with it." Pain and associated motor behavior in individuals with back pain is now considered to be an adaptation to minimize real or perceived risk of provoking more pain or (re)injury (van Dieën et al. 2017). As a person in pain engages in the world, there is an ongoing threat to the integrity of the body and concern regarding triggering more pain. For example, they will often stiffen their bodies (combining increased muscular co-contraction with reduced movement and sensory feedback) to protect themselves (ibid.). The resulting short-term reduction of pain and injury is positively reinforcing and therefore quickly learned. In the long-term, and in the absence of tissue damage, these safety behaviors are linked to threat avoidance, which strongly reinforces the behavior and paradoxically leads to persistent pain and disability. The reasons for this are not fully understood, but it appears that part of the story relates to the repetition of maladaptive sensorimotor cycles, changes to the nervous system (e.g., sensitization), learning and self-efficacy, and environmental reinforcements (i.e., the dominant cultural message to rest when experiencing pain to avoid harm/damage). These factors form barriers to the

completion of daily or work-related physical activities (e.g., bending and lifting) without bothersome pain. In simple terms, people become stuck in a rut. With this perspective, it follows that persistent pain interventions should be aimed at all sources of threat that can be modified, not just the biological, muscle or joint injury, but also the messages patients receive from others and their attitudes and beliefs associated with these messages.

Overlooked sources of threat include well meaning, but potentially *nocebic* messages from healthcare providers, the workplace, family/friends, and the media. A body of literature is slowly developing in this area (Darlow 2016; Karos 2017; Setchell et al. 2017; Stilwell and Harman 2017a). Many patients experiencing back pain hope for the discovery of a clear organic cause of their pain and clinicians do their best to fulfill this expectation by providing a physical diagnosis (e.g., intervertebral disc bulge) to "hang their hat on" (Slade et al. 2011; Stilwell et al. 2017; Stilwell and Harman 2017b). This is misleading as most back pain cannot be tied to a specific biomedical cause (Maher et al. 2017) and this medicalization of a widespread phenomenon may backfire - resulting in increased pain, disability, fear, guilt, and poor adherence to evidence-based treatment recommendations, such as advice to return to daily movements/exercise (Stilwell and Harman 2017a). Many clinicians are quick to blame and stigmatize "difficult" patients; yet, embodiment and meaning is always relational - created through interaction with others, including clinicians (Nicholls et al. 2016). Pain is dependent on meaning, which is never context-free.

Ward and Stapleton (2012), Clark (2015, 2016), and Gallagher (2017) described how embodied and embedded perspectives are congruent with the paradigm of predictive processing that is growing in popularity. There are also connections between enactivism and extended cognition, which are discussed later. The version of predictive processing that we are referring to is based on the idea that perception is created by predictions informed by our past experiences and processing at a sub-conscious level based on predictions of what sensation, movement, or event will happen next. More specifically, Clark (2015, p. 5) described how "… perception involves the use of a unified body of acquired knowledge (a multi-level 'generative model') to predict the incoming sensory barrage." Further, the generative model is considered to be the "… multi-area, multi-scale, body-and-action involving grip on the unfolding sensory stream" (Clark 2015, p. 9). This perspective clearly appreciates the embodied and embedded nature of perception. In the enactive approach to pain, these elements are interconnected and dependent on each other. When information from the world does not align with predictions, prediction error signals are generated. As we force the resolution of an error, new models/predictions are made, or behavior is altered to make the model fit.

Predictive processing simultaneously appreciates the body as an object and subject, and aligns with clinical observations of those experiencing persistent back pain. When asking patients to engage in a movement they fear will increase their pain, they often predict negative events (e.g., tissue damage or dysfunction and increased pain). Through graded exposure (Vlaeyen et al. 2002) to feared movement, negative predictions (priors) are violated when the feared event does not occur, leading to new predictions (posteriors). The goal of this intervention is to update the generative model/predictions in a favorable direction (i.e., "I can bend without injuring myself and experiencing severe pain"). In essence, top-down and bottom-up streams of information align (i.e., the

patient predicts that they can bend forward comfortably, and this is matched when the therapist guides them in the relaxed movement). It is reasonable to speculate that when there are no error signals, this minimizes surprise and the need to adapt through pain/maladaptive motor behavior, which then becomes the new expectation when moving. In the psychology literature, some recommend little education before exposure to maximize inhibitory learning through expectancy violation (i.e., expectations do not match actual outcome) (Craske et al. 2014). This also aligns with predictive processing: if exposure is successful, expectancy violation results in error signals and the generative model updates as unlearning takes place and new predictions are generated. In summary, pain is always an embedded experience; therefore, situational contexts (past, present, and expectations of the future) need to be considered.

4.3 Enacted

The *enactive approach* stems from the interdisciplinary work of Varela et al. (1991). They built on Varela's previous work with Maturana where they set out to define the characteristics of living organisms - arguing that being *autopoietic* was the essential property to living (Maturana and Varela 1980, 1987/1992; Varela et al. 1974). Autopoiesis refers to an *operationally closed* system that is self-creating, self-maintaining, precarious, and later described to be adaptive by Di Paolo (2005, 2009). Maturana and Varela argued how autopoietic systems can occur at many different levels (e.g., living cell or person) and how *structural coupling* affords interaction between these systems. Although autopoietic systems have closure/boundaries, they can couple with the environment - resulting in exchanges of matter and sense-making. Building on this theoretical foundation, Varela et al. (1991) theorized that cognition is a relational process that is *enacted* (brought forth) through an organism's embodied interaction with the world. This contrasts with the traditional cognitivist view that the brain forms representational mapping or a replicated internal model of the world. Although there are E-based proponents who are sympathetic to traditional representational views of the mind, once again, we align ourselves with the form of embodiment and enactivism put forth by Varela et al. (1991) and Gallagher (2017). With this perspective, the brain, as part of the body–environment system is as Prinz (2004) put it, is *set up to be set off* – "Set up by evolution and developmental processes, and by prior experience and plastic changes; set off in dynamical response patterns by the agent's worldly engagements. On this view the brain works as an integral part of the organism which responds dynamically to environmental changes" (Gallagher 2019, p. 2).

The precarious nature of an autopoietic system is key as it makes situations or events meaningful or significant from a concerned point of view; the system "… is always menaced by concern (*Sorge*)…" (Weber and Varela 2002, p. 113). The organism aims to avoid threat/death and maintain its identity and, "by defining itself and thereby creating the domains of self and world, the organism creates a perspective which changes the world from a neutral place to an *Umwelt*[2] that always means something in relation to the organism" (Weber and Varela 2002, p. 117–118). As emphasized by

[2] *Umwelt* is the world as it is experienced by a particular organism. As described by Thompson (2007, p. 59) an *Umwelt* is "… an animal's environment in the sense of its lived, phenomenal world, the world as it presents itself to that animal thanks to its sensorimotor repertoire."

Colombetti (2010), meaning is created by the organism for the organism; yet, meaning is relational - the organism is always coupled to an environment with affordances, as described in the *embedded* section above. Here, Gibsonian ecological approaches of affordances blend with enactivism, and can be viewed as ontologically and epistemologically complementary – they aim to explain behaviour in terms of the organism–environment relations from opposite ends (Baggs and Chemero 2018). Ecological psychologists use an ontologic strategy to explain how the environment constrains how the world appears to an organism, while enactivists use an epistemic strategy to explain how the world appears relative to an organism's skills, abilities, and histories (Baggs and Chemero 2018). Together, these differing points of view contribute to a more comprehensive account of action and perception.

When considering an enactive approach to back pain, we suggest that the ongoing presence of threat – such as threat of bodily injury, triggering or worsening of pain, or the inability to work or engage in valued activities is key to the persistent perception of pain. The enactive approach moves us beyond Cartesian dualism, to the interconnected and inseparable interaction between body, mind, and environment. From an enactive perspective, cognition is a relational process, in that: "… there is a mutual shaping between organism and environment that generates—or enacts—a meaningful world determined by the goals, needs and capacities of the former" (Stendera 2015, p. 265). An enactive approach views cognition as a form of sense-making – it is not a matter of representing a pre-given world, but rather an active, embodied process creating meaning or significance. In other words, sense-making occurs when a person (or another autopoietic system) finds significance in its world. Maiese summarized the enactive approach as: "All living systems are sense-making systems by virtue of their autonomous and adaptive nature and the fact that they must regulate their own self-generating activity and exchanges with the environment in order to survive" (Maiese 2015, p. 973). Threat to a system demands adaptation involving regulation of the relationship with the environment and resulting internal states (Ongaro and Ward 2017). Threat and meaning are always relational, and pain is a mode of self-regulation that unfolds when there is serious threat to this precarious system. This process facilitates bodily/identity protection as well as verbal and non-verbal communication with others (e.g., bystanders, family, friends, clinicians).

To further the argument that an enactive approach is helpful to understanding pain, the sense-making of pain through one's connection to the environment strongly aligns with pain perception. People are coupled to the environment, including other people that help generate a range of meanings and adaptations. Recently, more attention has been paid to the dynamics between two or more autonomous/autopoietic systems (people) and how they make sense together. De Jaegher and Di Paolo (2007) have explicitly expanded the enactive concept of sense-making into the social domain, in the form of *participatory sense-making*. Participatory sense-making occurs when two (or more) people engage in interactions that produce meaning or significance that could not be produced by either individual alone. In other words, embodied and embedded systems (people) actively participate in the generation of meaning through being-in-

[2] *Umwelt* is the world as it is experienced by a particular organism. As described by Thompson (2007, p. 59) an *Umwelt* is "… an animal's environment in the sense of its lived, phenomenal world, the world as it presents itself to that animal thanks to its sensorimotor repertoire."

the-world and connecting with each other. With this, embodiment, embeddedness, and enaction are inseparable. This sense-making between two people is particularly relevant when considering the patient-practitioner relationship and the meaning of the patient's pain.

Unlike existing pain theories, the enactive approach embraces the role of the non-neural body, action, environment, and meaning/sense-making. An enactive approach to pain is not constrained by current brain-centric conceptions (e.g., pain is an output of the brain) or biomedical approaches (e.g., pain is caused by disks, facet joints etc.). Instead, a broader perspective is taken, considering the action-oriented person (with a brain and body), in a specific context/environment. With an enactive perspective, perception is viewed not as something static or *in* us, it is a process or something we *do* (Noë 2004). This contrasts with contemporary pain theories (e.g., neuromatrix theory) that separate bodily movement as an output or response to, rather than as an essential element of the pain experience. The enactive approach accepts the brain and nociception as physiological processes involved in pain perception yet, avoids reductionist thinking by considering the complex coupling of systems (past and present).

At this point, the enactivist position may seem contrary to predictive processing as described in the previous section; however, we must consider the different levels of analysis and how they fit together. Clark takes the position that predictive processing is congruent with enactivism as it is "… fundamentally in the business of serving action within the context of rolling sensorimotor cycles" (Clark 2016, p. 291). Further, that the generative model functions "… just as enactivists might insist—to enable and maintain structural couplings that serve our needs and keep us viable" (Clark 2016, p. 293). The predictive processing and enactivist connection is further discussed in section 4.5 on extended cognition.

4.4 Emotive

Emotion and affect are terms that are often used interchangeably; however, a common way that they are differentiated is to consider affect as the conscious experience or *feeling* tied to an emotion, and emotion as the physiological display of feelings (Ketai 1975). Many view emotion/affect as purely mental phenomena – rejecting bodily (and non-neural) contributions. Philosophers of cognitive science have challenged this view, instead considering it as intertwined and enactive, overcoming the false dichotomy between cognition (in the thinking/mental sense) and bodily action. In fact, there is strong support for *bodily feedback theories*, where bodily expressions or manipulations (e.g., changes in posture or facial movements) help shape subjective emotive experiences (Niedenthal 2007; Price and Harmon-Jones 2015).

Maiese advocates for an enactive account of emotion (Maiese 2014). She has described emotion as a way of engaging with, and making sense of one's surroundings (Maiese 2014). She has also argued that emotion is a mode of embodied and enactive appraisal and is the primary way in which we engage with, interpret, and make sense of the world through "desiderative feelings of affective framing" (Maiese 2011, p. 3). Affective framing is the process whereby one interprets people, objects, facts, states of affairs, ourselves, etc. in terms of embodied desiderative feelings (i.e., embodied directedness/desire). Maiese has argued that we focus our attention towards things in our environment that we care about and that are important to us. She compared this to

Heidegger's *care* or *concern* (*Sorge*). Similar to Maiese, Colombetti has argued for an enactive approach to emotion, proposing that emotion should be conceptualized as a faculty of the whole embodied and embedded organism (Colombetti 2010). She has stated that: "Evaluations arise in this organism in virtue of its embodied and situated character, and the whole situated organism carries meaning as such — not by way of some separate abstract cognitive-evaluative faculty" (Colombetti 2010, p. 146). In essence, Maiese and Colombetti fuse together the cognitive, bodily, and environmental elements of emotion – making emotion fully enactive.

Thompson and Stapleton have also discussed emotion, detailing how sense-making comprises emotion and that an enactive approach does not view cognition and emotion as separate (Thompson and Stapleton 2009). Further, they argued that emotion/affect, along with motivated action is a mode of self-regulation and that cognition/emotion/affect cannot be either "body neutral" (in that the body plays no major role) or "envatted" (brain in vat/jar, with no body) (Thompson and Stapleton 2009). This is in line with Colombetti's writings describing sense-making as a "bodily cognitive-emotional form of understanding" that belongs to all autopoietic and adaptive (living) systems (Colombetti 2010).

Pain aligns with enactive descriptions of emotion/cognition, including the concepts of autopoiesis and affective framing. The precarious nature of living organisms creates the grounds for elaborate self-regulation and adaptive processes. As noted earlier, pain can be considered as one of those adaptive processes or modes, ensuring the survival and identity of an organism in the face of a real or perceived threat. Further, it can be argued that when a person experiences pain, enactive versions of emotion are always intertwined and inseparable from the experience. With persistent pain, the person is under constant real or perceived threat, stuck in a liminal state and trying to adapt through enacting pain/emotion. This enactive-emotive consideration of pain aligns with research connecting fear, anxiety, and catastrophizing to the amplification and maintenance of pain (Leeuw et al. 2007; Vlaeyen and Linton 2012).

A strong emotive driver in the experience of pain is fear, such as fear of the pain itself and fear of tissue damage. Distraction, by focusing attention away from sources of threat can reduce pain, while directing attention towards meaningful sources of threat can amplify it. An example that demonstrates the influence of the meaning associated with a stimulus (and here, there is fear of tissue damage) and attention to that meaning is found in the study by Arntz and Claassens (2004). They convinced participants through verbal suggestion that a cold metal bar placed on their neck was either hot or cold. Those who believed the bar was hot rated it as more painful than participants who believed that it was cold. Further, those scoring the bar stimulus as tissue damaging also rated it higher on pain intensity. This is a clear example of how meaning shapes the experience of pain and that perceived tissue damage shapes (amplifies) pain intensity. Similar findings were reported by Moseley and Arntz (2007). They modified visual cues associated with a noxious stimulus such that red meant hot and more tissue damaging, while blue meant cold, and less tissue damaging. They found that threat of tissue damage affected the experience, with the red cue, pain was rated as more unpleasant and intense.

We conceptualize meaning (along with pain) as not a purely internal process; it is enactive-emotive where verbal suggestion, visual cues, and other contextual factors combine with past experience, knowledge, and attention/expectations to form meaning

(e.g., hot materials will cause more tissue damage and pain compared to cold materials). That said, we are not implying that meaning can be easily reconceptualized or that pain can be simply thought away. There are many drivers that can maintain meanings of threat, many of which are unconscious. This includes ongoing nociception in scenarios where noxious mechanical, chemical, or thermal stimuli persist, as well as the presence of bioplastic changes involving the amplification and potentiation of nociceptive signals – resulting in hyperalgesia and allodynia (i.e., peripheral and central sensitization). It can now be appreciated how the 'Es' presented so far are inseparable; when pain is considered an enactive process, it is inherently embodied, embedded, and emotive/affective. The fifth E (extended) builds on these connections and further challenges traditional pain paradigms as it considers how people, culture, and non-biological items can act as scaffolding for the experience of pain.

4.5 Extended

Clark and Chalmers proposed the thesis of the extended mind, where objects within the environment can function as a part of the mind (Clark and Chalmers 1998). They described how biological organisms could couple to external resources; for example, a person with Alzheimer's disease can use a pen and paper to serve the function of memory (e.g., write down directions). The pen, paper, and written notes can be considered as scaffolding or parts of an individual's cognitive/mental processes and identity. In other words, the notes become a source of memory or an extended cognitive process. The extended mind thesis clearly challenges traditional boundaries of cognition.

Gallagher (2017) described how enactivist approaches are like the concept of the extended mind in that cognition is not entirely "in the head," instead; it is distributed across the brain-body-environment. However, he stated: "in contrast to Clark's functionalist view, enactivists claim that bodily processes shape and contribute to the constitution of consciousness and cognition in an irreducible and irreplaceable way. Specifically, on the enactivist view, biological aspects of bodily life, including organismic and emotion regulation of the entire body, have a permeating effect on cognition, as do processes of sensorimotor coupling between organism and environment" (Gallagher 2017, p. 40–41). Further, Gallagher (2018) has summarized work related to how the extended mind goes beyond notebooks, pens, iPhones etc.; it is also about engagement with large-scale institutions (e.g., academic, scientific, cultural) that enable cognition and certain types of cognitive accomplishments. This connection between enactivism and the extended mind has been building for several years, but not without resistance and division (ibid).

Of the extended mind "waves," we align with the third wave that is still in progress, which Gallagher (2018) has characterized as an integration of predictive processing and enactivist dynamics. He describes how enactivist interpretations of predictive processing reframe the "generative model" and inference - diverging from strong representationalist interpretations where an inner world is somehow constructed. Instead, the body (with a brain) attunes with the environment that affords interaction. Further, we can view generative models and active inference in non-representationalist terms in that a person does not "have" a model of the world, instead "… it *is* the model—it embodies the model in the way a wave forms its own barrel: the dynamics of the organism-environment instantiates its own model" (Gallagher 2018 p. 441).

When considering the enactive approach to pain, we move from it being just *in the brain* or *in the back* – to it being a process that emerges or unfolds through a whole person who is inseparable from the world. With an extended perspective in musculoskeletal care, the use of prosthetics, canes, and wheelchairs are common and how these non-biological items shape action and perception needs to be explored. We also need to consider the institutional perspective. Gallagher's (2018) extended mind consideration of the legal institution parallels the pain institution; patients engage (couple) with clinics and society, and this generates more scaffolding for their pain experience. Common pain explanations and treatments shape cognition and can reinforce pain-related behaviors and the pain experience (and how people engage in the world, with others). The view that the back is fragile and needs to be protected is ubiquitous and only recently have there been high-impact calls to action to initiate a cultural shift to reduce iatrogenic clinical and societal messages (Buchbinder et al. 2018). These ideas overlap with interdisciplinary enactive research collaborations that have furthered the understanding of how people and culture constitute cognition. De Jaegher and Di Paolo's work on intersubjectivity and participatory sense-making can be readily applied to interactions that facilitate or hinder the experience of pain by modulating threat or safety (perceived or real). There is evidence that healthcare interactions/contextual factors can unintentionally facilitate nocebo effects - such as the generation, amplification, and maintenance of pain (Testa and Rossettini 2016). Without interaction and sense-making, pain (or its amplification or maintenance) may not unfold – or otherwise manifest. People move through life interacting with others; this shapes the process that is the sense of self, the meaning attributed to past experiences, and confirms or updates predictions about the future. While pain is experienced from a first-person perspective, it can be viewed not as something that is happening inside the body, but a relational process of sense-making where objects from the environment and other people are a part of the process.

5 Moving beyond the biopsychosocial model

Historically, categorizing pain into biological, psychological, and social components has been used to understand the complexity of pain. However, considering advancements in pain research, Engel's biopsychosocial model can be built upon. For example, growing awareness of the immune system's role in persistent pain blurs the lines between central and peripheral mechanisms, the biological and the psychological, and the role of environmental and social factors (Eisenberger and Cole 2012; Marchand et al. 2005). But shifting to a new conceptualization of pain is challenging as Sapolsky discussed, noting that the: "… boundaries between different categories are often arbitrary, but once some arbitrary boundary exists, we forget that it is arbitrary and get way too impressed with its importance" (Sapolsky 2017 p. 17). He gives the example of how the visual spectrum is a continuum of wavelengths and that different cultures arbitrarily fabricate different boundaries for naming colors. Further, he adds that the more attention we pay to boundaries, the less attention we pay to complete pictures. This has clearly occurred with the biopsychosocial model of pain, with many back pain clinicians currently debating where the pendulum should swing - towards the biological (e.g., lumbar disk pathology is the driver of back pain) or the psychosocial

(e.g., fear-avoidance of movement is the driver of back pain). Perhaps it is time to use an enactive approach, where the integration and dynamics of both ends of the pendulum are central to its theoretical foundation.

Separating the person from their environment creates an artificial boundary. Whitehead presented this idea almost a century ago, stating: "We cannot determine with what molecules the brain begins and the rest of the body ends. Further, we cannot tell with what molecules the body ends and the external world begins. The truth is that the brain is continuous with the body, and the body is continuous with the rest of the natural world" (Whitehead 1933, p. 225). Whitehead's perspective nicely aligns with our E-based consideration of pain and how we are *in and of the world* (Noë 2009). Figure 1 reflects this shift in thinking.

The enactive approach to pain overcomes the limitations of the biopsychosocial model and provides a robust theoretical perspective that is holistic and safeguards against the trichotomization or dichotomization of a person in pain. It also explicitly incorporates the phenomenological first-person experience of pain. An adaptation of Thompson's (2014) metaphoric explanation of cognition is used here to summarize pain as a enactive brain-body-world process that is relational, not something immaterial or physical to be found in the body or the brain.

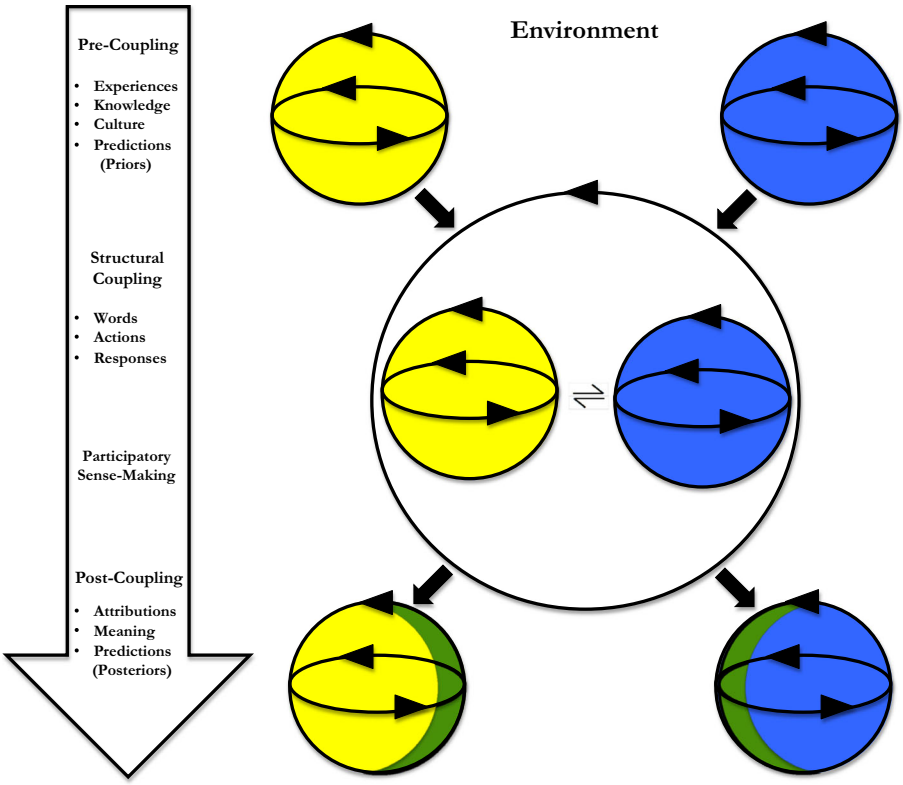

Fig. 1 Moving from the biopsychosocial Venn diagram (**a**), to a schematic of a dynamic person (adapted from Maturana and Varela (1987/1992); the outer circle represents an organism and the inner circle represents the organism's nervous system) coupled to a changing environment (**b**)

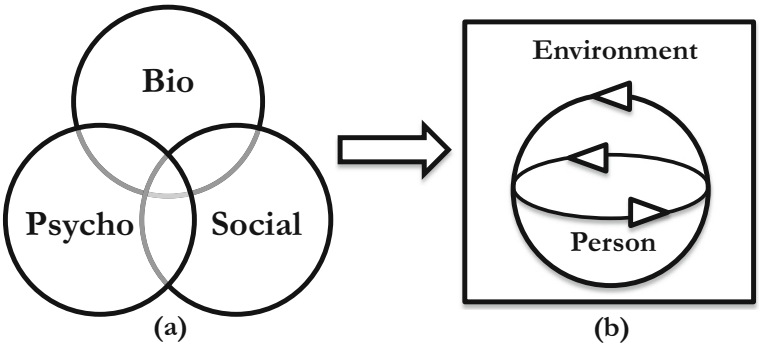

Fig. 2 Schematic of two embodied and autopoietic people (e.g., yellow = clinician, blue = patient) structurally coupling, resulting in sense-making and altered self-regulation (represented in green). Post-coupling sense-making and self-regulation may take many forms (or shades of green), such as brief reflection on the patient's condition from the clinician's perspective, or threat-based attribution and meaning from the patient's perspective. This schematic is inspired and adapted from the work of Maturana and Varela (1987/1992) and Øberg et al. (2015)

> Saying that pain is in the brain is like saying flight is in a bird's wings. A brain is needed to have pain and wings are needed to fly – but to understand pain or flight, one needs to consider the whole picture and the relational nature between things like a person (with a body/brain) and their social/environmental context; or the bird and the atmosphere. It follows that the experience of pain will not be found in the blood, brain, or other bodily tissues. The tissues in the body or the networks in the brain are not the key to pain – instead they are pieces of a larger system that is adapting and striving to sustain into the future. This always involves the environment that we shape and that shapes us.

Figure 2 represents the relational, enactive nature of healthcare interaction (or another social interaction) and how threat-based attributions, meaning, and predictions help generate, amplify, or maintain pain. In contrast, safety-based attributions, meaning, and predictions can mitigate pain. Similar to the phenomenological model of illness proposed by Toombs (1990), meaning is constituted in the clinician-patient relationship; yet, their individual meanings are significantly and qualitatively different.

With the enactive conceptualization presented in this paper, pain can be considered a process of unpleasant or distressing sense-making from the perspective of an embedded person attempting to adapt and self-regulate to preserve their embodied identity/existence that is threatened. With this definition, pain is a *process,* emphasizing its developmental and relational nature. Further, the first-person experience of pain is preserved, while also emphasizing the embeddedness of the organism; this includes coupling to others and the environment - providing scaffolding for the process of the pain experience. Compared to the IASP definition, the focus on tissue damage is removed and replaced with the concept of a *threat* to one's identity/existence. This is grounded in the extensive literature on: (1) the absence of an isometric or linear relationship between nociception and pain, (2) how nociception is not necessary for pain and (3) the concept of autopoiesis, encompassing the precarious nature of life and

the need to adapt in the face of threat. Yet, there is a caveat under point 2, we suggest that nociception must be experienced during development and pain must be learned, as those with rare genetic alterations (i.e., congenital insensitivity to pain) that impede nociception do not experience pain (Nagasako et al. 2003).

Currently, we are exploring the enactive approach to pain with clinicians, students, and educators to evaluate the extent it can be applied to patient education and incorporated into university-level pain curricula. At this point in time, it appears that clinicians and students can understand the enactive approach when it is explained in lay terms and it appears to have potential to overcome the biopsychosocial model's weaknesses that were argued in this paper. Although we were critical of the biopsychosocial model, we believe that the enactive approach supplements and builds on it, rather than contradicts or confronts it. Detailed discussion regarding the practical application of the enactive approach to pain is beyond the scope of this paper; however, we will now briefly comment on potential educational, assessment, and interventional benefits.

We believe that this new consideration of pain may shift students' and clinicians' explanatory pain theories and subsequently alter their approaches to pain education with their patients. More specifically, we believe there is potential to help students and clinicians realize that the boundaries of the biological, psychological, and social are artificial, and that pain is never purely biological or psychological/psychosocial. Indeed, as we have explored above, the explanation of the perception of pain goes beyond these constructs. Similarly, it may help clinicians and patients move away from modular or mereological fallacies. In terms of patient education, we anticipate that the enactive approach may help clinicians avoid current and problematic pain explanations such as "pain is in the brain" or "retrain your brain." It may also challenge clinicians who feel that they can identify the "root cause" of pain (e.g., "you have pain because your muscles are weak"). We offer an enactive alternative; all pain is real, and it always involves many factors associated with the person (not just the brain and not just the back) and their interactions with their environment. If there is credible information suggesting the person is in danger or under threat, pain is experienced. This enactive pain explanation aligns with the approach taken by Moseley and Butler (2017), but differs in the theoretical foundation and steers clear of neurocentrism that can result in patient confusion or perceived stigmatization.

The enactive perspective aligns with emerging pain assessment models, such as the Multimodal Assessment Model of Pain (MAP) that emphasizes how pain experience is a function of the whole person, who is influenced by environmental and contextual factors (Wideman et al. 2019). MAP recognizes that pain expression (i.e., patients' narratives and behaviours) and measures (i.e., quantitative self- and non-self report measures) can be assessed; yet, that pain experience cannot be observed. MAP considers first- and third-person perspectives related to pain, with qualitative pain narrative as the best available proxy for inferring pain in others. Under this model, clinicians can quantify patients' pain-related data; however, importance is placed on validating patients' pain reports – regardless of other clinical findings. This has potential to help mitigate patient stigmatization and build the therapeutic alliance; therefore, enactive/MAP considerations of pain need to be further explored.

Regarding potential enactive pain interventions, others' E-based work offers helpful guidance and a source of optimism. Martiny and Aggerholm (2016) explored E-based

therapies for people with cerebral palsy. This included a camp run by an interdisciplinary team that confronted participants with challenging activities (e.g., skiing) in a supportive social setting. In contrast to common therapeutic approaches, the overall aim of these activities was not to learn to ski or learn a skill to improve motor function, but rather to create an embodied experience of overcoming challenges. The aim was to work with the participants' "… experience of uncertainty, disbelief in their own abilities, self-doubt, and their use of maladaptive control strategies such as extensive planning, worrying, and bodily monitoring" (Martiny and Aggerholm 2016, p. 4) (experiences similar to those with persistent pain). The camp helped participants embody and situate their thoughts in bodily and social experiences and this included exposure-based procedures (an intervention used in persistent pain, described earlier). Participants were asked to describe their expectations and evaluate their own performance in positive terms; the aim was to shift their attention from many of the failures that they expected to (and did) experience, to successful experiences they hoped to, and did achieve. We believe similar programs could be established for patients with non-specific low back pain, where clinicians would consider the way they could modify the environment and their educational approach, using affordances or cues to open new possibilities for action/perception. For example, therapeutic exercise could be used in novel ways – not focusing on "right" movements or motor control per se; instead, focusing on overcoming challenging or meaningful movements that are being avoided. This may build self-efficacy (a key construct in rehabilitation; Bandura 1997), similar to how Martiny and Aggerholm's (2016) intervention worked with self-control. In predictive processing terms, the aim of these interventions would be to update the generative model of movement-related pain.

6 Conclusion

Pain is such a compelling topic, it incorporates human suffering and the importance of medical intervention. Many clinicians are still biomedically-focused, ascribing (intentionally or not) to early pain theories as they relay the message to patients that levels of nociception/tissue damage equal levels of pain. In contrast, some clinicians purport to embrace contemporary pain theories considered to be under the biopsychosocial umbrella, such as the neuromatrix theory. Yet, problematic neurocentric explanations are given, such as: pain is an output of the brain; the brain decides if you are in pain; pain is in the brain etc. Strictly tissue-based pain approaches have been heavily challenged, yet few have questioned the growing popularity of brain-centric pain explanations. Telling patients that their pain is "in their brain" does not fairly or accurately represent our understanding of the creation of the meaning of pain; on the contrary, it has clearly negative consequences. Further, these explanations lack rigor as they are often either dualist or physicalist and are not concordant with research findings. The biopsychosocial model was put forward as a solution; however, it provides little theoretical guidance and lacks phenomenological considerations of experience. Further, the biopsychosocial model is often trichotomized or dichotomized – thereby missing that a person is a dynamic whole – embedded in an environment. It is nonsensical to think there is purely peripheral or central pain, purely biological or psychogenic pain, or pain in the absence of an environmental influence. There are no

separate circles to form a Venn diagram as shown in Fig. 1, and pain is not located *in* any of the circles. The stance in this paper is that pain, while felt in a location (i.e., low back), is a relational brain-body-world process of cognition that unfolds. As described by Di Paolo (2009), cognition has no location. In other words, people experiencing pain are non-decomposable, non-linear systems and cannot be modeled like a machine with a collection of separable components. The components (bio, psycho, social) cannot be separated from each part, nor do they explain the whole (embedded person experiencing pain). Engel partially argued this when he applied general systems theory. Still, the seduction to split pain into bio, psycho, or social components is apparent and will likely continue, especially in the management of challenging conditions such as persistent back pain. Therefore, other paradigms need to be considered, building on the biopsychosocial model.

Considering the limitations of the pain theories presented, an enactive approach to pain was explored as an alternative big picture framework. Informed by established theory and research by phenomenologists and cognitive scientists, pain was described as: (1) *Embodied*, (2) *Embedded*, (3) *Enacted*, (4) *Emotive*, and (5) *Extended*. Overall, with an enactive approach, pain does not reside in a mysterious immaterial mind, nor is it entirely to be found in the blood, brain, or other bodily tissues. Instead, it is a relational and emergent process of sense-making through a lived body that is inseparable from the world that we shape and that shapes us. With this perspective the experience of pain cannot be observed or measured, and qualitative pain narrative remains the best available proxy for inferring pain in others.

7 Limitations and considerations

In reference to E-based approaches to cognition, Kiverstein and Clark (2009, p. 1) comment that "given this large surface diversity, it seems fair to ask what, if anything, forms the deep theoretical core of the embodied, embedded approach? Equally importantly, we may ask to what extent the various projects pursued under the single umbrella are in fact harmonious?" They rightly highlight the ongoing issue of heterogeneity within E-based approaches. This forms the basis of a significant limitation in this paper, as some of our E-based considerations are likely to be viewed as self-contradictory. Without further theoretical debate and progress, the practical application of the enactive approach to pain may fall into the same problem we criticize (i.e., the biopsychosocial model being applied in a fragmented fashion). However, in the words of Kiverstein and Clark (2009, p. 6), we believe that the "… somewhat fuzzy collection of related (though not necessarily clear or mutually consistent) theses" are starting to form more coherent and distinct models. We find that the enactive approach to pain described in this paper has deep theoretical leverage and alignment that helps overcome issues with current pain theories and models, while also adding novel considerations such as affordances and the tight relationship between perception and action. At this point in time, we find E-based considerations refreshing as they provide novel, non-stigmatizing clinical considerations of pain; therefore, we are currently in the process of conducting clinical research in this area.

Although limitations in objective or third-person approaches to understanding the experience of pain were presented, our stance is not that surrogate or proximate

measures of pain have no value. They may be of value where self-report is not possible. Also, third-person approaches may help identify important physiological mechanisms and pharmacological targets. Third-person data may enlighten the phenomenology of pain (and vice versa), or together they may prove to be more valuable than each on their own (Gallagher and Zahavi 2012). Still, when a conscious person with the capacity to communicate is present, we maintain that striving for third-person or objective measures of the pain experience is misguided. It devalues the first-person experience of pain and obscures the process of sense-making.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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