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ORIGINAL RESEARCH

Synthesising boredom: a predictive processing approach

Tom Darling[1]

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Abstract
I identify and then aim to resolve a tension between the psychological and existential conceptions of boredom. The dominant view in psychology is that boredom is an emotional state that is adaptive and self-regulatory. In contrast, in the philosophical phenomenological tradition, boredom is often considered as an existentially important mood. I leverage the predictive processing framework to offer an integrative account of boredom that allows us to resolve these tensions. This account explains the functional aspects of boredom-as-emotion in the psychological literature, offering a principled way of defining boredom's function in terms of prediction-error-minimisation. However, mediated through predictive processing, we can also integrate the phenomenological view of boredom as a mood; in this light, boredom tracks our grip on the world – revealing a potentially fundamental (mis)attunement.

Keywords Boredom · Predictive processing · Phenomenology · Heidegger · Affect

1 Introduction: the problem of boredom

It seems natural to speak of 'the problem of boredom' – as philosopher Lars Svendsen (2005) titles his boredom-inspired book's first chapter. We are 'bored to death', and attempting to 'kill time' to stave off boredom. Why do we hate being bored so much and why is boredom such a problem? Goodstein (2005) suggests our boredom discourse reflects a wider meaning crisis, that it is a symptom of the existential problem of finding meaning in existence. In this sense, boredom may be "a metaphor for the postmodern condition" (Spacks, 1995, p.260), as, despite increasing opportunity for

✉ Tom Darling
thomas.darling@monash.edu

1 Monash Centre for Consciousness & Contemplative Studies, Monash University, Clayton, Australia

interesting pursuits and engagement with the world, boredom persists, potentially even growing into a modern epidemic (Dalle Pezze & Salzani, 2009; Danckert & Eastwood, 2020; Weybright et al., 2020). The call is there for boredom to be taken seriously – as a ubiquitous, and potentially problematic, aspect of (modern) life.

This call has partially motivated the dramatic increase in the psychological study of boredom, particularly in the last fifteen years (Lin & Westgate In Press; Piotrowski & Watt, 2022). Here, boredom is acknowledged as a ubiquitous emotion, and is largely positioned as an important self-regulatory mechanism (e.g.Danckert et al., 2018; Elpidorou, 2018b, 2022). Particularly, this research stresses how boredom disengages an agent from their current activity, while attempting to re-engage and motivate the agent towards more interesting and meaningful activities (Eastwood et al., 2012; Van Tilburg & Igou, 2012). Often this realigns the agent towards their goals (Bench & Lench, 2013), and towards an intermediate 'Goldilocks' zone of complexity (Danckert & Merrifield, 2018; Danckert & Elpidorou, 2023), where an agent is optimally engaged due to their skills relatively matching domain complexity.

However, there is a danger for this (functional self-regulating emotion) construal of boredom to become too narrow – missing a central problem of boredom that philosophers are concerned with. As Slaby (2010, p.101) says: "boredom, if looked at in the right way, can reveal elements of the predicament of human existence". That is, boredom can present as an *existential* problem; a view promoted in the phenomenological tradition. This tradition, particularly following Heidegger (1962, 1995), often conceptualises boredom as a mood (*Stimmung*), which turns the problem of boredom into one of *how* we engage with the world (seeRatcliffe, 2010, 2013b; Freeman & Elpidorou, 2015;, 2020; Mulhall, 2011).

Although, boredom as a Heideggerian mood is some distance from the psychological understanding of boredom as a largely functional emotional state. I suggest a turn to predictive processing (broadly understood) as being crucial for reconciling the two perspectives. The predictive processing framework suggests that humans are inferential (i.e. predictive) agents, who optimise their predictive success by minimising their prediction error (a formal quantity used to quantify divergence between predictions and sensory signals). Utilising this framework, I suggest that boredom as an emotion assists self-regulation, tracking a rate of (prediction) error reduction – compared to an agent's expected error reduction. As a mood, boredom may exist higher in the hierarchical system (leaning on formal notions of hierarchical predictive processing) as a hyperprior. In this sense it may act as a generalised 'grip' on the world (Kiverstein et al., 2019), tracking across-time how an agent is attuned, particularly in terms of long-term and domain-general expectations.

The turn to predictive processing to conceptualise boredom is promising for multiple reasons. First, it accommodates and extends the dominant (functional) psychological view of boredom. Predictive processing promotes a kind of functional account itself; however, it powerfully furnishes an explanation of the psychological optimal 'Goldilocks' zone in terms of allostatic self-regulation and prediction-error-minimisation. This formalises the zone in terms of agent-relative surprise (a formal measure of uncertainty; Friston, 2012a; Schwartenbeck et al., 2013) and prediction error under certain assumptions (Friston, 2012b). In doing so, the turn to predictive processing explains why the Goldilocks zone emerges; as a feature of (approximate

Bayesian) optimal prediction error minimisation. Beyond this, by leaning on active inference, the account explains central features of boredom from psychology—which are difficult to theoretically link—such as the "call to action" (Danckert & Elpidorou, 2023, p.494) that boredom presents. Predictive processing intertwines action (as active inference) with cognitive function; this inextricably connects the Goldilocks zone and boredom's call for action. Without such a unifying theoretical account, it is difficult to envisage a complete theory of boredom's function—one which is simultaneously able to explain the various cognitive-affective-motivational components of the state.

Second, this account begins to naturalise aspects of the phenomenological tradition that treat boredom existentially. On the surface, this may appear contradictory to Heidegger's fundamental project. However, contemporary predictive processing and active inference approaches show promising insight into the nature of our (human) existence and experience (e.g., Nave et al., 2022; Ramstead et al., 2022; Sandved-Smith et al., 2021) – in line with the phenomenologists' aims. Beyond shedding light on the phenomenology of boredom, the present account is particularly useful as it serves to reconcile the phenomenological conception of boredom with the common psychological conception; as prominent philosopher of boredom, Andreas Elpidorou, questions (2018c, p.177): "it is unclear whether there is a way of doing justice to both [functional and phenomenological] outlooks". Embracing both outlooks, under predictive processing, enables an account with an eye to the whole 'problem' of boredom.

Appealing to phenomenological insight is also important for grounding predictive processing (in the empirical-experiential world). This helps a computational theory like predictive processing develop with reference to the various target phenomena it aims to explain. Thus an underlying motivation of this paper is to thicken the empirical basis of predictive accounts, which often discuss boredom, as it *appears* an agent who seeks to minimise surprise ought to seek boredom (e.g. Friston et al., 2012; Sun & Firestone, 2020)[1].

Lastly, the predictive account provides a unique take on boredom's conceptual status. There is wide-ranging debate about what boredom is. Is it an emotion or mood (or even feeling)? Is it a unitary concept or construct? How should boredom be defined? (see Elpidorou, 2021; Westgate, 2020). In predictive processing, different kinds of affective states (e.g. emotion and mood) simply exist at different levels of the predictive hierarchy, and concern different spatiotemporal scales. In this way predictive processing unifies multiple 'types' of boredom, in a move that is explanatorily parsimonious. It also provides potential (deflationary) definitions of boredom, which can be read from the formalisms underlying predictive processing.

[1] This is known as the 'dark room problem', which I do not explore here.

2 Boredom as a self-regulating emotion

There are countless problems defining and describing boredom in psychology (Raffaelli et al., 2018; Westgate & Steidle, 2020). Here I attempt to capture its essence from the psychological literature.

Boredom is often positioned as a highly motivating emotional state, which acts to self-regulate (Bench & Lench, 2013, 2019; Danckert et al., 2018; Elpidorou, 2018a; Van Tilburg & Igou, 2011). This is reflected in the most common definition of boredom presented in the contemporary psychological literature, which suggests it is the "aversive experience of wanting, but being unable, to engage in satisfying activity" (Eastwood et al., 2012, p.483). This is sometimes phrased, following Tolstoy, as "a desire for desires" (1899; Danckert, 2019, p. 37). Boredom is the state that both helps to disengage an agent from their current activity, but also to re-engage; to search for new interests and satisfying activity.

Attention is often theorised as an important mechanism in boredom's regulatory role, and is central to many boredom theories (Eastwood et al., 2012; Malkovsky et al., 2012; Tam et al., 2021; Westgate & Wilson, 2018). When bored, the mind may wander, with agents struggling to maintain attention on the present task (Danckert & Merrifield, 2018; Yakobi et al., 2021). These attentional lapses may signal or be caused by boredom (Cheyne et al., 2006; Carriere et al., 2008). In turn, wandering attention may reveal salient affordances of an environment, which presents an agent with heightened opportunity costs; stimulating boredom if one is unable to engage with these features of the environment (Struk et al., 2020). Boredom has this crucial property of searching and seeking for more interesting opportunities (Bench & Lench, 2019). It is not just that one is currently disengaged; one wishes to *be* engaged, to find a more fulfilling activity or a more stimulating environment.

An agent's attention is often drawn to salient and meaningful opportunities, where this kind of perceived *meaning*, or *meaningfulness*, plays a crucial role in boredom's self-regulatory function (Chan et al., 2018; Van Tilburg & Igou, 2019; Westgate & Wilson, 2018). In this case, boredom drives one to escape meaningless situations, by aiming one toward what one might find more meaningful (Barbalet, 1999; Van Tilburg & Igou, 2011; Van Tilburg et al., 2013). Particularly, this connection to meaning highlights boredom's largely agent-relative nature; it crucially depends upon an agent's specific goals and skillset. For instance, whether one is bored playing chess depends partly on if the game of chess is (or can be) considered meaningful to one, just as watching televised golf may (not) be.

Boredom's regulatory role is also commonly positioned as managing the switch between *explorative* and *exploitative* modes (Danckert, 2019), or as a solution to similar biological and computational trade-off problems in the wider literature (Geana et al., 2016; Gomez-Ramirez & Costa, 2017; Kurzban 2013; Mugon et al., 2018; Wolff & Martarelli, 2020; Yu et al., 2019). That is, boredom plays a role in whether an agent should exploit its current environment, or explore new environments – and catalyses the switch in both directions. Opportunity costs (a)rise in exploitation, and boredom may play a part in an agent realising these costs, particularly when an agent cannot sustain their attention on their current task (Milyavskaya et al., 2019; Struk et al., 2020; Wojtowicz et al., 2019; Agrawal et al., 2022). Though, boredom may also encourage disengagement from overly complex domains, particularly highlighted in the computational literature on curiosity-based exploration (e.g. Ten et al., 2021). In this literature, boredom is conceived, alongside creativity and fun (e.g. Schmidhuber, 1991, 2010), as a component of intrinsic motivation networks that aim toward maximising epistemic (or informational) gain (e.g. Baldassarre & Mirolli, 2013; Barto et al., 2013; Friston et al., 2017a; Gottlieb et al., 2013; Schwartenbeck et al., 2013).

This psychological construal largely categorises boredom as an *emotion* (Westgate, 2020), where, within psychology, emotions are typically seen as short-lived, intentional and responding to environmental features (Beedie et al., 2005; Ekkekakis, 2013). Despite this common conceptualisation, whether boredom is an emotion, mood, feeling or experience, is sometimes obscure(d) in psychology (see Eastwood & Gorelik, 2019; Yao, 2022). This conceptual difficulty generates and sustains the contemporary discussion of whether boredom is a unitary concept or construct (e.g. Elpidorou, 2021; Tempelaar & Niculescu, 2022).

A compelling way to understand boredom is to suggest a functional theory, which argues boredom *does* something, and that it should be defined by the (functional) role it plays (Elpidorou, 2022; Danckert & Elpidorou, 2023). Many theoretical accounts of boredom which are not strictly 'functional theories' (in the precise sense), still broadly appeal to boredom's function. For instance, Westgate and Wilson (2018) introduce their *Meaning and Attentional Components* model of boredom as responding to, and being broader than, a 'functional theory'. Though, their theory still describes boredom largely in terms of functional regulation: "Boredom motivates people to take steps toward restoring successful engagement in a meaningful activity" (2018, p.690), particularly through attention regulation. How we ought to best understand boredom's function is an open question; I will argue predictive processing provides a powerful solution.

In summary, this research presents a compelling case for positioning boredom as a functional emotion which assists self-regulation. To this end, boredom helps catalyse domain switches, plays a part in regulating attentional processes, and pushes an agent toward what they find engaging and stimulating. Without boredom an agent would struggle to disengage from repetitive and unengaging tasks, and struggle to re-engage with goal-aligned, interesting and meaningful ones.

This is a powerful way to construe boredom. However, it is partly[2] in tension with the phenomenological emphasis on boredom as a mood, and the concomitant existential problem that it presents. In this existential light, we cannot (only) treat boredom by searching for the next productive use of time, or the next interesting activity to engage with; that, in order to 'solve' boredom, an agent must simply find an interesting activity to engage with. This view fails to see we already have next to endless opportunity for interesting engagement with the world (if able to see it). And yet, boredom prevails in the modern world, signalling a kind of ontological deficiency, or, if I may borrow the phrase, acting as a "canary in the coal mine of modern existence"

[2] I say partly, as a strictly 'functional' theory of boredom does not preclude boredom from being understood as a mood. However, the emphasis matters here, and many psychological accounts emphasise a kind of self-regulating *emotion* view of boredom that generates part of the 'problem' of boredom that philosophers worry about (e.g. Calhoun (2011); Svendsen (2005); Goodstein (2005); McDonald (2019); Ringmar (2019).

(Dreyfus & Kelly, 2011, p.26). Boredom in this sense is a fundamental problem, which partly concerns how one currently relates to the world, finds meaning in that relation, and experiences their existence.

3 Heidegger's phenomenology of mood

Conceptualising boredom (partly) as a mood, as a constitutive affective comportment that is broader than simply an emotion, is a central insight from Heidegger's philosophy (Slaby, 2015). This forms part of Heidegger's aim to contribute to a theoretical understanding of affective aspects of existence, rectifying traditional neglect (Ratcliffe, 2002). To this end, Heidegger wrote extensively on boredom, covering some 130 (originally German) pages in The Fundamental Concepts of Metaphysics (1995), where he identified boredom as a *Grundstimmung*; a fundamental (grounding) mood or attunement. Boredom in this light is critical to our engagement with the world, and of finding meaning in the world through that engagement.

Though, mood in philosophy has a murky history (Freeman, 2015; Stephan, 2017). Typically, mood is positioned as distinct from emotion, with some philosophers being careful not to conflate the two. Part of this distinction is couched in terms of intentionality – where emotions are largely intentional, moods are typically pre-intentional (e.g. Kind, 2013). They are characterised as a kind of generalised affective state, existing longer temporally than emotions, and thus having widespread effects (DeLancey, 2006). This conception is somewhat distinct from the psychological 'mood' (Freeman, 2014), despite similarities.

In the Heideggerian phenomenological tradition, this general characterisation follows. Mood is distinct from emotion (Ratcliffe, 2002), though never explicitly distinguished by Heidegger (Ratcliffe, 2013a). Particularly, mood is suggested to be more generalised than emotion (Ratcliffe, 2012); however, they are *not* just 'generalised emotions' (Ratcliffe, 2013b). This is because moods are not just a more generalised form of an emotional state; they do not necessarily carry valence, intentionality or similar attributes typically ascribed to emotions. Rather, Heideggerian moods condition the possibility for emotions, in that they precondition how we are disposed to perceiving and interacting with the world. Where emotions are towards the world and are feelings that we *have*, moods, in contrast, are something we find ourselves *in* (Svendsen, 2005). They are not towards specific objects in the world – like my fear of a bear – rather, they colour our entire existence like an essential background atmosphere (Heidegger 1995, p.67).

Though, moods go beyond just colouring existence, they condition its possibility; serving a "fundamental disclosive function" (Thonhauser, 2020, p.104). In this sense moods constitute part of our existence (Elpidorou, 2013; Freeman, 2014, 2015), and enable the world to be disclosed relationally to the mood one finds themselves in (Elpidorou & Freeman, 2015). Thus, moods matter greatly. They determine how we find ourselves in the world (Ratcliffe, 2013a), which is a central concern in Heidegger's analysis of being (Dasein).

Heidegger's analysis of being (particularly in Being and Time) suggests that we do not find ourselves in the world as disinterested spectators, and that there is no 'objective view' we approach the world with (Ratcliffe, 2010). Rather, we approach the world through our moods, and as such the world reveals itself in virtue of these moods. Mood is in this sense primordial – moods afford a "primordial disclosure" (Heidegger, 1962, p.134). They are ontologically basic, and for Heidegger come prior to subject-object distinctions (Ratcliffe, 2013b). This is because, in Heidegger's analysis, the fundamental subject-object distinction (which separates us from the world) is a feature of a mistaken philosophical ontology (Dreyfus, 1991; Blattner, 2006). We cannot come to know, or theorise, about *being* in a sort of disinterested, disembodied, pre-theoretic way. As Ratcliffe (2002, p.287) argues, following Heidegger: "the sciences constitute a derivative means of disclosing the world and our place within it". On the other hand, it is suggested, moods constitute a privileged means for disclosing reality – they reveal the world through (in virtue of being essential to) experience.

Heidegger idiosyncratically employed and constructed language to circumvent some of the problems that he saw in traditional philosophy (considered to be baked in to the existing language). For instance, Heidegger uses the term *Stimmung*, which is typically translated as mood[3] (e.g. Macquarie and Robinson 1962; Dreyfus, 1991), in parallel with *Befindlichkeit*, which has been literally translated as findingness (Haugeland, 2013), to discuss our affective existence. Although, translating Heidegger is replete with difficulty; for instance, attunement has been the translation for both *Stimmung* and *Befindlichkeit* (Thonhauser, 2021a). This translation grows from an etymological connection (from *Stimmung* particularly) to literally 'tuning' a musical instrument (Elpidorou & Freeman, 2015). Then, moods arise in relation to how we are 'tuned' in accordance or disharmony with the world.

Mood is sometimes suggested to be 'deep' (e.g. Slaby, 2015; Ratcliffe, 2013a), in the sense that "[Moods are a] fundamental manner and fundamental way of Being" (Heidegger 1995, p.67). Heidegger seems to suggest moods are somewhat (or sometimes) unconscious; they are not an internal mental state (Freeman & Elpidorou, 2015), or an "inner condition which then reaches forth" (Heidegger, 1962, p.176). Instead, Heidegger (e.g. 1962, p.183) suggests we are always in a mood, which means moods are ubiquitous and constant (Slaby, 2015). This is to say we are always disposed to receive the world in a particular way - there is no other way to be.

The Heideggerian 'mood' is distinct from the folk psychological 'mood', which might have negative valence, or might be thought of as a broadly 'bad mood'. While Heidegger's *Stimmung* does still refer to a kind of affective experience, it also describes the relation one finds themselves in to the world (Elpidorou, 2015). In this way, they condition how we experience things as mattering (Ratcliffe, 2010; Elpidorou, 2013), informing our care and concernful involvement toward the world, through which the world (and our sense of reality) is disclosed to us. So, where affective and valenced states arise, they are guided by the mood we are in. This is because we are beings that find ourselves intrinsically caring about the world; it matters to us if we live or die, are in love or lonely, win or lose. Our moods elucidate this 'care-structure', directing our involvement with the world, and creating the landscape in which emotions arise.

[3] 'Mood' as a translation for *Stimmung* likely fails to capture the entirety of Heidegger's original meaning, and has a complex history (seeThonhauser (2021a, Thonhauser, 2021b).

There are difficulties in clearly demarcating emotion and mood in Heidegger's account. That is to say there is a fair amount of continuity between the two categories, with many affective states like boredom likely presenting in a range of ways (Ratcliffe, 2013b). I do not take boredom to be strictly (and only) unconscious (somewhat toward a Heideggerian fundamental mood), or always arising consciously and directed (like an intentional emotion).

As an emotional state, boredom is typically directed (has intentionality) towards specific things in the world, whether that be a book, speech, or dinner party. In this way it responds to the world, often triggering action to avoid prolonged boredom. On the other hand, mood is not reactive in the same way – we are always and already in a mood when we come to the world, so that world is disclosed to us in relation to the mood. This draws attention to the type of problem that boredom may present us with (as a mood) - that is, a problem of how we are attuned. The world itself may appear bleak and without opportunity for engagement. So, try as one might to re-engage, to search for more interesting activities, this may be impossible.

4 The Predictive Processing Approach

Predictive processing might not seem the most natural place to situate Heideggerian phenomenology.[4] However, this turn is motivated by the broader project of naturalising phenomenology (e.g. Petitot et al., 1999). That is, it aims to integrate aspects of the phenomenological tradition with the natural sciences. There are various potential philosophical problems with any attempt to 'naturalise' phenomenology, though few deny the approach possesses *some* potential (e.g. Bayne, 2004; Zahavi, 2004; Gallagher, 2012; Ramstead, 2015)[5].

I take a broad-church approach in the present account which, as Zahavi (2010, p.8) puts it: simply lets "phenomenology engage in a fruitful exchange and collaboration with empirical science". In the case of boredom, I see great potential for just such fruitful collaboration – mediated through predictive processing – between the growing empirical literature and Heidegger's phenomenology.

To this (integrative) end, I turn to predictive processing, which has been heralded as a potentially unifying theoretical and computational framework for mind, body and life (Friston, 2010; Clark, 2013; Hohwy, 2013). Predictive processing unites perception, action, cognition and emotion under the broad banner of approximate Bayesian inference, suggesting humans are in the game of minimising their prediction error in order to survive and thrive in a volatile world. Predictive processing shares many theoretical commitments with the active inference framework, and more broadly the Free Energy Principle. Together, these frameworks suggest we construct hierarchical generative models of the world; attempting to represent, through inference, the hid-

[4] Though some see the fit as natural, particularly due to the temporal and enactive dynamics of predictive processing (see Albarracin et al., 2023; Kiverstein et al., 2020; Neemeh & Gallagher, 2020; Ramstead et al., 2020). (Thanks to an anonymous reviewer for noting this).

[5] I admit there remain various criticisms of attempts to 'naturalise' Heidegger. However, if it is thought that Heidegger is on to something fundamental about human existence, it seems important to (at least attempt to) describe this in terms of modern cognitive science.

den causes of our perceptions, where the divergence in our predictions from reality cause and are signalled by prediction errors (or, roughly, free-energy). Thus, we are prediction error minimising agents (Hohwy, 2018), constantly attempting to self-regulate by comparing our hypotheses to reality, by leaning on prediction error, in order to survive. We modulate prediction errors through *precision-weighting* (Kwisthout et al., 2017; Schwartenbeck et al., 2015), which allows context-dependent modulation of prediction errors, given prior learning and evidence. These formally represent the inverse-variance of a probability distribution, and roughly reflect 'confidence' in our expectations (Parr et al., 2022). That is, we afford a higher precision-weighting to signals we are confident in, and are able to down-regulate uncertain signals – like the cause of a specific sound in a noisy environment – by affording that signal low precision. Particularly though, through *active* inference, these frameworks incorporate the idea that we are able to modulate and confirm our predictions by acting in the world (Friston et al., 2010, 2017b), potentially modifying that world in the process of confirming or disconfirming our predictions – in a form of self-evidencing (Hohwy, 2016).

There are many pre-existing and accessible descriptions of predictive processing, active inference and the Free Energy Principle (see Hohwy, 2013, 2020; Clark, 2013, 2015; Wanja & Wiese, 2017; Andrews, 2021; Parr et al., 2022 etc.). Here I turn directly to the predictive account of affect to furnish a discussion of boredom.

4.1 Affective inference

Within predictive processing, emotions are frequently conceptualised as interoceptive inferences that act in the service of *allostasis* (Seth & Friston, 2016; Barrett, 2017; Critchley & Garfinkel, 2017), where allostasis labels the anticipatory processes that organisms employ in order to survive over time (despite a changing environment) (Sterling & Eyer, 1988). This interoceptive view suggests emotions arise due to predictions about internal physiological states through us generatively modelling their (hidden) causes (Seth, 2013). We expect to exist in particular physiological (attractor) states (in the neighbourhood of homeostatic set-points), and emotions arise due to predictions about afferent physiological signals and how they diverge from expectations. This grounds emotions in the physiological features that they are suggested to be constituted by. For example, a fearful state is characterised by the predictions about physiological signals of fear (rising heart rate, trembling etc.) (Clark, 2015).[6]

Information-theoretic approaches differ in focus from the (often more biologically inspired) interoceptive approach to emotion. In these accounts, affect is characterised primarily through valence (Joffily & Coricelli, 2013; Van de Cruys, 2017) – an essential aspect of core-affect (Russell, 2003). Emotional valence reflects the

[6] The interoceptive view of emotion largely coheres with constructionist accounts of emotion, exemplified in Lisa Feldman-Barrett's Theory of Constructed Emotion (Barrett, 2017). Barrett argues emotions are not innate 'natural kinds' (opposing 'basic emotion' theories e.g. Ekman (1992), rather they are constructed (inferred). Then, boredom is partly conceptual; we learn the concept through our life, language, culture and so forth. Our interoceptive feedback which signals a 'boredom experience', in this view, necessarily accords with and partly arises due to our concept of boredom, which governs how we interpret (make inferences about) these signals.

predictive agent's success or failure at reducing error; positive valence (a 'feeling-good') amounts to a reduction in prediction error (or free-energy – given some qualifications). Then, the gradient of error-reduction is a cause of valence – and is thus deemed 'error-dynamics' due to the unfolding nature of error-reduction across time (Van de Cruys, 2017). Crucially, all of this occurs relative to the agent's *expected* error-reduction (Kiverstein et al., 2019), which results in a richly agent and context-relative error-reducing scheme. Affect then becomes a powerful tool for learning, by guiding an agent's interaction with the world based on slopes (i.e. gradients) of error reduction.

Emotions are also associated with the precision of beliefs about future action, as they depend upon confidence in action-policies (through depending on expectations about error-reduction, given policy selection). Because of this, emotions can also be thought of as reflecting (precision-based) uncertainty about the consequences of action (Clark et al., 2018), in effect, linking affect and action in the predictive cycle. In this sense emotions reflect states of action-readiness (Kiverstein & Miller, 2015), which promote particular action policies for prediction error minimising agents.

Affect has also been computationally modelled in the active inference framework (see especially Hesp et al., 2021), which is theoretically intertwined with predictive processing. Here it is suggested an (artificial) agent infers valence based on their model's expected precision (Hesp et al., 2021)[7]. This amounts to a kind of confidence that an agent's actions will lead to their preferred outcomes. Then valence arises due to predictions about how one expects error reduction will go, given action-policies (where an action-policy includes inferences about the probabilistic outcomes of that policy, determining which action should be undertaken (Friston et al., 2017b). Valence then signals to an agent the 'subjective fitness' (Hesp et al., 2021) of their model, which conditions the actions chosen based upon their anticipated positive or negative valence. Affectivity in this sense is crucial to guiding an agent's engagement with the world.

Beyond emotion, mood is theorised to be a kind of hyperprior in predictive accounts (Clark et al., 2018; Clark & Watson, 2023), expanding on the notion of Bayesian 'priors' (roughly the accumulation of evidence and previous predictions). In hierarchical Bayesian accounts, a hyperprior is just a type of prior encoded higher in the hierarchy, making them more time-invariant. This means a mood encodes beliefs about lower level parameters, and partly determines the precision-estimations that are afforded to the cascading prediction-errors. Then, if emotions reflect short-term changes in precision, these emotions are modulated by mood, which track and average over the longer-term error-dynamics (Clark et al., 2018) – reflecting a kind of 'overall faring' of the predictive agent's pursuit of error minimisation (Kiverstein et al., 2020). In this view, moods condition an agent's involvement with the world, partly determining the possibility for the instantiation of specific emotions, which arise partly in virtue of the mood one is in. The mood provides a more continuous feeling of predictive success, which might pre-reflectively signal an agent's predictive grip (Ramstead et al., 2020), and thus might be largely unconscious. This sug-

[7] This active inference account provides a computational model of affect, which provides further plausibility to the predictive story outlined above.

gests that, before receiving perceptual input, we are in a mood, which influences our predictions[8], particularly through precision-based modulation of our uncertainty.

Kiverstein et al. (2020) argue that mood in the predictive system reflects an agent's 'grip' on the world, much like the Heideggerian 'attunement'. A "feeling of grip" arises through an agent's error-dynamics (i.e. rates of relative to expected error-reduction) (Kiverstein et al., 2019), with mood informing how we find ourselves in the world at a given time, creating a sense of direction and momentum (Eldar et al., 2016). That is, how one is currently moving through the world. Just as a Heideggerian mood reflects how one is positioned in the world, determining and elucidating the care-structure of our experience, it reflects how we are 'attuned'. Then, attunement (as a direct translation of Heidegger's *Stimmung* – alongside 'mood') takes on a somewhat literal meaning in the predictive framework. An attunement (literally) reflects how one is positioned to attribute precision-weightings (tunings) to their predictions; meaning our moods 'tune' our predictions, and reflect how we are (at)tuned to the world (Kiverstein et al., 2020).

This predictive view of mood has potentially deep resonance with Heidegger's analysis of mood. He suggests moods are not outside of the world, or states that we are 'in'. Rather, they arise within our relation to the world, partly creating that world, while partly, in a dynamic sense, responding to that world. This dynamic and relational understanding is concordant with the predictive story. It suggests we come to the world with predictions that are informed by (Bayesian) priors (which can be thought of as experience, knowledge, beliefs and so forth). These 'priors' partly determine what we find in the world. They direct our attention, determine what we engage with, and reveal salient affordance-related features of the environment (Rietveld & Kiverstein, 2014; where affordances describe the Gibsonian concept (1979) of environmental features 'offering' an animal action opportunity). When making predictions we rely on our past experience and previous predictions, which determine how we are positioned to place precision-estimations. Simultaneously we are constantly and dynamically updating our predictions based on prediction error, particularly realised through perceptual, interoceptive and active inference. In this sense the world is concurrently creating and shaping us; determining our generative model, and the expectations we come to have.

Moods are also fundamental to our involvement with the world in terms of things mattering to us, directing our sense of care toward the world. Often this is guided through valence and affective experience, which are linked to states of action-readiness (in the Frijdian sense (1986) (e.g. Kiverstein & Miller, 2015; Bruineberg & Rietveld, 2014). The world invites us to act, opening itself to us through salient affordances which relationally depend on our skills(et) (Rietveld & Kiverstein, 2014; Van Dijk & Rietveld, 2017; Bruineberg et al., 2021). The feeling of valence and affect is embedded within this complex relational structure, particularly through their embodied and situated nature (Colombetti, 2017). What we care about is partly dependent on us, but is also driven by our environment (our culture, language and so forth), and is realised and directed through affective and embodied experience. So, the Heideg-

[8] It is debateable whether this view necessitates a kind of cognitive penetrability, where cognitive factors alter our perceptions (see Hohwy (2017); Macpherson (2017); Marchi (2020).

gerian suggestion that moods are world-revealing – that they direct and allow for meaningful engagement – concords with the predictive view.

To summarise, I have suggested mood and emotion can be understood predictively, as part of a rich affective inference scheme that aims to minimise long-term prediction error. Valence is hypothesised to reflect the gradient of error-reduction (roughly if one is going better or worse than expected at reducing error). Then, emotions reflect shorter-term predictions about afferent physiological signals, and respond to local fluctuations in error-dynamics. Above them, mood is conceptualised as a hyperprior, reflecting our 'grip' on the world. Moods track long-term averages or 'momentum' of error-dynamics, encoding longer-term regularities about the world, and constraining how we are disposed to engage with (i.e. act in and perceive through inference) the environment.

5 Synthesising boredom

5.1 Adaptive boredom

As discussed in Sect. 1, boredom is often described functionally, with a contemporary focus on the 'good' (i.e. benefits) of boredom (e.g. Elpidorou, 2018b). Part of this adaptivity can be cached out in terms of allostasis, which is naturally spoken about, and arguably best understood, within predictive processing and associated frameworks (e.g. Barrett et al., 2016; Corcoran & Hohwy, 2019; Corcoran et al., 2020; Tschantz et al., 2022). Organisms must employ allostatic mechanisms that pre-emptively regulate their internal environments and energetic resources (McEwen & Wingfield, 2003; Sterling, 2012; Shulken & Sterling 2019). Boredom, understood as a predictive emotional state, provides just such organismic self-regulation. For instance, it alerts and assists an agent in switching between exploitation and exploration, acting predictively to signal that another domain may be better based on probabilistic expectations. The agent cannot know for certain whether they should make this switch, and instead rely on their model of the world (including prior experience, knowledge etc.) to guide their choice. Understood in this light, predictive processing provides a theoretical mechanism through which an agent manages these domain-switches. It suggests the agent is continuously monitoring various levels of predictions – about their environment, bodily states, desired outcomes – in order to survive. Then, domain switches occur due to rising levels of prediction error (violations of one's model), that lead to actions aimed at resolving uncertainty.

The adaptive nature of boredom can be particularly observed in its connection to a 'Goldilocks zone' of learning and proximal development (Danckert, 2019; Lin & Westgate In Press). This idea suggests both overly complex and overly simple tasks are ineffective at stimulating optimal learning, based on decreasing engagement (and rising boredom) at either end of the continuum (Westgate & Wilson, 2018). Boredom is often conceived as arising from simplicity, though, boredom research suggests that overly complex activities also inspire the state (e.g. Acee et al., 2010; Pekrun et al., 2002; Westgate, 2020). Imagine activities some people (could) find boring – going to the opera, or playing golf or chess. These activities are far from overly simplistic and rather may trigger boredom from too much complexity (deemed “information overload” by Klapp (1986). The agent cannot find a suitable engagement point and cannot learn or achieve predictive success. Boredom is then suggested to catalyse domain switches as a form of self-regulation, allowing the agent to reduce error more optimally.

The Goldilocks idea is reinforced by research into zones of proximal development. For example, listening to music of intermediate complexity (relative to an agent’s expertise) seems to be selected for, enjoyed, and intrinsically rewarded (Gold et al., 2019). For students, relative skillset compared to difficulty of a task is correlated to effort and boredom (Asseburg & Frey, 2013). Child development studies suggest even infants allocate attention based upon relative complexity, preferring intermediate complexity (Kidd et al., 2012), and modulate attention toward maximising learning (Poli et al., 2020).

These findings inform a predictive processing account of play (Andersen et al., 2023), which positions intermediate complexity and, by proxy, the Goldilocks zone, as essential to optimal learning. When activities are overly simplistic or overly complex, an agent is unable to efficiently minimise their prediction errors. This is because in order to maximally reduce error, an agent must have sufficient (non-zero) levels of prediction error, which are subsequently reduced. Then, for a prediction-error-minimising agent, gradients of error reduction are critical, as steeper gradients allow for maximal error reduction and learning, which affords long-term reduction in overall prediction error. As Kiverstein et al. argue: “being sensitive to error dynamics guarantees that the agent avoids wasting time in places where regularities are either already learned or too complex given the agent’s skill level” (2019 p.2864).

Putting these parts together, the hypothesis is that boredom arises as a mechanism (both cognitive and physiological) that tracks prediction errors through a ‘Goldilocks zone’, helping an agent to domain switch to better reduce uncertainty. In terms of error dynamics, boredom arises when the learning rate is suboptimal, which is suggested to arise with a negative valence (which reflects this worse-than-expected gradient or prediction error reduction). Although, an experience of boredom is itself inferred, based on interpretations of afferent physiological signals, and the priors (and model) than an agent possesses. These priors inform the landscape of action-policies available to an agent, with boredom affectively contributing to the selection between these action-policies. That is, boredom partly determines an agent’s next action; particularly, as the agent seeks to change the world to minimise their boredom.

This picture from predictive processing validates the psychological construal of boredom as a functional and self-regulating emotion. However, it further operationalises our understanding of boredom, providing a potential mechanism through which boredom operates; the error-dynamics in a predictive organism. Particularly, leaning on *active* inference affords a principled way to characterise the relation between boredom and the “call to action” that it promotes (Danckert & Elpidorou, 2023). This is because, in the predictive processing framework, action is fundamentally intertwined with an agent’s pursuit of prediction-error-minimisation.

5.2 Maladaptive boredom

While boredom's self-regulatory and adaptive role is becoming more prominent within the psychological and wider literature, there remain obvious maladaptive components and consequences of boredom. Boredom drives people toward unhealthy and maladaptive behaviours in order to cope with, and avoid, boredom, partly as a form of existential avoidance – where a person is "unwilling to remain in contact with private experiences" (Hayes et al., 1996, p.1154). In the boredom literature, these strategies have been deemed "existential escapes" (Moynihan, Tilburg & Igou 2021b; Van Tilburg & Igou, 2022). To 'escape' is to avoid the particularly existential feelings encouraged by boredom, and to launch into activities that counteract these feelings (particularly the feeling of meaninglessness) through diversion.

There are many ways we escape boredom and its related existential feelings. We use diversions as coping mechanisms, which present as low self-awareness activities, often rooted in biologically basic functioning (Moynihan, Tilburg & Igou 2021b). These coping mechanisms align with many addictive and unhealthy behaviours people engage with to avoid boredom – particularly in (binge) eating (Abramson & Stinson, 1977; Moynihan et al., 2015; Havermans, Vancleef & Kalamatianos 2015), drinking alcohol (Biolcati et al., 2016, 2018) sex (Moynihan et al., 2021a), gambling (Blaszczynski et al., 1990; Mercer & Eastwood, 2010), drug taking (Lee et al., 2007; LePera, 2011), and modern technological addictions to gaming (Larche & Dixon, 2021), pornography (Moynihan et al., 2022) and social media or general mobile phone use (Whelan et al., 2020; Al-Saggaf et al., 2019; Chou et al., 2018). These strategies partly reflect the wider-known connection between boredom and impulsivity (e.g. Watt & Vodanovich, 1992; Moynihan, Igou & Van Tilburg, 2017). The contention here is that people employ these escapes as boredom management strategies, and more fundamentally, as mechanisms to cope with existence.

These escapes are often biologically basic, which become maladaptive through turning many of the necessities of life into cycles of abuse fed by over-consumption. In these cases, we are 'learning' to use these strategies as coping mechanisms. There is not necessarily a disease or pathology (Lewis, 2017; Sterling, 2020); the system is functioning largely how it is meant to (biologically). That is, we are utilising the biological strategies which, in some contexts, enable survival. In predictive processing terms, we are partly learning to attend to short-term error-dynamics, at the expense of the overall and long-term well-being of the system. Actions may seem adaptive when they are undertaken in order to optimise short-term error-reduction, though they may prove to increase long-term error – as, for example, in addiction, which often undermines long-term physical and mental health, social functioning and so forth (Miller et al., 2020). This is the case in the evidence discussed above; in the short-term these strategies may feel great (due to their error-dynamics). Globally however, they increase the agent's prediction error, often by worsening an agent's ability (particularly their future capacity) for error-reduction. So, while attending to momentary error-dynamics (in the case of boredom-as-emotion) can be adaptive, a too narrow focus, can lead to maladaptivity.

When we avoid boredom, we may also miss the information it is aiming to provide the predictive system. For instance, we may ignore the fact that the domain we are currently in is overly simple or complex – or goal-incongruent. In fact, this has to be a possibility if it is accepted that boredom has a powerful functional aspect. This function implies that 'running away' from boredom can be detrimental, as an agent may fail to realise boredom's function; say, tracking the intended Goldilocks zone. Thus, if an agent overly avoids boredom they may miss the information this emotion aims to convey and contains – making them worse prediction-error-minimisers. This is particularly the case when short-term positive error slopes (broadly instantiated in positive valence), are prioritised over, or mistaken for, long-term and global improvements in the system, often at the expense of the system's future capacity for error-reduction. However, in the predictive framework, it also makes sense why these short-term actions taken to alleviate boredom (i.e. eating) are chosen. These actions reduce local uncertainty, often feel great (due to their local error-dynamics), and in some contexts (particularly if the future is highly uncertain) prove effective allostatic strategies.

Further, action crucially allows an agent to influence the action-perception loop, providing the mechanism through which an agent garners specific and desired observations (epistemically foraging towards confirming predictions), and allows an agent to modulate the world to elicit desired outcomes (partly shaping it toward confirming predictions) (Parr et al., 2022). When agents attempt to avoid boredom, launching themselves into simple activity (eating, scrolling their phone), they do successfully simplify and act in the world to confirm their predictions – utilising non-goal-directed action to precisely minimise prediction error (see Perrykkad & Hohwy 2020)[9]. However, if the individual is too eager to escape boredom, they risk selecting *any* action policy that successfully reduces local error.

5.3 The existential problem of boredom

As discussed, boredom may become maladaptive, forming one type of 'problem' that boredom presents as. However, boredom also presents as an existential problem, conceptualised here in terms of the phenomenological account of mood. By integrating Heidegger's notion of mood, with predictive processing, we are better able to conceptualise boredom and the problem it poses.

Predictive processing suggests that this existential problem is, in fact, a similar type of problem to the narrower one. This is because the mechanisms proposed in predictive processing – predictions, prediction errors, precision – apply globally to the system, at various time-scales and processing domains. So, rather than propose any fundamental and essential distinctions between these different sorts of maladaptivity or 'problems' of boredom, predictive processing attempts to explain them in essentially similar ways, using the tools it has at its disposal. Indeed, this is part of the appeal of predictive processing – we don't have to posit various mechanisms and explanations at different scales.

[9] There is also reason to believe these 'simple' actions policies (like eating, scrolling a phone) serve to increase sense of agency; by simply but successfully reducing error (as predicted) through self-determined actions (see Friston et al. (2013); Perrykkad et al. (2021).

To give an example, *precision* can be highlighted as a potential mechanism that leads to maladaptivity. Recall, precision is a type of 'confidence' in predictions (though not to be confused with confidence in the more typical and psychological usage). Precision is critical in the successful updating of prediction errors, which are propagated and modulated with precision-estimates. When boredom as a mood arises, there is likely to be aberrant and overly rigid precision estimation.[10] A disruption in accurately attributing precision-estimates may lead to global and pervasive prediction errors, that permeate across time and context for that predictive agent. Particularly, this compromises allostatic potential, by reducing an agent's ability to update predictions and beliefs optimally. Stuck in an overly-rigid bored mood (a sticky hyperprior), an agent may fail to flexibly and accurately update their beliefs in line with incoming sensory data, and misattribute confidence to the expected consequences of action (Clark & Watson, 2023). This might practically mean an agent fails to see *anything* as interesting, engaging, or worth acting upon – simply no action policy is appealing.

The degree to which a particular plan of action is appealing is, in active inference, scored by the degree to which a course of action minimises expected surprise or, technically, uncertainty (noting that, in information theory, surprise is self-information, and the expected or average self-information is entropy).[11] This means that if all plausible courses of action fail to resolve uncertainty, no single course stands out as appealing. In this case, the agent has a low precision of beliefs about actions; in other words, a loss of (subpersonal) confidence in 'what to do next'.

One can now see how active inference helps to naturalise boredom, by construing the Goldilocks regime as directed toward actions that resolve uncertainty (and maximise self-evidence). If there is no epistemic affordance available, there is nothing further to learn and there can be no appealing action; because the world has become too simple and familiar – bereft of expected information gain. Conversely, if the world is too complex, there is no clear way forward in terms of resolving uncertainty.

To flesh out the technical details, expected surprise has two components, one pertaining to expected information gain and one to expected cost, where cost is measured in terms of the surprise associated with particular outcomes. The expected information gain – a.k.a. intrinsic motivation – (Barto et al., 2013; Schmidhuber, 2010; Vigorito & Barto, 2010) is important here and can come in several flavours. When the expected information gain – or resolution of uncertainty – concerns states of affairs in the world, this scores the salience of various cues that have an epistemic affordance. When the uncertainty pertains to the parameters of our generative models, salience becomes 'novelty'; namely, 'what would happen if I did that?' (Schwartenbeck et al., 2019). These technical definitions of salience and novelty can now be read as the "salient and meaningful opportunities" (that boredom directs one toward; outlined

[10] An agent's *attention* is often suggested as a mechanism for controlling precision-estimation (e.g. Feldman and Friston (2010). Aberrant precision estimation could then be explained partly in terms of dysfunctional attentional processes – a common component of boredom.

[11] I am appreciative to an anonymous reviewer for expounding these technical details of active inference, in this and the following paragraphs.

above), which acquire a central role in predictive processing that is action – and implicitly future – oriented.

The affective inference view of boredom, outlined in Sect. 3.1, suggests that a bored mood arises as a generalised affective reflection of how the predictive agent is tracking (relative to their expectations) in their reduction of prediction error – encoded as a hyperprior (Clark et al., 2018). This roughly 'averages' over shorter term learning progress (gradients of error-reduction), reflecting the overall faring of an agent (Kiverstein et al., 2020). So, a (maladaptive) bored mood may partly reflect a kind of continual and repeated failure in the short-term to update beliefs and act in the world in ways that optimise our error-dynamics. Repeated failures of this sort may lead to a loss of grip on the world – a failure of attunement – where the maladaptive bored mood leads to one finding it impossible to find *anything* interesting, as this possibility is precluded by the mood one finds themselves in. The world itself is boring.

This is exemplified in depression, which, for Clark et al. (2018), reflects a kind of certainty (high-precision) that the world is itself uncertain – a prediction that that agent's future predictions will not be accurate. This mood then constrains predictions about the shorter-term changes in prediction error; modulating how afferent physiological signals are categorised.

Consider, as a further example, the active inference description of depression offered by Ramstead et al.:

> In active inference terms, the precision on the expected free energy is so low that it cannot drive action any longer: all policies are experienced as having little to no relative affordance, and no longer solicit the agent to act. In other words, these actions are still, subjectively, things that *could* be done, but not things *I* can do (2020 p. 27).

This description owes partly to, and has significant overlap with, phenomenological accounts. Consider Matthew Ratcliffe's descriptions of depression:

> The possibility of anything appearing as practically significant is gone… the world therefore *offers* nothing (2013b, p.173).
> The world might still incorporate meaningful projects but its allure is gone and it no longer solicits any action (2013a,p.586).

The idea of our world 'alluring' us in particular ways speaks to our 'attunements'; our moods. The world 'invites' us forward (particularly through encouraging action), naturally revealing possibilities for interaction and engagement. This is exemplified in phenomenological accounts of 'skillful coping' (e.g. Dreyfus, 2014), 'smooth coping' (e.g. Wheeler, 2005), or 'skillful action' (e.g. Rietveld, 2008), where, through one's skill in a domain, actions become effortless and obvious. A classic example comes from Merleau-Ponty (1963 p.168-9/182-3); describing how a soccer player sees, is invited, and moves through a gap in the defence, effortlessly engaging with the field of play through their expertise in the domain.

In boredom, our movement – or lack-thereof – through the world becomes abruptly obvious to us. We are stuck at a crossroads deciding our next action. Rather than invitations eliciting obvious responses from us, the world may lose its alluring shine – its 'affective allure' (Krueger & Colombetti, 2018). While the psychological definition of boredom includes an aspect of re-engagement, understanding boredom as an existential mood limits this possibility. The world itself appears differently to the agent; diminishing the possibility for successful re-engagement.

Like in depression, a profound sense of boredom may encourage and reflect a bland quality to existence, well characterised by Frankl's term of an "existential vacuum" (1967), where air and life is drained away through meaninglessness. This kind of problem rooted in a fundamental disposition or attunement which conditions how we see the world. In being attuned by boredom, the world and we exist under its dull atmosphere. In a mood, we are not bored specifically with things in the world; our boredom is more generalised and towards the whole world. It is not necessarily that we are bored with a specific task, with boredom highlighting our negative learning progress, or existence outside the Goldilocks zone. Rather, we come to the world in boredom, which colours the entire action and engagement landscape relationally; under the dull-atmospheric mood.

This phenomenological insight is concordant with the predictive story, which suggests our view of the world is conditioned deeply by our priors – the evidence and experiences we have accrued. Our moods reflect how, as an organism, we are faring in our prediction error minimising pursuit, averaging our learning progress over time, compared with our predicted progress. The mood in which we come to the world partly determines the kinds of predictions we have for that world, and the appeal of pursuing particular action-policies. In this way they position the agent's predictions and particularly the precision placed on those predictions.

6 Concluding remarks

In reconciling the philosophical and psychological conceptions of boredom, I have appealed to predictive processing and, in particular, active inference. Active inference can be read as a process theory for predictive processing that foregrounds the enactive engagement with the sensed world. In naturalising (the phenomenology of) boredom, I have carefully navigated through different kinds of active inference; namely, interoceptive inference; (e.g. Barrett et al., 2016; Seth & Friston, 2016), emotional inference (e.g. Barrett, 2014; Smith et al., 2019) and affective inference (Clark et al., 2018; Hesp et al., 2021). It may be worth clarifying the distinctions between these kinds of inference and how they relate to valence, emotions, mood and affect.

In brief, active inference in the interoceptive domain leads to interoceptive inference, with a special focus on making sense of interoceptive signals and their predictions, where allostatic predictions provide homeostatic setpoints for autonomic reflexes. Interoception can therefore be regarded as a domain specific component of active inference that provides important sources of evidence for the predictive agent. In contrast, emotional inference does not commit exclusively to interoceptive sources of evidence but assimilates evidence for various emotional states that, in turn, furnish top-down predictions (i.e. empirical priors) for subordinate hierarchical (planning as) inference (e.g. Attias, 2003; Botvinick & Toussaint, 2012). Emotional inference of this sort may contextualise the belief updating that underwrites affective inference; namely, beliefs—not about states of affairs—but the action policies that are likely to be pursued. At a coarse-grained level of analysis, uncertainty or loss of (subpersonal) confidence about 'what to do next' is generally associated with negative valence and affect; whereas a precise belief about the requisite course of action has a positive valence. In short, affective inference is a more specific aspect of planning that speaks directly to the precision of (subpersonal) beliefs about action. In this setting, emotions and affect may be linked to the precision of beliefs over policies, whereas mood is a longer-term feature of affective inference that may involve hyperpriors over precision.[12]

This rich inference schema explains both views of boredom promoted in psychology and existential phenomenology, particularly, as both an emotion and mood. The predictive processing synthesis of these perspectives builds on the contemporary functional understanding of boredom (e.g. Danckert & Elpidorou, 2023; Elpidorou, 2022). In fact, predictive processing is perhaps the best way to progress this functional account. Predictive processing specifies boredom's function in terms of prediction-error-minimisation, which casts the Goldilocks regime as a necessary aspect of (approximate Bayesian) optimal inference. In the process, it unifies various features and definitions of boredom, like its "call to action" (Danckert & Elpidorou, 2023), relation to attention (e.g. Eastwood et al., 2012), and conceptualisation as both emotion and mood. Though, as the existential treatment of boredom stresses, a bored mood fundamentally affects how one experiences the world – limiting the (affective) allure of particular action policies. This accords with predictive processing, which suggests attunements (or 'moods') are a kind of hyperprior that tunes an agent's predictive machinery, specifically in terms of precision. Reconciling these disparate conceptualisations, functions and 'problems' of boredom is a difficult task. I have argued predictive processing offers an embracing synthesis that affords significant explanatory potential along these various dimensions.

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[12] I am appreciative for an anonymous reviewer who differentiated the kinds of active and affective inference highlighted here.

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