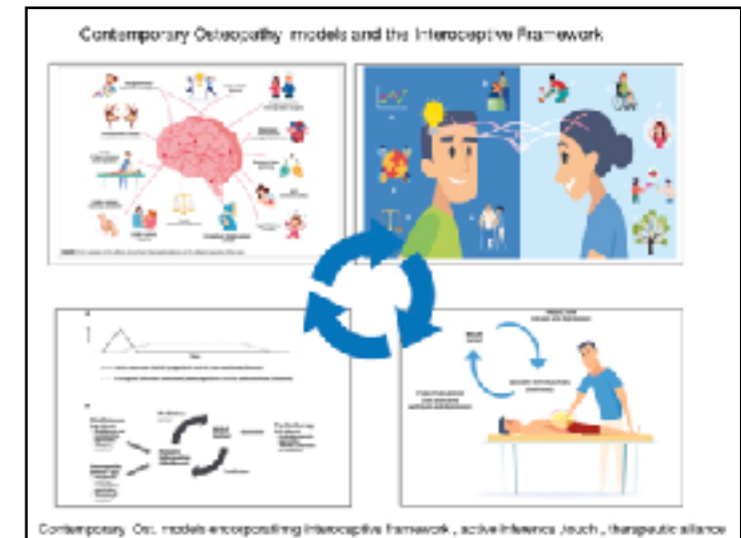
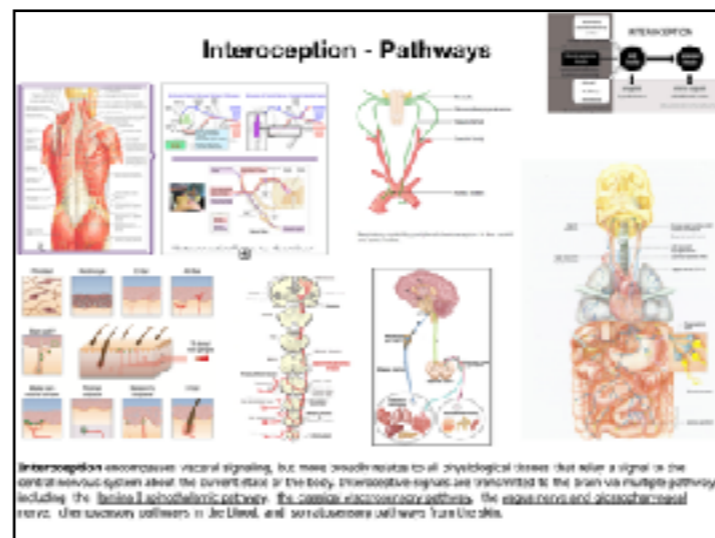
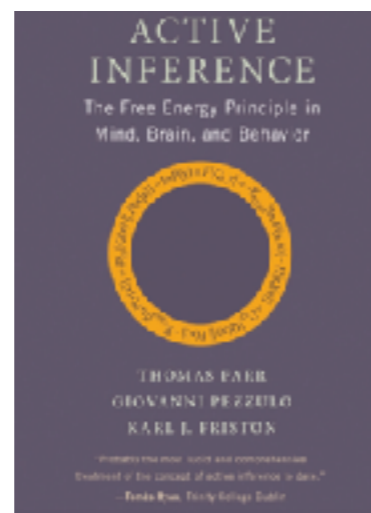
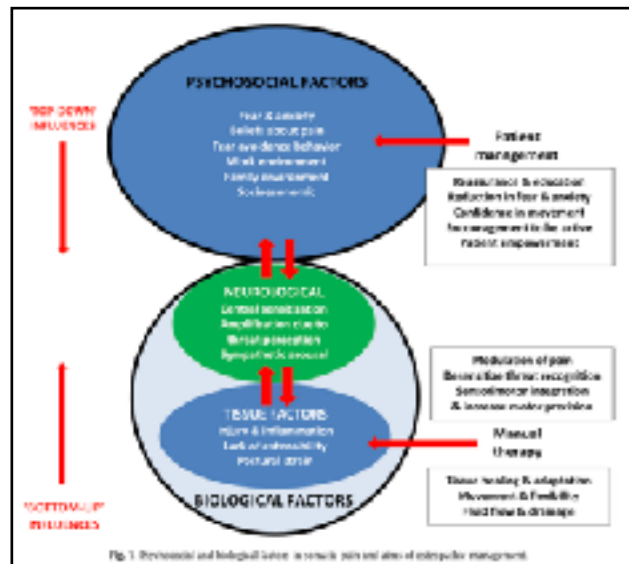


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Supplemental Material - Resources



Biosychosocial considerations within Osteopathy

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Masterclass

Integrating osteopathic approaches based on biopsychosocial therapeutic mechanisms. Part 1: The mechanisms

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Masterclass

Integrating osteopathic approaches based on biopsychosocial therapeutic mechanisms. Part 2: Clinical approach

Gary Fryer, B.Sc.(Osteopathy), Ph.D., ^{a,b,*}

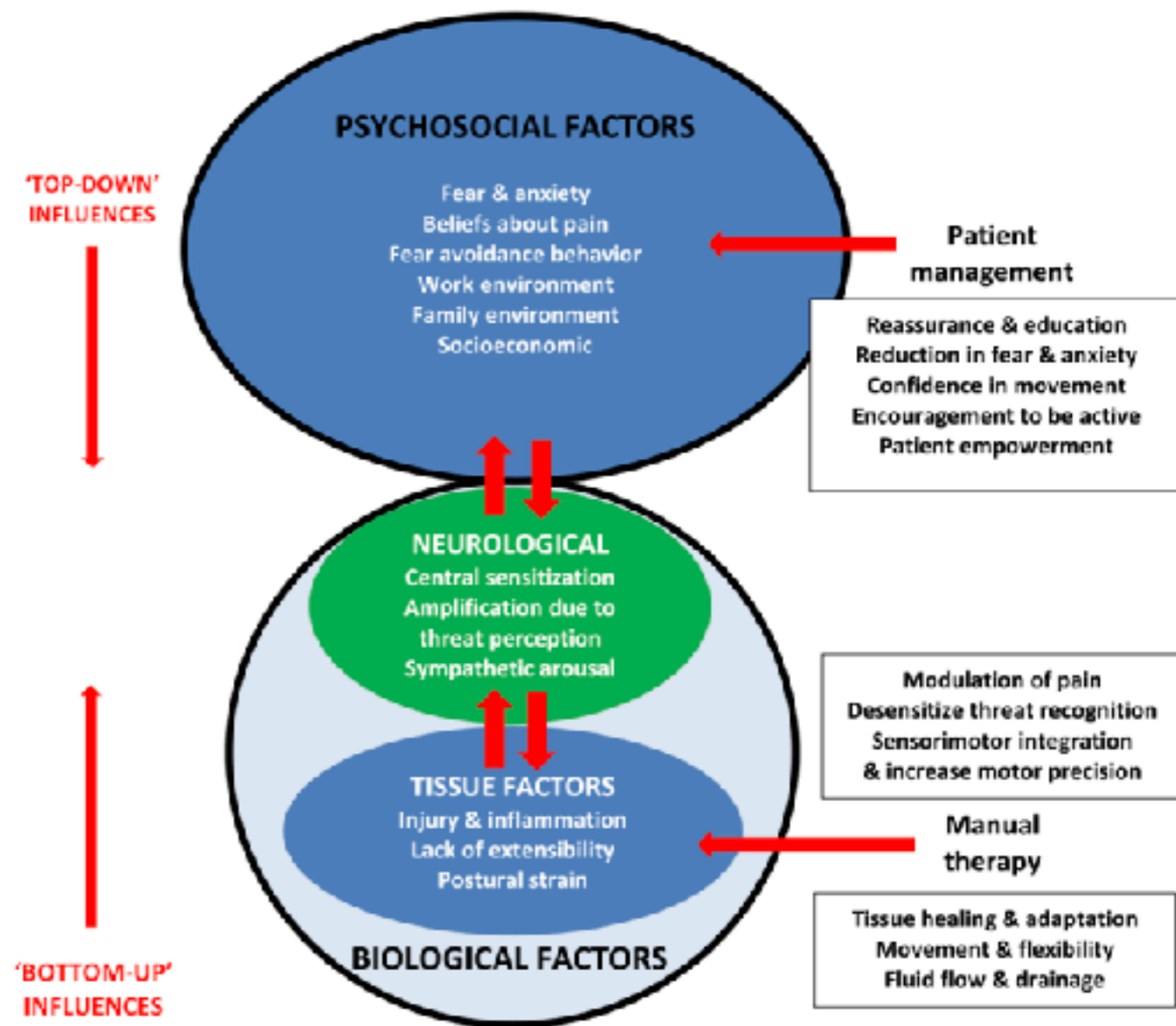
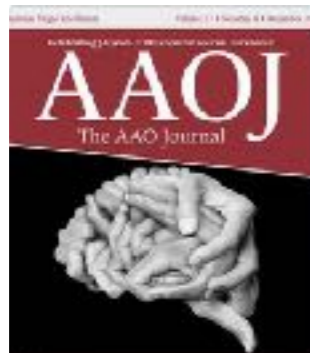


Fig. 1. Psychosocial and biological factors in somatic pain and aims of osteopathic management.



Biosychosocial considerations within Osteopathy

Effect of a general osteopathic treatment on body satisfaction, global self perception and anxiety: A randomized trial in asymptomatic female students

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Laura Maroye^a, Luc Evers^b, Paul Klein^c, Véronique Feipel^a

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Fig. 1 General osteopathic treatment procedure: illustrations of several techniques for the upper limb (A), the pelvic girdle (B), the foot (C) and the cervical spine (D, E).



Conclusions: The present study suggests that an osteopathic approach using articular and soft tissue mobilisations has an effect, at least in the short term, on anxiety and global body perception. Further investigation is needed to confirm the relevance and broaden the scope of the present study.

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Implications for clinical practice

- This study shows the effects of osteopathic manual therapy (OMT) on different psychological features in asymptomatic subjects.
- Consideration should be given to non-specific effects of osteopathic manual practice.
- A potential benefit of OMT for patients with non-musculoskeletal disorders could be investigated.
- The potential impact of OMT on psychological features, such as anxiety, in patients with musculoskeletal disorders opens interesting perspectives.



On the Origin of Interoception

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Charles Scott Sherrington

27 November 1857 – 4 March 1952

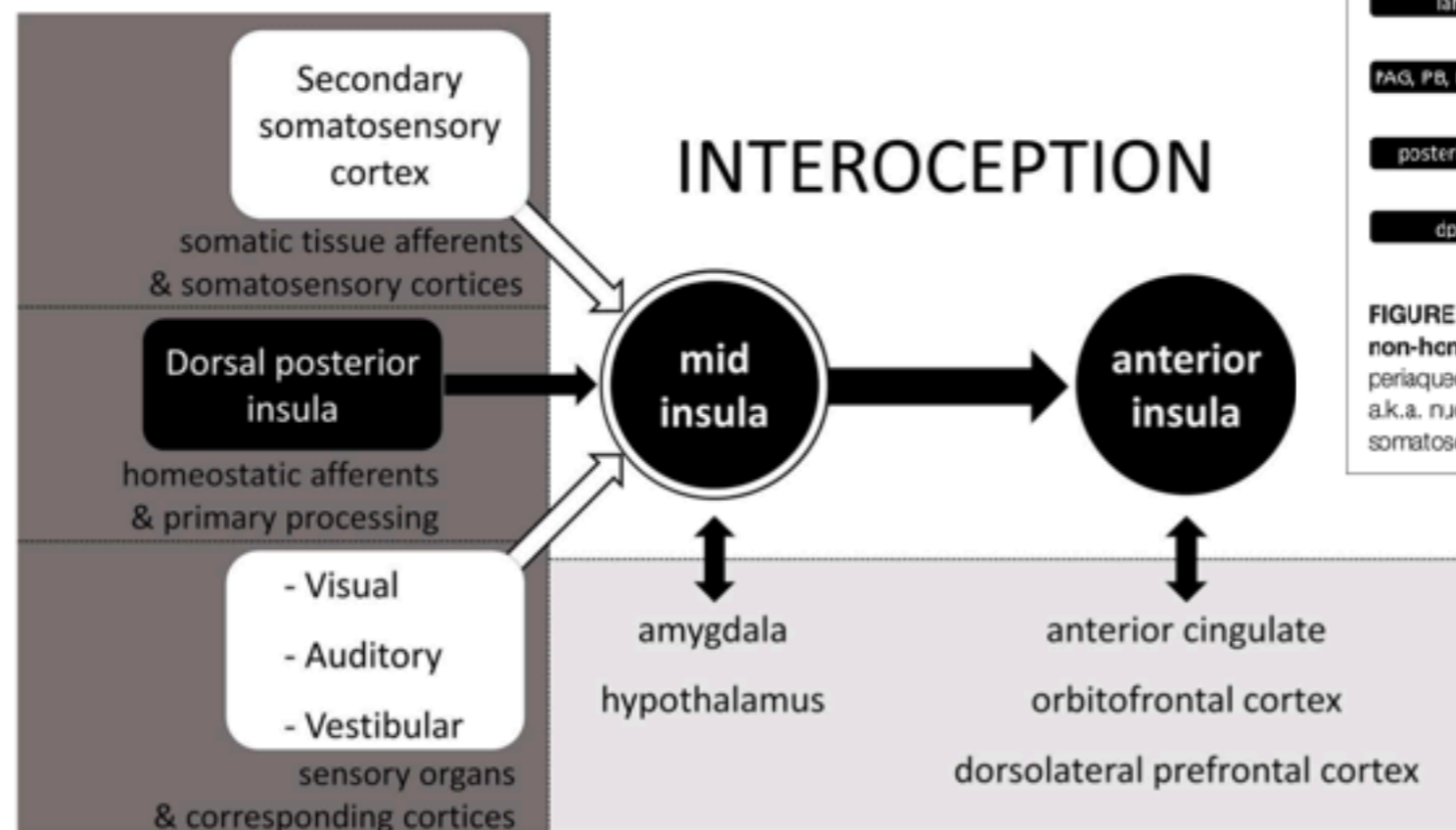


FIGURE 2 | The neurophysiology of interoception. Schematic simplification of the neurophysiology behind the cross-modal integrated (re)representation of the body status, otherwise known as interoception. Adapted from Craig (2008).

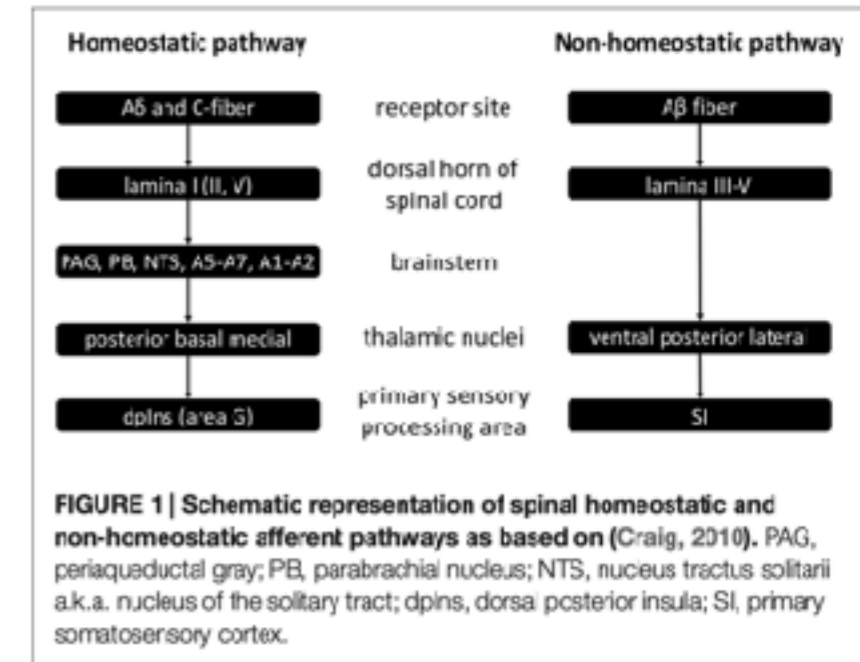
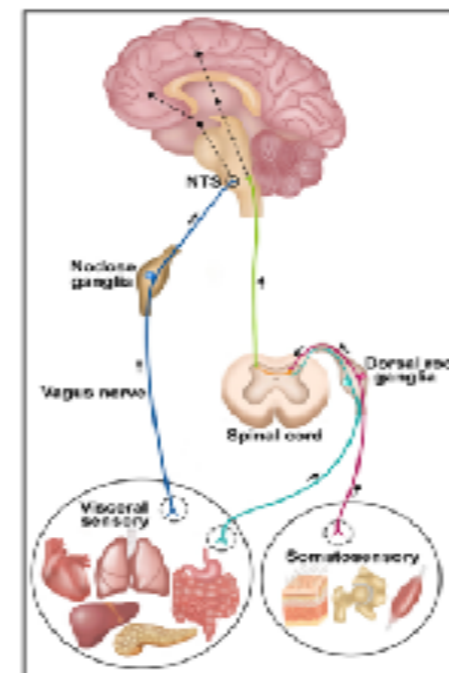
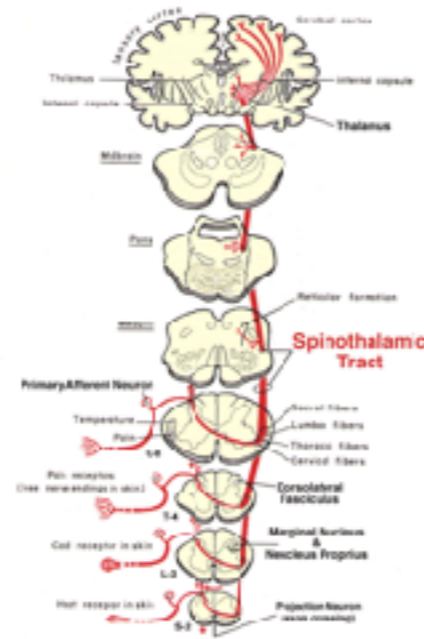
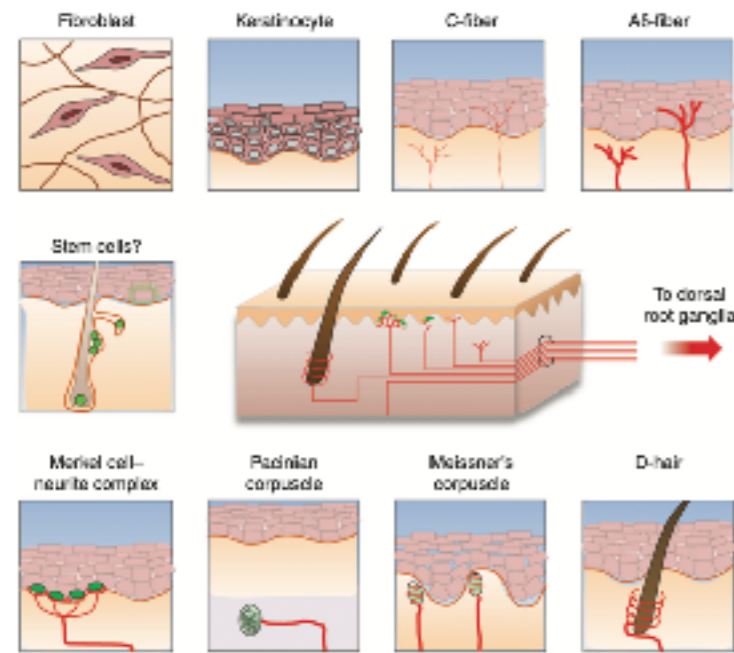
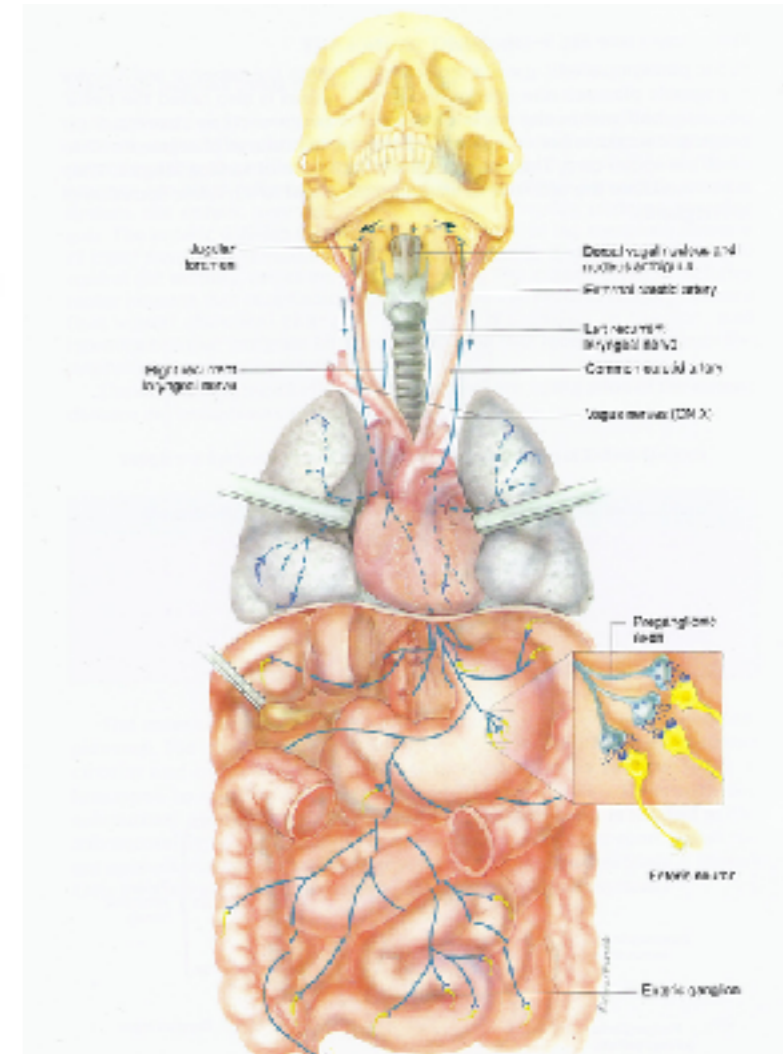
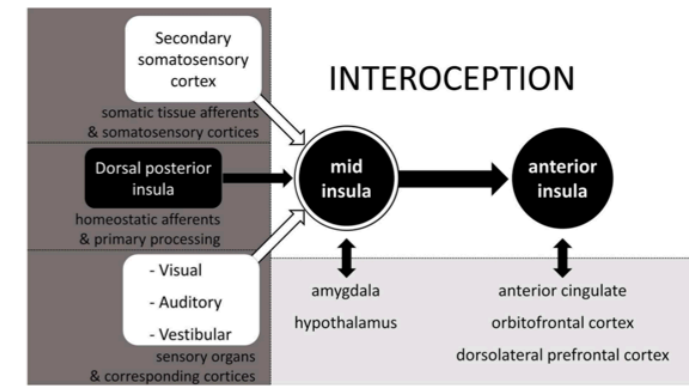
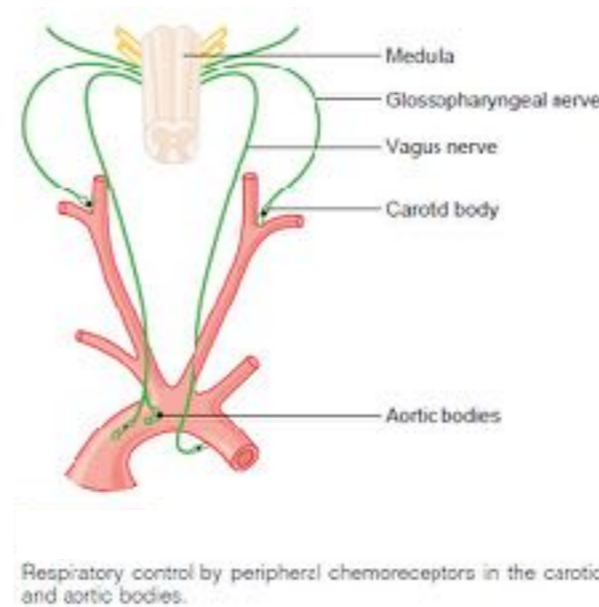
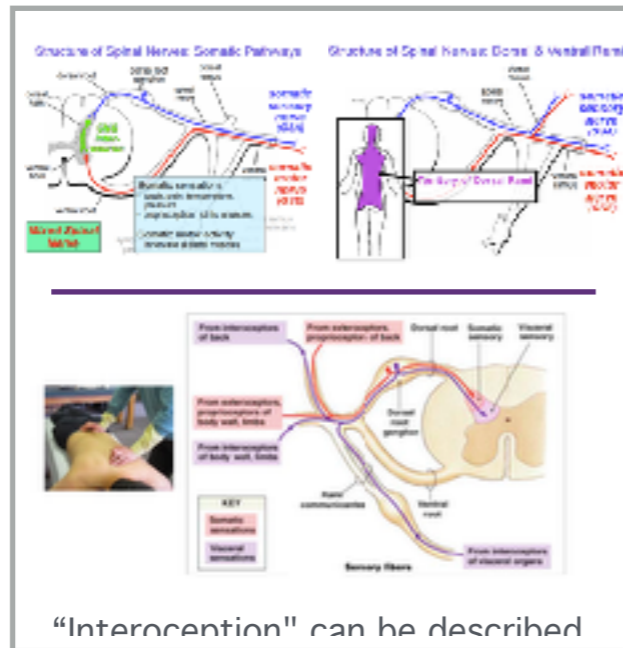
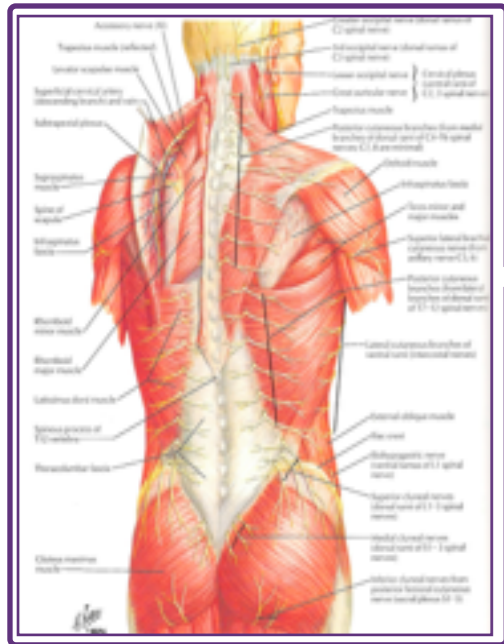


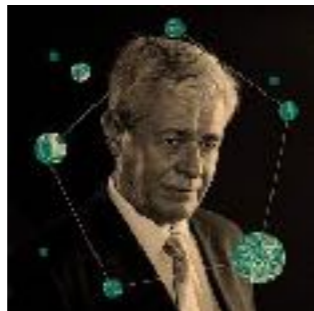
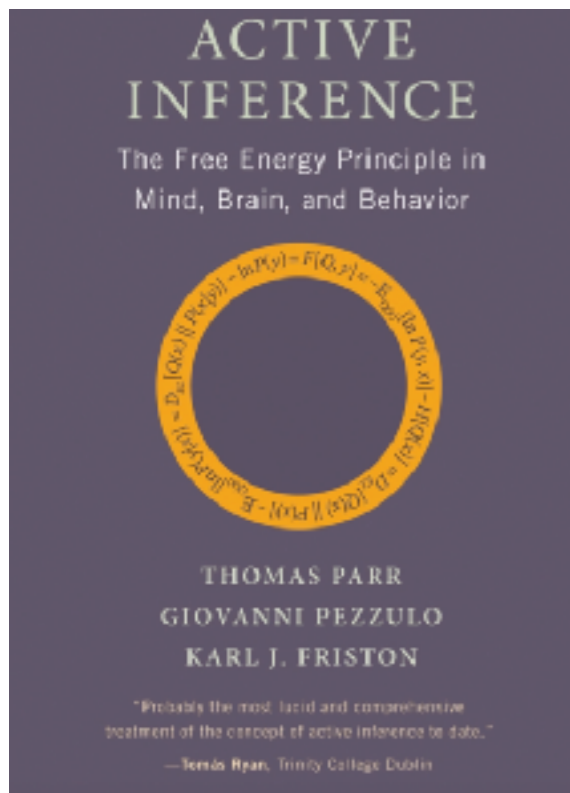
FIGURE 1 | Schematic representation of spinal homeostatic and non-homeostatic afferent pathways as based on (Craig, 2010). PAG, periaqueductal gray; PB, parabrachial nucleus; NTS, nucleus tractus solitarius a.k.a. nucleus of the solitary tract; dpIns, dorsal posterior insula; SI, primary somatosensory cortex.

Interoception is contemporarily defined as the sense of the internal state of the body. This can be both conscious and non-conscious. It encompasses the brain's process of integrating signals relayed from the body into specific subregions—like the brainstem, thalamus, insula, somatosensory, and anterior cingulate cortex—allowing for a nuanced representation of the physiological state of the body. This is important for maintaining homeostatic conditions in the body and, potentially, facilitating self-awareness.

Interoception - Pathways



Interoception encompasses visceral signaling, but more broadly relates to all physiological tissues that relay a signal to the central nervous system about the current state of the body. Interoceptive signals are transmitted to the brain via multiple pathways including the lamina I spinothalamic pathway, the classical viscerosensory pathway, the vagus nerve and glossopharyngeal nerve, chemosensory pathways in the blood, and somatosensory pathways from the skin.



To Stay or not to stay in Bed ? - that is the question

To be “alive”, Friston says, is to act in ways that reduce the gulf between your expectations and your sensory inputs. He calls his idea the “Free Energy principle”

Friston views his principle as an “as if” concept. Biological things don’t need to minimize free energy in order to exist, but they behave and self-organize as if they do

Back in the 19th century, Helmholtz explained that the brain could be thought of as a Bayesian”probability machine”.

Our brains, Helmholtz believed, “compute and perceive in a probabilistic manner” , constantly making predictions and adjusting beliefs based on what the senses contribute. - The brain therefore seeks to minimize “prediction error.”

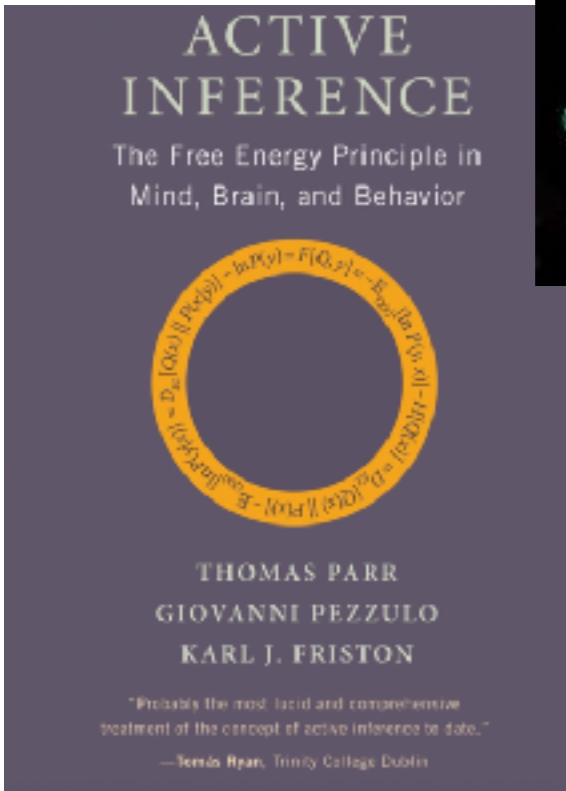
For example, if I believe I should be out of bed and my senses tell me I’m still laying down, my brain can resolve this inconsistency or surprise by altering my belief. Instead of getting up and being ready to go, why not sleep some more?



In a way, the idea of the brain as an “inference engine” serves as the foundation of Friston’s Free Energy principle.

“Free energy is the difference between the states you expect to be in and the states your senses tell you that you are in ”

Free Energy principle proposes two modes of action for the brain when it makes a prediction that isn't consistent with what the senses relay back, or when "free energy is high"



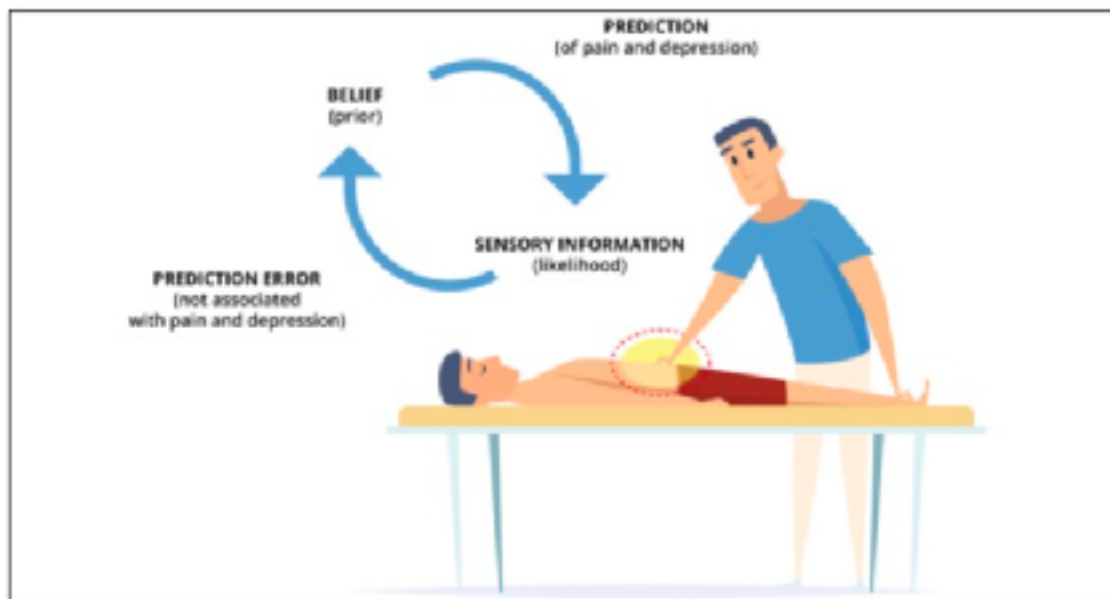
1. The brain revises its prediction so that its belief matches sensory input. (Helmholtz's concept)
2. The brain signals the body to act in a way so that the body is in a new state and new sensory input matches the pre-existing belief. (active inference)

Revisiting our bed example, I now have another way of resolving the inconsistency. My brain can command my muscles to engage so that I get myself outside of the bed.



Now, my senses tell me I am out of bed, which matches my prior belief.

With the addition of active inference, we can explain not only our changing beliefs and perceptions but also the motivations behind the actions our bodies take



This is significant in context of the "nature" of the osteopathic treatment we give, how it is "perceived" by those receiving treatment, and the "nature" of both our "hands on" and "hands off" dialogue between patient and practitioner

Current theories of interoceptive processing

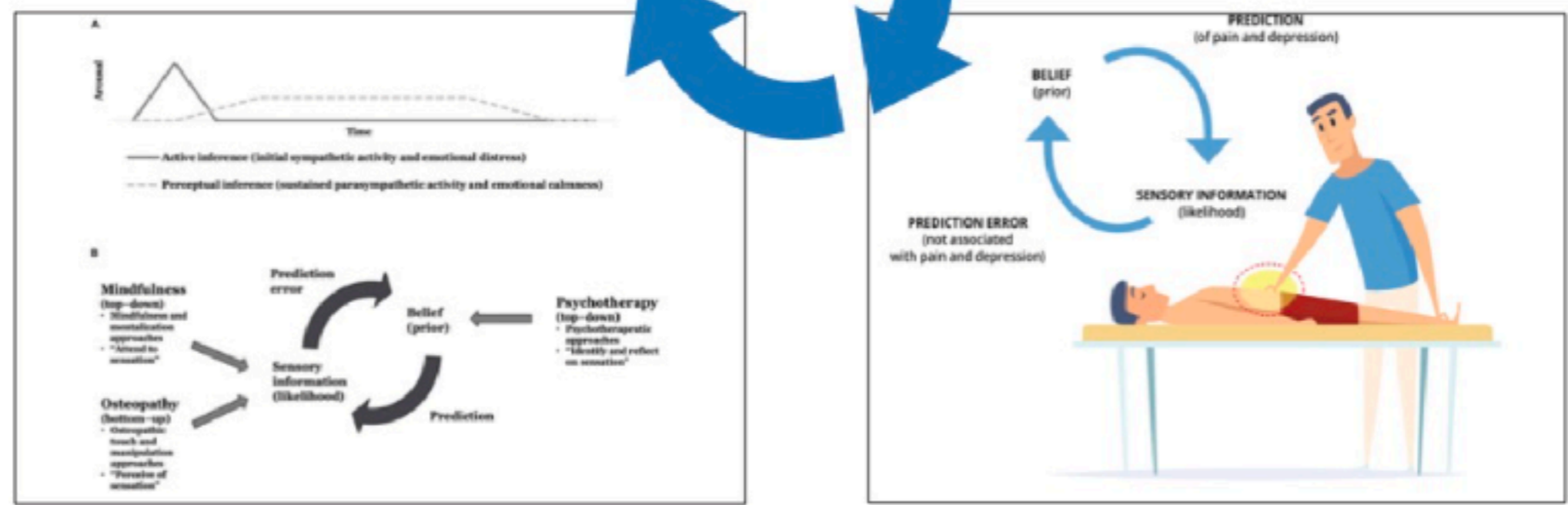
Embodied predictive interoception coding (EPIC)

- The EPIC model proposes a method of understanding the brain's response to stimuli contrary to the classic "stimulus-response" model.
- The classical view of information processing is that when a peripheral stimulus provided information to the central nervous system, it was processed in the brain, and a response was elicited.
- The EPIC model deviates from this and proposes that the brain is involved in a process of **active inference**, that is, assiduously making predictions about situations based on previous experiences.
- These predictions, when coupled with incoming sensory signals, allow the brain to compute a prediction error.
- Interoceptive prediction errors signal the occurrence of discrepancies within the body, which the brain attempts to minimize.


This can be done by :

- 1) modifying the predictions through brain-related pathways,
 - 2) altering the body position/location in order to better align incoming sensory signals with the prediction, or
 - 3) altering the brain's method of receiving incoming stimuli.
- Interoceptive prediction error signals are a key component of many theories of interoceptive dysfunction in physical and mental health.

Contemporary Osteopathy models and the Interoceptive Framework



Contemporary Ost. models incorporating interoceptive framework , active inference ,touch , therapeutic alliance


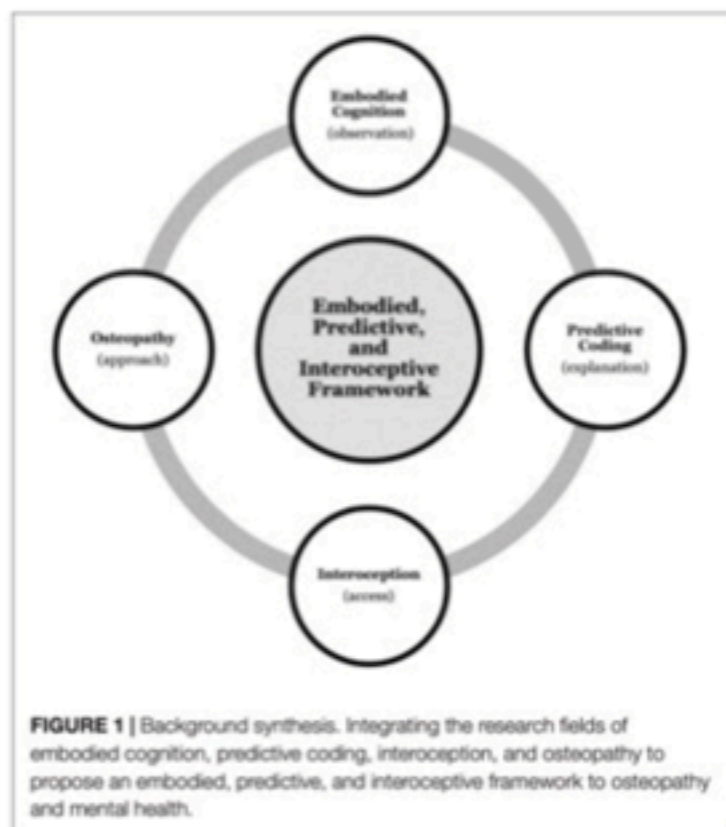


Osteopathy and Mental Health: An Embodied, Predictive, and Interoceptive Framework

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- Embodiment is an interdisciplinary field of research spanning disciplines like philosophy, psychology, psychiatry, and neuroscience (Fuchs and Schlimme, 2009).
- Theories of embodiment argue that cognition and emotion depend on embodied simulations (Veenstra et al., 2016).
- Cognition and emotion are based upon reinstatements of perception, relating to external (exteroceptive) and internal (interoceptive) sensory states, and action, relating to (proprioceptive) motor states, which produce simulations of previous experiences in one's self (Niedenthal, 2007; Kiefer and Trumpp, 2012).

Predictive coding (also known as **predictive processing**) is a theory of brain function in which the brain is constantly generating and updating a mental model of the environment. The model is used to generate predictions of sensory input that are compared to actual sensory input. This comparison results in prediction errors that are then used to update and revise the mental mode

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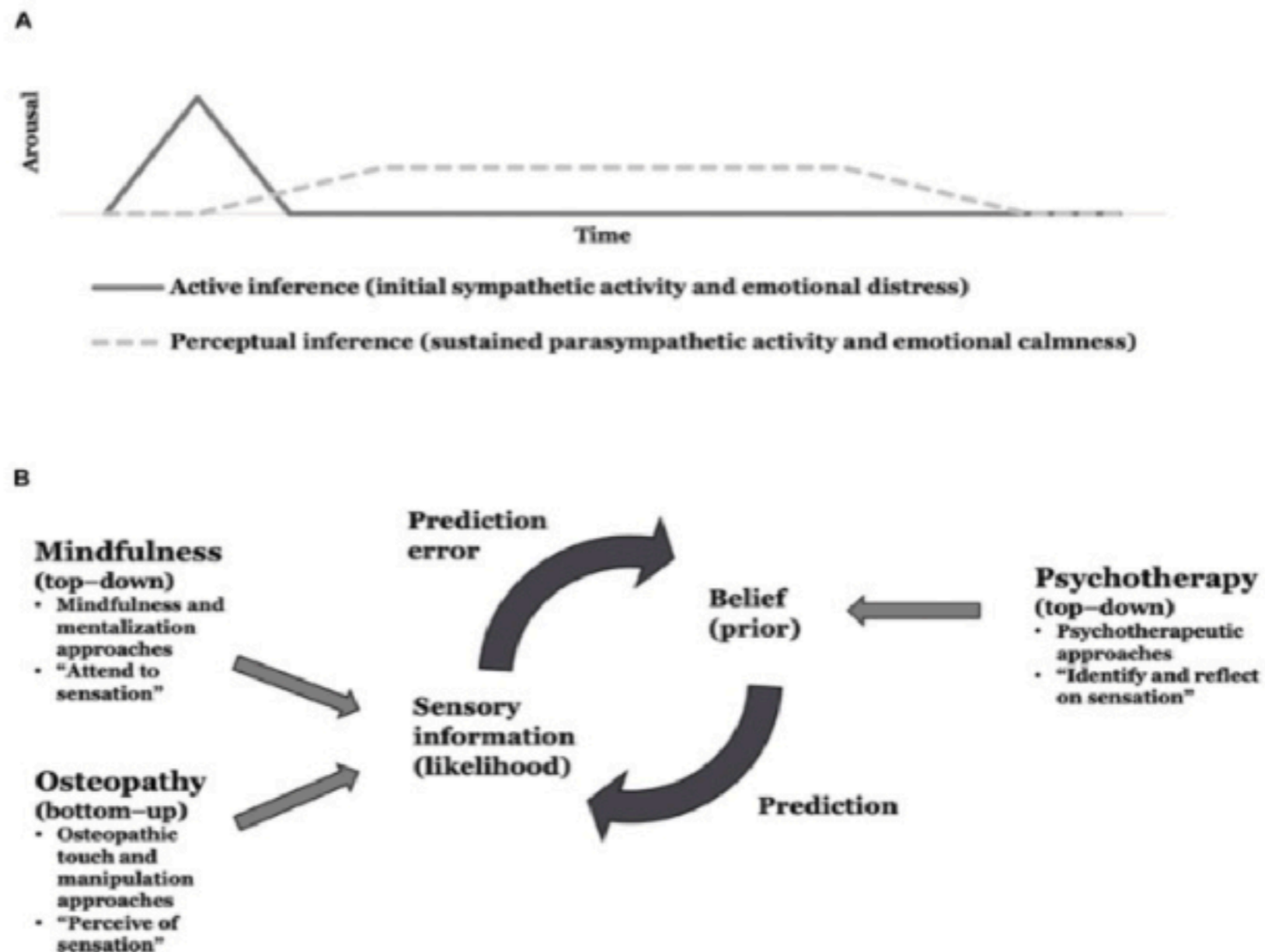
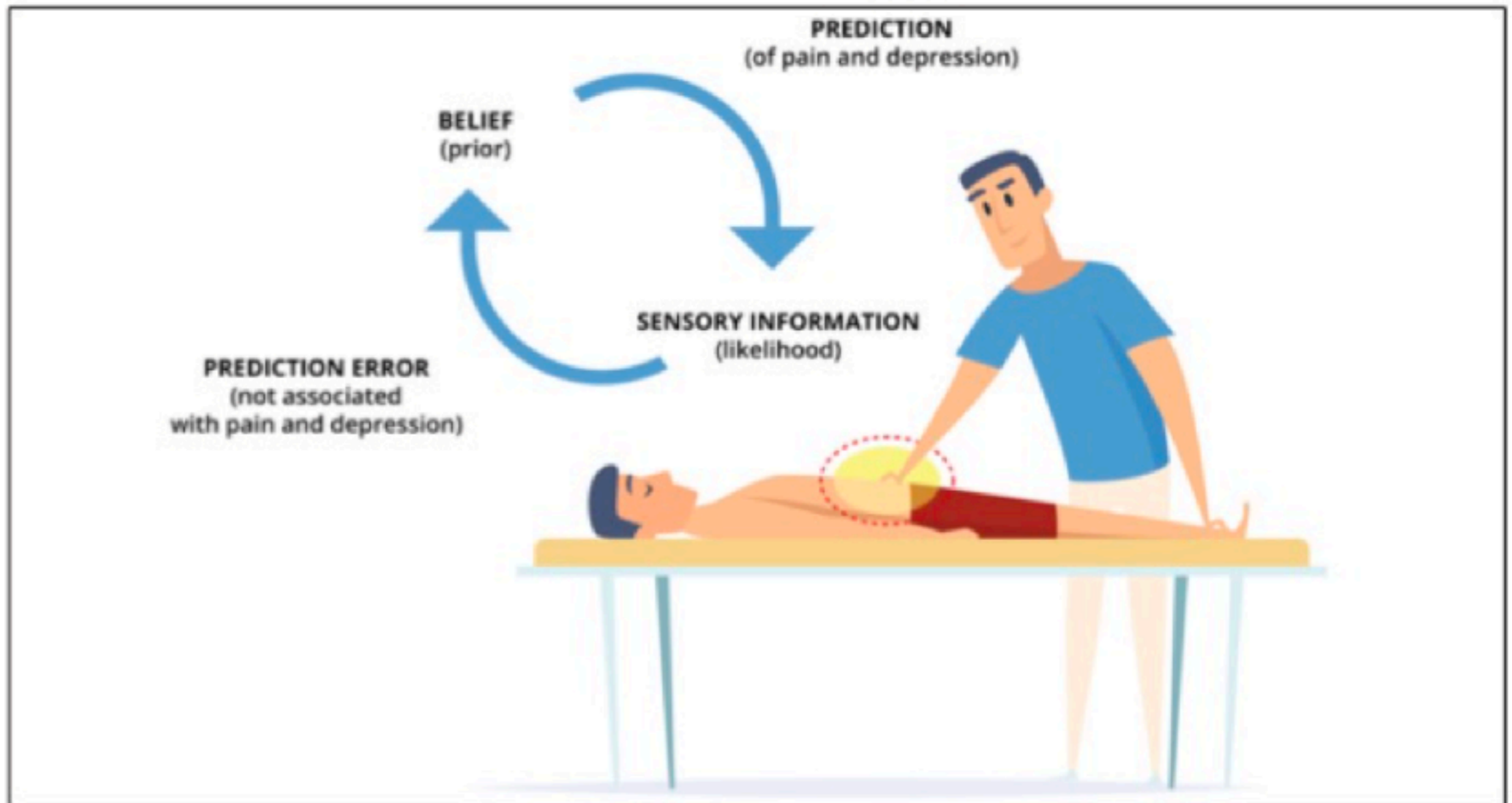
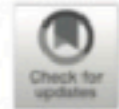


FIGURE 3 | Implications for future research testing the theoretical framework. **(A)** An active and perceptual inference perspective to reason autonomic and emotional responses in osteopathic practice. **(B)** A proposition for a multidisciplinary interoceptive exposure therapy to physical and comorbid mental symptoms or conditions.

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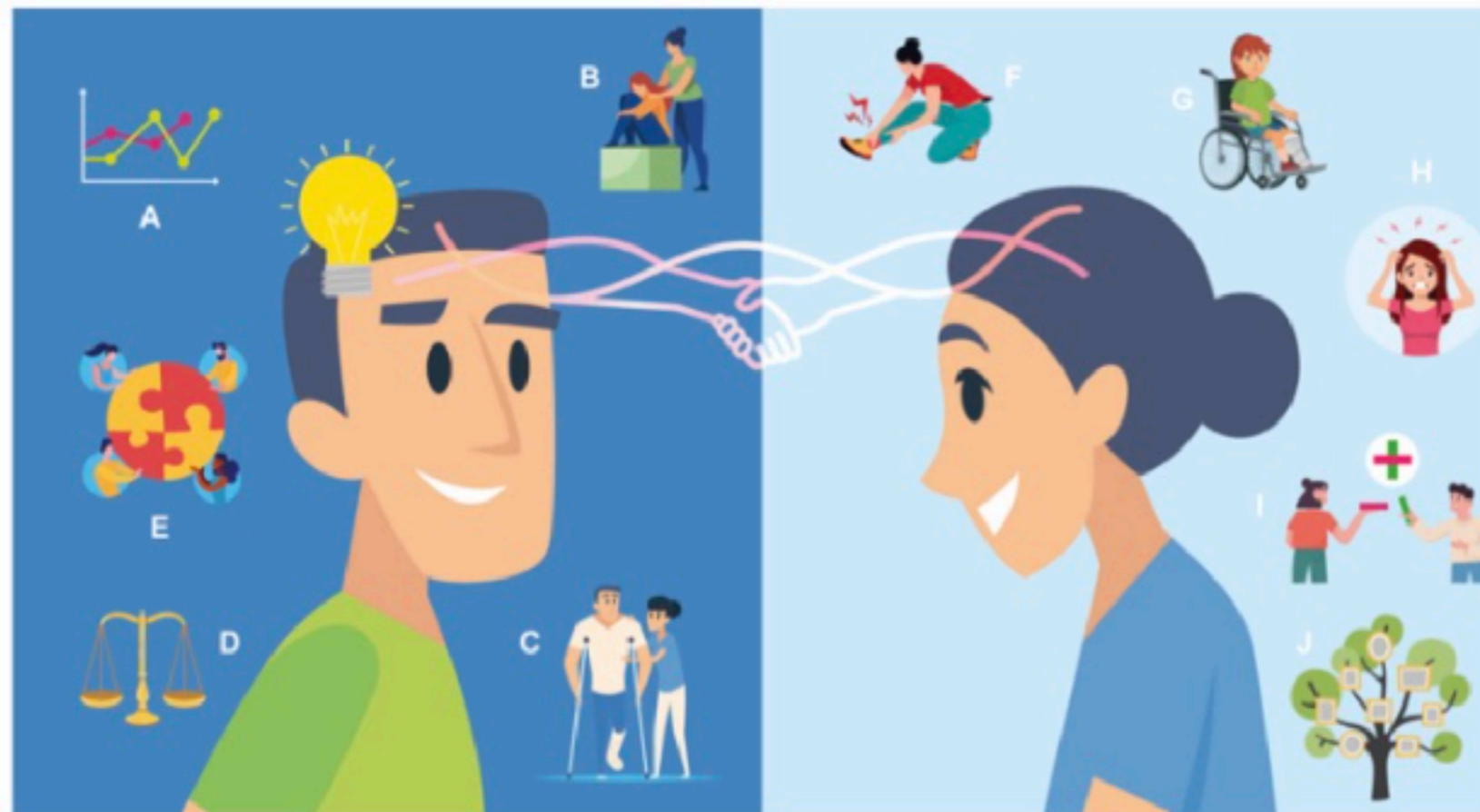
● **FIGURE 2 | An embodied, predictive, and interoceptive framework to osteopathy and mental health.**

Therapeutic Alliance as Active Inference: The Role of Therapeutic Touch and Synchrony

HYPOTHESIS AND THEORY
published: 17 February 2022
doi: 10.3389/fpsyg.2022.783894



Zoe McParlin¹, Francesco Cerritelli¹, Karl J. Friston² and Jorge E. Esteves^{1,2*}



! | Therapeutic alliance as active inference. **(A)** Opportunity to build a synchronous relationship and understanding of the injury. **(B)** Opportunity to show empathy to reduce anxiety and fears. **(C)** Working together to create a therapeutic alliance for recovery. **(D)** Regulating disrupted allostasis. **(E)** Joint attention to regulate allostasis and support recovery. **(F)** Injury and pain—“what have I done?” **(G)** Fears of what the injury will become. **(H)** Anxiety over the injury. **(I)** The hope of collaborative communication to understand and create a treatment and management plan. **(J)** Previous priors surrounding the injury including injury beliefs, social expectations, family and injury history.

Therapeutic Alliance as Active Inference: The Role of Therapeutic Touch and Synchrony



Zoe McParlin¹, Francesco Cerritelli¹, Karl J. Friston² and Jorge E. Esteves^{1,3**}

- The therapeutic alliance (TA) is a collaborative working relationship between a clinician and patient and is a critical component of person-centered care because it contributes to positive clinical outcomes across multiple healthcare disciplines (Miciak et al., 2019; Ryu et al., 2021).
- Recognizing, gaining trust and aligning an individual's unique beliefs or "priors" through cooperative communication is crucial in patient management and establishing a beneficial TA (Kinney et al., 2018)
- Touch can be viewed as key in various situations for the interpersonal inference necessary for establishing interpersonal connections and, potentially, synchrony (Hertenstein et al., 2006a; Fonagy and Allison, 2014).
- Touch can increase trust, compliance, and generosity; while simultaneously reducing anxiety and threatening negative emotions (Morrison et al., 2010).
- Additionally, it can be used to assist in accurately applying context to infer different hidden thoughts, communicative intentions and at least 6 different emotions of others including love, fear and anger, with between 48 and 83% accuracy (Hertenstein et al., 2006b).
- The more precise one becomes at inferring others' thoughts and actions, the more adept one establishes common ground, trust, synchrony, and a beneficial therapeutic alliance.

Therapeutic Alliance as Active Inference: The Role of Therapeutic Touch and Synchrony

Zoe McParlin¹, Francesco Cerritelli¹, Karl J. Friston² and Jorge E. Esteves^{1,3,4*}

