“The somatic roots of affect: Towards a body-centered education”

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Author: Ignacio Cea[1,2,3], PhD. (igneocj@gmail.com)
(Orcid: 0000-0002-7322-1977)

1. *Center for Research, Creation and Innovation, & Faculty of Philosophy and Religious Sciences, Universidad Católica de Temuco, Chile.*
2. *Center for Social and Cognitive Neuroscience, School of Psychology – Adolfo Ibanez University* Diagonal las Torres 2640, Peñalolén, Edificio C, Santiago de Chile
3. *Universidad Alberto Hurtado. Faculty of Philosophy and Humanities. Philosophy Department.* Alameda 1869, 4º piso, Santiago, Santiago de Chile

Abstract

The deep influence of affectivity on learning is now widely acknowledged (Hargreaves et al., 2010; Keefer et al., 2018; Sánchez-Álvarez et al., 2020; Shafait et al., 2021). For instance, it has been shown that affect influences key learning-relevant processes such as motivation, perception, behavior and critical thinking (Izard, 2002; Mayer & Salovey, 1997). Evidence also shows that emotion and mood strongly influence attention, which in turn drives learning and memory (Elbertson et al., 2010; Elias et al., 1997). Intersubjective phenomena such as degree of affection and respect between child and teacher also affects the child’s learning processes, academic outcomes and brain development (Kusché & Greenberg, 2006; A. M. Ryan & Patrick, 2001). However, the relevant literature is not paying attention to increasing evidence showing that affective phenomena are rooted in interoceptive and homeostatic self and co-regulatory processes within and between people’s living bodies (Barrett, 2017; Carvalho & Damasio, 2021; Craig, 2015, 2018; Fotopoulou et al., 2022; Fotopoulou & Tsakiris, 2017; A. K. Seth & Friston, 2016). In this theoretical chapter, we explore this connection and its importance for learning. We argue that since 1) affective experience plays a fundamental role in learning; and 2) affective experience is rooted in the homeostatic self/co-regulation of living bodies; therefore, 3) the homeostatic self/co-regulation of living bodies plays a fundamental role in learning. In other words, there is an intra and interpersonal somatic dimension of learning that demands explicit consideration in educational contexts. In this way, we aim to contribute to an understanding of learning and education that moves away from an individualistic, brain-centered information-processing conception, towards one centered on sentient, interdependent living bodies.

Keywords: interoception, homeostasis, affective consciousness, learning, emotions

1. Introduction

In educational contexts, learning is traditionally depicted as an eminently cognitive phenomenon, and as such, as essentially involving information-processing of cognitive representations in the brain, aimed at storing newly acquired information in long-term memory. For instance, in the APA dictionary of psychology, it is stated that

> Learning involves consciously or nonconsciously attending to relevant aspects of incoming information, mentally organizing the information into a coherent cognitive representation, and integrating it with relevant existing knowledge activated from long-term memory. (VandenBos, 2015, p. 594)

While we think that it is undeniable that learning involves a wide spectrum of sophisticated cognitive capacities, in this chapter we argue that cognition does not work alone, it is fundamentally shaped and influenced by the affective states of both the individual and the group, which in turn, are rooted in the interoceptively felt regulation and co-regulation of homeostasis in and between bodies, in the context of the social and physical conditions of the environment, under the imperative of life preservation and flourishing.

More specifically, throughout this chapter, we develop the following argument:

1 – Affective experience plays a fundamental role in learning

2 – Affective experience is rooted in the homeostatic self/co-regulation of living bodies

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Therefore,

3 - Homeostatic self/co-regulation in and between living bodies plays a fundamental role in learning.[1]

Hence, if we want to achieve a more complete and profound comprehension of learning and enhance teaching-learning practices, then we need to pay far more attention to the continuous self/co-regulation of life within and between learners' bodies; moving away

[1] Note for philosophers: the argument assumes that if X is grounded (rooted) in Y, then if X plays a fundamental role in Z, then Y does too.

from the traditional brain-centered information-processing conception, and towards one in which the sentient, living bodies of students are center-stage.

We are going to proceed as follows. In section 2 we will review and discuss empirical data showing the many and multifaceted ways in which affective experience affects the learning process and plays a crucial role in it, thus supporting premise 1 of our main argument. Then, in section 3, we will present and analyze theoretical and empirical findings showing the bodily, life-regulatory grounds of affective states in and between individuals, thus supporting premise 2 of our main argument. In the final section we restate the main conclusion of our argument, namely that bodily self/co-regulation must be acknowledged as a core dimension of learning in educational contexts. We end up emphasizing the philosophical implications of this, pointing towards the need of a radical reconceptualization of cognition and learning, and a new understanding of the human person that learns.

2. Affective experience plays a fundamental role in learning

Research has shown that affect profoundly shapes the learning process. This has been studied both at the more general level concerning how affective states influence the overall learning process and its outcomes, and at more fine-grained levels in which affectivity has been found to dramatically influence different processes that are integral to learning, namely perception, attention, memory and motivation. In this section, we first introduce what we understand by "affect" (section 2.1), then discuss its impact on learning at a general level (section 2.2), and with respect to perception (section 2.3), attention (section 2.4), memory (section 2.5) and motivation (section 2.6).

2.1 Introducing affect

In everyday usage, "affect" simply means something like "to change", "to impact", "to make a difference", etc. Now, when it comes to *psychological affect,* which is our topic, we are talking about a special kind of change or impact, notably an experiential impact involving changes in both the body and the mind (Barrett & Bliss-Moreau, 2009; Colombetti, 2013). As eloquently expressed by philosopher Giovanna Colombetti,

> "Affectivity" refers to the capacity or possibility to be "done something," to be "struck" or "influenced"… This influence is not merely physical or mechanical (as when one says that the daily amount of sunlight affects the air temperature) but psychological. It refers to the capacity to be personally affected, to be "touched" in a meaningful way by what is affecting one" (Colombetti 2013, pp. 1-2)

There is a wide spectrum of affective states. The most common focus of scientific research are emotions and moods. Nonetheless, affective experience goes beyond these categories, also including, among others, a fundamental "*feeling of being alive*" (Cea & Martínez-Pernía, 2023; Damasio, 1994; Fuchs, 2012; Seth, 2021), *existential feelings* (Ratcliffe, 2008), and *affective atmospheres* (Fuchs, 2013). Now, given the fact that emotions and moods have been far more studied than these other categories, including their intimate relation to learning and their somatic bases, they will also be the affective experiences that will more often occupy our attention throughout this chapter.

Now, a very useful and influential construct that illuminates the most basic aspects of both moods and emotions is *core affect* (Russell, 1980, 2003; Russell & Barrett, 1999; Yik et al., 2011). It designates an elementary building block of all affective life that moreover, seems to be present in every conscious state. It is constituted by a dimension of *hedonic valence* (i.e. feels more or less "good"/pleasant or "bad"/unpleasant), and a dimension of *arousal/activation* (i.e. some degree of felt energization/activation or de-energization/deactivation). More specifically, core affect is defined as "a neurophysiological state that is consciously accessible as a simple, nonreflective feeling that is an integral blend of hedonic (pleasure–displeasure) and arousal (sleepy–activated) values" (Russell, 2003, p. 147).

Core affect would be at the heart of all the background feelings that incessantly accompany us in our everyday life, even if we do not pay explicit attention to them or are not experiencing any particularly intense emotional episode. For instance, a person having a background feeling of excitement or enthusiasm would be in a pleasant and aroused state, while an individual feeling sad or tired will in the opposite spectrum: an unpleasant and deactivated state. A feeling of serenity or calmness, on the other hand, would be the integral blend of pleasantness and deactivation. Several examples of everyday background feelings as core affective states are shown in Figure 1.

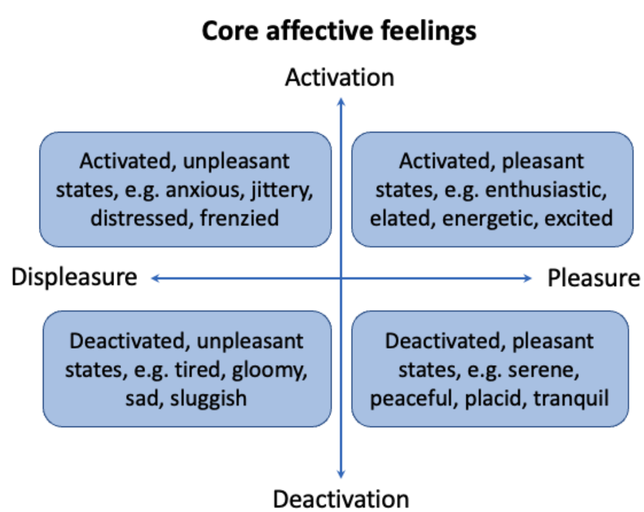

Figure 1. Examples of common background feelings as core affective states constituted by activation and hedonic values. Adapted from (Yik et al., 2011).

The arousal and hedonic dimensions of core affective states are not mere decoration. According to the *affective information principle,* "*affective feelings are conscious registrations of unconscious appraisals of something as good or bad in some way"* (G. Clore & Schiller, 2018, p. 533). In particular, the hedonic dimension of core affect would embody a valuation of current circumstances as either beneficial or damaging, while the arousal dimension would embody urgency information (Clore and Schiller 2018), which is consistent with arousing events being more prone to attract attention, be prioritized (Simon, 1967) and remembered (Cahill & McGaugh, 1998). Also, based on the physiological and experiential aspects of both the valence and arousal dimensions, it has been recently hypothesized that core affect is *intrinsically motivational*: highly activated states tend to energize the subject to act*,* either to prolong a current pleasant state (e.g. elation, enthusiasm) or to change it if it is unpleasant (e.g. anxiety, jittery); while deactivated states dispose the person to remain inactive, either to prolong it if it is pleasant (e.g. relaxation, serenity), or to change if unpleasant (e.g. tiredness, gloomy) (Cea & Martínez-Pernía, 2023).

According to Russell and Barrett, moods can be understood basically as identical to core affects extended through time (hours or days), while emotions may be regarded as more complex psycho-physiological processes in which core affects are attributed to a perceived event (Russell 2003), or contextually conceptualized according to socially contingent emotion categories (Barrett, 2017). Evidently, their *constructivist* approach to emotions differs substantially from the *basic emotion theory* approach that has been championed by renowned psychologists such as Ekman (1984, 1999) and Izard (1992), who claim that there are a number of "basic", not psychologically-constructed, universally shared emotions (e.g. fear, sadness, happiness, disgust, etc.). These "basic" emotions are claimed to be *discrete*, i.e. constituted by a clearly distinguishable pattern of psychological, physiological and neurobiological components that differentiate one emotion from another; *elemental*, i.e. being the constituents of other more complex emotional experiences; and *evolutionary basic,* as they are thought to have evolved as dedicated mechanisms to deal with specific tasks and circumstances (e.g. lost in the case of sadness, threat in the case of fear, etc.) (Ekman 1999). Having presented these competing approaches, it is important to clarify that throughout this chapter we are not going to favor one approach or the other. We present these different perspectives just to have a glimpse of the complexities involved in affective research and to offer a general introduction to key concepts such as affect, emotions and moods.

Having introduced central elements of affectivity, in the following subsection we are going to present a large body of evidence showing the many ways in which affective states such as emotions and moods impact the learning process and its outcomes at a general level, both individually and collectively. Then in later sections, we will discuss the pervading influence of affect on specific psychological capacities that are integral to the overall learning process (i.e. perception, attention, memory and motivation).

2.2. Influence of affect on learning at a general level.

Affect influences learning in many different ways. To start, when students learn to do a task, they also learn whether or not they enjoy doing it (Zajonc, 1980). There is also what researchers call *hot cognition*, in which thoughts and memories become emotionally charged as learners pay attention to new information (Ormrod et al., 2019). For instance, when a student hears that a new discovery in medical research holds the potential of radically improving the health conditions of cancer patients and feels very excited about it; or when a student feels very sad when hearing news about unjust and impoverished living conditions in some countries, she will more likely pay attention to it, remain thinking about it for a long period and continuously elaborate on it, compared to more emotionally neutral new information (Bower, 1994; Manns & Bass, 2016). Additionally, over the long run, learners will more easily recall emotionally-loaded information than neutral contents (LaBar & Phelps, 1998; Phelps & Sharot, 2008). This research is nicely summarized by Bracket (2019), when he writes that

> Children learn what they care about. They're no different from adults in that regard… depending on our emotional state, our chemical and hormonal profiles change dramatically and our brains function differently. The three most important aspects of learning—attention, focus, and memory—are all controlled by our emotions, not by cognition. (p. 431)

This is closely related to the fact that, according to many authors, the affective dimension of the learning experience, i.e. the feelings triggered or accompanying the perception of, and elaboration on new information, become an integral aspect of the contents and skills learned (Bower & Forgas, 2001; Minsky, 2007). Of course, this could either facilitate or hinder new knowledge, given that the affects involved could vary in their hedonic valence (pleasant-unpleasant dimension) and hence in the value and attractiveness of the new knowledge. For instance, the pleasure and satisfaction accompanying successfully solving mathematical problems, both positively color the contents and abilities being acquired and motivate further engagement with the activity. Indeed, students who are in a positive mood are more likely to think creatively and meaningfully learn a topic (Ormrod et al., 2019). In contrast, the feelings of anxiety and frustration associated with not being able to go successfully through some mathematical exercises will likely impregnate these contents and skills with negative value and aversion, i.e. the topic will be disliked (Carver & Scheier, 1990; Goetz et al., 2008). Additionally, people in bad moods (feeling sad, frustrated or bored) are more likely to absorb new contents in inflexible and superficial ways (Ahmed et al., 2013; Efklides, 2011). Furthermore, especial attention should be paid to the early emotional experiences of young children at school, because an association of going to school and negative emotions can hamper future academic achievement (Hernández et al., 2018).

This is substantiated by neuroscientific research showing that in strong negative feelings like high anxiety, fear or hopelessness our brains secrete cortisol, the stress hormone, which, along with a myriad of parallel neurobiological and physiological processes related to our fight-or-flight response, is associated with inhibition of the prefrontal cortex and the consequent impairment of the learning process (Bracket 2019).

Nonetheless, it is important to differentiate between *facilitating* and *debilitating* anxiety. The former puts learners in the position of facing *challenges* that can be successfully overcome, corresponding to low levels of anxiety that motivate learners to look into the details, anticipate potential problems, do homework, study for tests, etc. In contrast, in *debilitating anxiety* learners are confronted to what they feel as *threats.* This corresponds to high and continuous levels of anxiety and stress that impede successful performance, impair attention, de-energize motivation and in general, undermine the overall learning process (Ormrod et al., 2019).

So, although strong and recurrent feelings of anxiety are mostly detrimental to learning, low and momentary levels can be an allied. What is the case for anxiety also applies to emotions and moods more generally, they serve distinct learning purposes. For instance, some amount of pessimism or seriousness can be beneficial with regard to analytical, quantitative and detailed tasks compared to a more positive frame of mind, which will likely be better for creative and heuristic thinking (G. Clore & Schiller, 2018).

Evidently, all this shows the primordial importance of developing emotional skills that can allow students to regulate their feelings in the learning process, for instance, managing emotions of frustration and helplessness so that they may persevere in their attempts to learn, even in challenging situations (Brackett, 2019; Brackett et al., 2018). In fact, empirical studies have shown that some degree of emotional intelligence, i.e. knowing how to recognize, use, understand and regulate affective states such as moods and emotions (Mayer & Salovey, 1997), is mandatory for developing and successfully implementing the cognitive skills that have historically been at the center of traditional education (Brendtro et al., 1990; Elias et al., 1997). For instance, high school students' abilities to manage their emotions are the best predictor of their academic success (di Fabio & Palazzeschi, 2009); existing a robust effect of emotional intelligence on academic performance (Sánchez-Álvarez et al., 2020). In general, research has consistently shown that implementing evidence-based social-emotional learning programs (SEL) in schools is strongly linked to enhanced academic success (Durlak et al., 2011).

Importantly, affectivity is a key aspect of learning not only individually, but also collectively, intersubjectively. This is beautifully expressed by Brooks (2019), when he states that "children learn from people they love… love in this context means willing the good of another, and offering active care for the whole person" (Brooks, 2019). We must not forget that learning often occurs in the context of interpersonal relationships; between students, and amid students and teachers. Research consistently shows the importance in the classroom of what, following Fuchs' terminology, may be called the *interpersonal affective* *atmosphere* (Fuchs, 2013). For instance, as long as the respect, communication and bond between teachers and learners is improved, the brain development, attention and learning of the students will be enhanced (Kusché & Greenberg, 2006). Also, supportive, respectful and warm interactions between students and teachers is associated with academic engagement and motivation (Ryan & Patrick, 2001). Also, when students feel a positive sense of belonging at school and learn in educational climates characterized by positive relationships, they do better academically (Osterman, 2000). Additionally, the level of trust that students feel towards their teachers is associated with enhanced learning outcomes (Shafait et al., 2021).

In sum, affective states such as emotions, moods and interpersonal atmospheres are of paramount importance to the learning experience and its outcomes. That is why, concerning academic achievement but also personal and collective well-being, affective skills (i.e. emotional intelligence) are as important as the more traditional cognitive ones. In the following subsections, we are going to deepen into the pervading influence of affect on learning processes, by briefly reviewing and discussing the empirical evidence of the impact of affect on specific psychological capacities that are integral to learning: perception, attention, memory and motivation.

2.3. Affect shapes perception

Perception is our window to the world around us, and is closely tight to learning. Learning from experience is a paradigmatic form of learning, perception is typically a fundamental ingredient of those experiences. Both in more active, learning-by-doing contexts, and in the more traditional, passive setting, as well as in everyday life, the information gathered by the senses is one of the main ingredients of the contents and skills that one learns.

Now, one may think that affective states like emotions are just occasional reactions to events (e.g. a house on fire), previously perceived solely in virtue of their sensory characteristics (e.g. colors, shapes, spatial location), and maybe also of the concepts (e.g. "house", "fire") employed to configure those sensory qualities into coherent percepts. However, a prominent line of research in the affective sciences strongly suggests that this is not the case, and that in contrast, all that we perceive is already tinged with affect, i.e. that *our moods and emotions to a great extent determine what we perceive and how we perceive it* (Barrett, 2017; Barrett & Bar, 2009; Cea & Martínez-Pernía, 2023; Fuchs, 2013; Ratcliffe, 2008; Zajonc, 1980). Late social psychologist Robert Zajonc expressed this idea eloquently:

> Perhaps all perceptions contain some affect. We do not just see "a house": we see "a handsome house," "an ugly house," or "a pretentious house." We do not just read an article. . . We read an "exciting" . . . "important" . . . or a "trivial" article. . . And the same goes for a sunset, a lightning flash, a flower, a dimple, a hangnail, a cockroach, the taste of quinine, . . . the color of earth in Umbria, the sound of traffic on 42nd Street, and . . . the sight of the letter Q. (Zajonc 1980, p. 154)

Zajonc is emphasizing that all we perceive is colored through the glasses of our current affect, which, broadly speaking, *qualifies* the object of perception in terms of the relevance and value it has in relation to ourselves in the present moment (e.g. an exciting, important or otherwise trivial article). This is related to the aforementioned *affective information principle* (section 2.1), according to which affective feelings embody both value and urgency information regarding the object of perception (Clore and Schiller, 2018). It is close to what Barrett (2017) calls *affective realism,* which refers to our tendency to perceive as properties of the world what really are affective qualities of our own experience. In other words, things are not intrinsically good or bad, urgent or insignificant, but we perceive them as such in virtue of our present affect.

There are many experimental demonstrations of this effect. Manipulating people's affective states, scientists can influence whether a drink is perceived as appetizing or distasteful (Berridge & Winkielman, 2003), if people are perceived as nice or mean (Li et al., 2007), and whether a painting is seen as beautiful or ugly (Clore & Storbeck, 2006). Also, job applicants are rated more negatively in rainy compared to sunny days (because of the influence of weather on mood), and, more tragically, a journalist with a camera can be seen as a terrorist with a gun by a highly aroused, stressed and frighten cop or soldier (Barrett 2017). Manipulating people's affect also makes a difference on whether a stranger is perceived as reliable, capable, attractive or nice, and even how the person's face is perceived (Anderson et al., 2012). A main neurobiological substrate for this pervading influence of our affective state on what (and how) we perceive would be the Orbitofrontal cortex (OFC), which, during object perception, is continuously integrating sensory signals from the world with affective information from the body, ensuring that no percept is devoid of affective significance (Barrett and Bar, 2009). The dramatic influence of affect on perception is nicely illustrated by psychologist-neuroscientist Lisa F. Barrett when she states that "you might think that in everyday life, the things you see and hear influence what you feel, but it's mostly the other way around: that what you feel alters your sight and hearing" (Barrett 2017, p. 79)

2.4 Affect directs attention

Both the world around us and inside our bodies provide much more information than we could possibly manage. That is why nature has given us attention, a powerful capacity to filter that otherwise overwhelming amount of stimulation, separating what will be further processed from what will be omitted (Hillyard et al., 1998). Attention is of paramount relevance for learning, given that on many models, attention determines the information that can be temporally stored in working memory, which is a prerequisite for new contents to reach a more permanent, stable place in long-term memory (Ormrod et al., 2019). Recent research has evidenced various ways in which affectivity has a notorious impact on this remarkable cognitive capacity.

First, there is converging evidence that the hedonic valence of moods and emotions is systematically associated with different forms of attention. More specifically, positively valenced feelings (e.g. being in a happy mood) lead to broad attention and global focus (Basso et al., 1996; Fredrickson & Branigan, 2005), while unpleasant states more likely conduce to a narrow focus of attention (Bar-Haim et al., 2007; M. Brackett, 2019). So, pleasant feelings tend to facilitate a broad style of attention in which people can more easily perceive or think about the "big picture", namely more global aspects of a situation or topic; while more unpleasant states such as seriousness or certain amount of anxiety or pessimism facilitate concentration on the details of a situation or idea. Hence, broadly speaking, more grave or unsmiling frames of mind seem to facilitate analysis, while more light or positive feelings promote a more holistic, synthetic view[2].

Second, research shows that stimuli that are emotionally charged preferentially captures attention, compared to neutral stimuli (Hajcak et al., 2018). A prominent concept in this line of research is *motivated attention,* which refers to the mostly reflexive engagement of attention with motivational imperatives related to survival such as reproductive opportunities, danger or food, but also other stimuli charged with emotional significance (Lang et al., 1997). For instance, various studies have shown that hunger, compared to satiety, significantly increases attention to food-related stimuli (Mogg et al., 1998) and hampers shifting attention away from them (Piech et al., 2009).

Recently, various experimental paradigms have been used to study how and why attention is preferentially directed to stimuli that is emotionally charged. One line of research focusses on how, compared to neutral stimuli, visual-spatial attention is preferentially allocated to emotional contents (MacNamara et al., 2013). Examples are studies in which participants have to perform visual search tasks: they are asked to find a target stimulus amid a background of distractors. Results consistently show that subjects locate the target faster if it is emotionally-loaded (e.g. a fear-inducing or erotic image), compared to a neutral target. Conversely, if the distractors are emotional, but not the target, the task is accomplished slower (Öhman et al., 2001). Other studies using eye tracking have obtained similar results: when simultaneously exposed to both neutral and emotional stimuli, people tend to fixate first on the latter (Calvo & Lang, 2004). In sum, a robust body of research shows that attention is preferentially and rapidly directed towards contents that are emotionally-charged (Brosch et al., 2011; Ikeda et al., 2013). Moreover, studies have also evidenced that this can subsequently result in a kind of perceptual interference, in which attentional resources remain trapped, so to speak, to the emotional stimulus, such that a neutral stimulus presented shortly after the emotional one is frequently not seen (Wang et al., 2012). This tendency to sustain attention towards emotional contents has been linked

[2] It is important to notice that some evidence suggests that this effect is in reality the result of positive affect being like a "go" signal that simply allows the default, more global mode attention to operate, while negative affect acts as a "stop" signal that reverse the default tendency, therefore facilitating a narrower attentional style. Thus, although it is not the common tendency, it is perfectly possible to have a more analytical frame of mind in positive mood and a more global view in negative mood (Clore and Schiller, 2018).

to the late positive potential (LPP), which is an event-related potential (ERP) detected at parietal electrode sites, and which is enhanced when a subject sees an emotional image, reads an emotional word or even after presented with emotional hand gestures (Hajcak et al., 2018). The LPP begins almost immediately after the emotional stimulus is presented and lasts even up to various seconds after stimulus offset, which presumably reflects the sustained allocation of attentional resources to emotional contents (Hajcak et al., 2018).

2.5 Affect impacts memory

Memory is fundamental for learning. Indeed, it is so important that in many contexts, learning is virtually equated with storing information in long-term memory, and memorization is often understood as an important task to achieve learning. However, it is plain that this picture oversimplifies the learning process, which is most effective not in the case of *rote learning* (trying to memorize without understanding), but in the case of *meaningful learning*, in which the student comprehends and integrates the new pieces of information into coherent wholes that are meaningfully related to previous knowledge (Ormrod et al., 2019). Nonetheless, even in this more complex picture of learning, memory is still fundamental. Arguably, even if learning comprises many capacities and distinct processes such as perception and attention, there could not be learning without memory. Hence, the impact of affect on memory is certainly of great importance for learning (Brackett, 2019).

More than a hundred years ago, William James stated that “an experience may be so exciting emotionally as almost to leave a scar upon the cerebral tissues” (James, 1890, p. 670). Current empirical research has confirmed and deepen James’ insight. To start, evidence shows that in the long run, students generally retrieve emotional material more easily than they remember non-emotional information (LaBar & Phelps, 1998; Phelps & Sharot, 2008). In the classroom, the emotional experience of learners turns into an integral aspect of their long-term network of associations (Immordino-Yang & Gotlieb, 2017).

Although *all* the details of both emotional and non-emotional experiences are not remembered accurately over time, memories charged with affective *arousal* are retrieved with more *vividness* than non-affective ones (Rubin & Kozin, 1984; Schaefer & Philippot, 2005); and with s*elective memory benefits*, i.e. more accuracy for some aspects of the emotional event (Kensinger & Schacter, 2018). Importantly, the vividness with which individuals remember arousing emotional experiences is associated with the *autonoetic consciousness* that according to Tulving (1985), defines episodic memory, i.e. the capacity for mentally traveling to the past and experiencing oneself as the subject of an earlier episode. In other words, the emotional significance of an event may be a fundamental and constitutive element of any episodic memory, whether we regard it as explicitly emotional or not. Concerning the details that are more prone to be remembered accurately, debates are still ongoing, but plausible candidates are those features of the emotional event that are more integral to it, those that are relevant for the goals of the subject, and those that captured more attentional resources (Levine & Edelstein, 2010).

Concerning the underlying neurobiological substrates for the impact of affective arousal on subjective vividness and selective memory benefits, evidence points to the amygdala as an essential component. For instance, larger amygdala activity during an arousing event is associated with greater likelihood that subjects will report vividly remembering that event (Mickley & Kensinger, 2008); and correlates positively with the subjective ratings of the vividness of the recollection (Kensinger et al., 2011). This is related to findings showing that amygdala activity in the retrieval phase is associated with greater feelings of reexperiencing the emotional event (Sharot et al., 2004). However, the amygdala alone is not able to ensure all these effects on memory, but works tied to noradrenaline release, probably because in the absence of noradrenaline, amygdala activity is unable to modulate the hippocampus, a key neural structure for long-term memory (Segal et al., 2012). Hence, bidirectional interactions between the amygdala and hippocampus are thought to be critical for the effects of emotional arousal on memory (McGaugh, 2013).

Concerning the effect of hedonic valence on memory, current research has delivered mixed findings. On some laboratory settings, when people are asked to retrieve pictorial or verbal stimuli, items associated with negative valence are more likely to be remembered than positive ones (Keightley et al., 2011). In contrast, in cases of self-referential or autobiographical tasks, the opposite happens: people tend to recall positive memories (Argembeau et al., 2005). Nonetheless, according to Kensinger and Schacter (2018), these and other seemingly conflicting findings may be explained by the hypothesis that memory has evolved to store the affective information most relevant to the subject's goals (Lazarus, 1991), and in the case of the self-referential processes positive information is typically more easily integrated (Matlin & Stang, 1978).

Now, in concordance with the evidence we reviewed in section 2.3 (affect and attention), negative moods are associated with the capacity to remember more detailed information than positive moods, probably due to the different styles of attention that they promote (Kensinger and Schacter, 2018). Recall that positive affect tends to facilitate a broader attentional focus, while negative affect promotes a narrow one. Hence, it is plausible that the impact of affective valence on attention has a subsequent influence on how new information is stored, given that attention works as a filter that separates what will go through further memory processes and what will not (Ormrod et al., 2019). Finally, there is also some evidence that different regions within the hippocampus are differentially activated depending on whether the episodes retrieved are positive or negative (Ford et al., 2014).

2.6 Affect and motivation

A basic condition that is needed for someone to engage in any learning activity is having the will, interest or motivation to do so. There is no meaningful learning of any content or skill if the student does not want to learn or even pay attention to the teacher, that is, if the learner is not motivated to engage in the learning process. Moreover, there is a distinction between *intrinsic* and *extrinsic* motivation. While both are related to an impetus to behave with certain purpose or direction, in extrinsic motivation the individual seeks an external reward (a high grade in a test or a present), while in intrinsic motivation the willingness to behave in certain way comes from the pleasure or interest in the activity itself (Ryan & Deci, 2017). Very importantly, it is intrinsic motivation which is mostly associated with enhanced satisfaction upon achievement, well-being, better academic outcomes and learning, compared to extrinsic motivation (Deci & Ryan, 2000).

Crucially, nature has equipped us with strong motivators: our emotions (Barrett, 2017; Brackett, 2019; Damasio, 1999; Panksepp, 1998). All emotions have a motivational component which is related to a particular focus of interest during an emotional episode. As psychologist Mark Brackett writes: “emotions determine what you care about in the moment” (Brackett, 2019, p. 64). For instance, fear motivates an individual to scape or avoid a perceived threat; anger promotes taking action in order to rectify a situation perceived as unjust, wrong or potentially harming; while happiness motivates engagement with pleasant activities like hobbies or spending time with loved ones (Barrett, 2017). From this follows that students who feel afraid or highly anxious and stressed regarding certain academic topic will be emotionally motivated to escape from it, which of course, will act as an obstacle for learning. On the other hand, certain degrees of anger sometimes help people achieve their goals (Mellers & McGraw, 2001). This is related to evidence suggesting that anger shares many aspects with *determination*, especially their *approach motivation* (Harmon-Jones & Harmon-Jones, 2018), which could facilitate that the learner faces and tries to overcome what hinders her achievement. Happiness, of course, facilitates engagement with pleasant activities. Hence, if students feel happy and enjoy the learning activities, further commitment and engagement is emotionally boosted.

In general, people are intrinsically motivated to learn something when they find it *interesting* (Ormrod et al., 2019). Importantly, interest is not solely a “cold” mental state characterized by cognitive arousal and a disposition to engage with a given topic, but is characteristically experienced along with feelings of excitement and enjoyment (Ainley & Ainley, 2011). Moreover, research (and everyday experience) shows that interest promotes spending more attention, time and becoming more cognitively engaged with a given topic (Barron, 2006). These results are probably related to the phenomenon of *motivated attention* that we reviewed in section 2.2, in which motivational imperatives capture attention and subsequent processing (Lang et al., 1997). Additionally, when learners are interested on a content, they learn it more meaningfully (Schraw & Lehman, 2001); and their academic achievement is boosted as well as their capacity to remember it in the long run (Jansen et al., 2016).

The large implications of interest as an intrinsic motivator for learning are related to the general rule according to which people tend to seek and engage in activities that cause pleasant feelings such as joy, satisfaction or achievement, even when confronted with adversity. For instance, when students enjoy what they are doing, they are more willing and efficient at solving difficult tasks, and their successful efforts often lead to excitement and pride (Shernoff & Csikszentmihalyi, 2009). On the contrary, students who feel bored will try to avoid the situation (falling asleep) or bring about an alternative source of stimulation (playing in the cellphone). Moreover, boredom and lack of achievement conform a vicious cycle, in which feeling bored leads to lowered achievement, which in turn, brings more boredom (Pekrun et al., 2014). The difference that emotion and motivation makes to learning is nicely expressed by Brackett (2019) when he writes that "linking emotion to learning ensures that students find classroom instruction relevant. It's what supports students in discovering their purpose and passion, it's what drives their persistence" (p. 70).

In sum, we have seen how recent empirical research converges to the conclusion that the affective state of an individual and also the interpersonal affective atmosphere of a group have strong and diverse effects on learning, as evidenced by the influence of affectivity on learning both at a general level, and by shaping crucial psychological processes that support and are integral to the overall learning process: perception, attention, memory and motivation. Having stablished the many ways in which affectivity shapes learning, we turn now to the somatic roots of affect.

3. Affective experience is rooted in the homeostatic self/co-regulation of living bodies

Affective states like emotions and moods defy the traditional sharp distinction between mind and body. They are eminently psycho-physiological or psychosomatic phenomena involving a complex interplay between cognitive, neural, physiological, social and conscious processes, comprising the body as a whole and its fundamental imperative to stay alive and well in relation to its physical and social environment (Barrett, 2017; Colombetti, 2013; Damasio, 2021; Fuchs, 2018; Seth, 2021). In this section, we are going to deepen into the bodily nature of affective states, through the examination of the crucial connection between affectivity, interoception and homeostatic regulation within and between the living bodies of people experiencing affect. We first introduce the key interrelated notions of interoception and homeostasis (section 3.1), then the probable homeostatic role of affective experience (section 3.2), the interoceptive and homeostatic foundations of affect (section 3.3) and finally the social dimension of interoception, homeostasis and affect (section 3.4).

3.1 Interoception and Body Homeostasis

Although Sherrington (1900) classified interoception as the sensory information coming strictly from the viscera, on a very influential paper Craig (2002) claimed that recent empirical evidence about the functional anatomy of the lamina I spinothalamocortical system, points strongly towards the need for a redefinition of interoception as involving sensory signals coming from the whole body, not just the viscera. He defines interoception as the *sense of the physiological condition of the body*, that includes feeling our body temperature, pains, tickles, itches, muscular and visceral sensations, thirst, hunger and other feelings related to critical aspects of our inner homeostatic balance(Craig, 2002, 2009, 2015). In the same vein, Cameron (2001) adds that understanding interoception as encompassing all afferent signals arising from the body, is essential to understand the mind-body relationship, especially why affective states are psychosomatic hybrids. A concordant but subtly different definition of interoception is given recently by Chen and colleagues (2021), who write that interoception "refers to the representation of the internal world, and includes the processes by which an organism senses, interprets, integrates, and regulates signals from within itself" (Chen et al., 2021, p. 3). These signals and their associated sensations and feeling are commonly classified as cardio-respiratory, gastrointestinal and urogenital, but following Craig's redefinition, also as thermosensory, nociceptive, tactile and other signals arising from widely distributed chemoreceptors and ergoreceptors, i.e. sensory fibers in muscles that signal energy use or workload (Craig 2015).

Interoception and its intimate connection to the maintenance of organismic homeostasis can be traced at least since the early twentieth century. Both interoception and homeostasis are related to what Bernard called the *milieu interieur* (internal environment) in the middle of the nineteenth century (Cameron, 2000). That concept pointed to the existence of a specific set of physiological parameters representing the normal internal condition of the organism required to remain alive and healthy. Years later, Cannon coined the term "homeostasis" to denote the physiological regulatory process aimed at preserving or restoring the state of equilibrium in which these vital parameters are within viable bounds regarding the continuity of life in the organism (Cannon, 1915). These vital parameters include levels of glucose, salt, water, oxygen, carbon dioxide, blood pressure, temperature, energy, metabolic rate, among many others (Craig 2015).

Neuroanatomically, the interceptive system is "a homeostatic afferent pathway… (which provides) the long-missing afferent complement of the efferent autonomic nervous system" (Craig 2002, p. 655). More specifically, small-diameter sensory fibers that innervate all tissues and organs in the body signal to lamina I neurons in the spine, constituting an interoceptive pathway that complements the sympathetic division of the autonomic nervous system. Another set of small-diameter sensory neurons innervating the interior of the body, in turn, convey their signals to the vagus and other parasympathetic cranial nerves and then to the nucleus of the solitary tract (NTS) in the medulla oblongata within the brainstem; serving as the sensory complement of the parasympathetic autonomic system. Both parasympathetic and sympathetic interoceptive pathways, project then to all homeostatic regions in the brainstem, and then, in primates, to relay regions in the thalamus, which finally convey the moment-to-moment interoceptive information of the whole body to the insular cortex (Craig 2015, 2018). In other words, the sensory interoceptive pathway and the motor autonomic system are both essential and mutually complementary components in the internal sensorimotor loop that continuously ensures the homeostatic balance of innumerable physiological parameters needed for life to continue and flourish in the bodies of humans and other nonhuman animals (Craig 2002, 2009, 2015, 2018)

3.2 Interoception and the homeostatic role of affect

Along with autonomic and interoceptive mechanisms, human homeostasis also comprises bodily feelings and motivations, that add another layer of complexity to the life-regulatory process. Basic forms of bodily affectivity such as feelings of pain, visceral urgency, hunger or thermosensation, promote specific behaviors and actions in the environment (e.g. searching for food or shelter), in accordance with the organism's homeostatic needs (Craig, 2015, 2018; Damasio, 2018, 2021; Denton et al., 2009; Solms, 2021)[3]. At the heart of this homeostatic role of affect is hedonic valence, which is regarded as one of the essential marks of affect (Duncan, 2006; Panksepp, 2017). It has been hypothesized that valence arises from the interaction of the interoceptive-autonomic system with the internal environment of the body in such a way that it informs the organism about the homeostatic viability of its current state, promoting in turn a corresponding behavior in consonance with the imperatives of life (Craig, 2015; Damasio, 2021; Denton et al., 2009; Solms, 2021).

A straightforward example is pain, whose negative valence is coherent with pain being a sort of alarm that signals damage to the organism's tissue integrity, motivating withdrawal behavior in the animal (Walters & Williams, 2019). Another example is thermosensation. Compare the pleasantness of drinking cold water when you are too hot with the unpleasantness of the same cold water if you were freezing, and the associated motivations to drink it in the former case and not to drink it in the latter. This everyday relationship between the felt valence of thermal sensations and thermal behavioral regulation is supported by empirical evidence (Craig, 2002; Satinoff, 1978). According to many authors, this generalizes: natural evolution has given us hedonic valence as a pre-reflective aspect of affective experience to instinctually regulate our behavior in relation to the homeostatic needs of our living bodies (Craig, 2015; Damasio, 2021; Denton et al., 2009; Solms, 2021)[4].

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[3] Human homeostasis also involves endocrine and immunological processes, which are also intermeshed with affective experience and both physiological and mental health (Damasio 2021, Craig 2018, Barrett 2017).

[4] However, this innate "wisdom of the body" is dramatically shaped by early social interactions (Fotopoulou & Tsakiris, 2017, see section 3.4 below), and is constantly subject to a type of associative learning: *affective learning* (Barrett and Bliss Moreau 2009).

In its fundamental form, the evolutionary birth of affect would be found in the interoceptive disclosure of inner physiological states as pleasant ("good"), or unpleasant ("bad"), as a function of their homeostatic significance (Craig, 2015; Damasio, 2021; Denton et al., 2009; Solms, 2021), which would have conferred an adaptive evolutionary advantage in comparison to entirely non-conscious, automatic mechanisms of regulation (Cameron, 2001; Damasio, 2021; Denton et al., 2009; Solms, 2021)[5].

Relatedly, according to a very recent proposal, the evolutionary birth of affect would comprise nothing less than the birth of consciousness itself (in its most basic affective form as *sentience*), which, moreover, would also entail the birth of a new form of learning: *unlimited associative learning* (UAL) (Ginsburg & Jablonka, 2019). UAL is the capacity for open-ended associations within and between modalities (e.g. visual, affective and cognitive modalities) at a time and across time, that would have led to the emergence of a complex and dramatically increased repertoire of behaviors in ancient organisms (Ginsburg and Jablonka, 2019). Intriguingly, given that meaningful learning involves the constructive association of new information with previous knowledge and experience (Ormrod et al., 2019), an important question that naturally arises is whether the multiple influences of affectivity on learning that we reviewed in section 2 somehow reflect a more fundamental and evolutionary ancient principle that links the appearance of sentience to the rise of more sophisticated forms of learning that eventually allowed the emergence of what we now call meaningful learning[6].

The homeostatic relevance of affective experience is neurobiologically substantiated by empirical evidence showing the "striking overlap in the neuroanatomical substrates that underlie interoceptive function, body regulation, and emotional and affective experience" (Quigley et al., 2021, p. 34). This crucial neurobiological fact is also emphasized by Craig (2018), who writes that "the integrative homeostatic processing mechanisms in the anterior insula (both right and left) provide a crucial substrate for all subjective feelings" (p. 226). Also, Barrett (2017) writes that "your interoceptive network controls your body, budgets your energy resources, and represents your internal sensations, all at the same time" (p. 70). Parvizi and Damasio, in turn, state that

> The intriguing overlap of functions attributable to the several families of brainstem nuclei - emotion, wakefulness and sleep, basic attention, and of course consciousness itself - becomes less intriguing when it is seen in the perspective of homeostasis, the ultimate physiological role of all the operations in which these nuclei are involved. (Parvizi & Damasio, 2001, p. 153)[7]

Hence, instead of being two clearly distinguishable phenomena, affective experience and homeostatic regulation are placed along a vital continuum. Moods, emotions and other

[5] Of course, the human condition is far more complicated and not always what feels good is beneficial for us or what feels bad harmful.

[6] Unfortunately, for space limitations, we are no able to deepen into this intriguing possibility here.

[7] It should be noticed that among researchers, there is discrepancy about whether the minimally sufficient neural substrates for interoceptive and affective experience are either subcortical (e.g. Solms, Merker, Panksepp, etc), or cortical (e.g. Craig, Barrett, Seth, etc.).

affective experiences are fundamentally grounded on the ancient but still sovereign imperative to remain alive and healthy, in the face of an endlessly lurking thermodynamic disintegration. Affect is an additional layer of homeostatic regulation that allows sentient organisms to thrive at increasingly more complex levels of organization and interaction.

3.3. Interoceptive phenomenology and affective experience

Let us deepen now into the relationship between interoceptive feelings of inner bodily changes and affective experience. In this regard, a useful distinction is proposed by Wiens (2005). It is a distinction between two levels of interoceptive-affective experience: a *pre-reflective* affective experience arising from interoceptively sensed inner physiological changes, and a more cognitively-loaded process of interoceptive *awareness*. The first level would be generated by the neural representation of interceptive feedback coming from the whole body, and would correspond to the purely felt aspect of emotions and moods, its affective phenomenology, without interpretation, conceptualization or any high-level cognitive process related to thought, reasoning or report. The second level, in contrast, would comprise, besides the representation of interoceptive feedback from the body, also the *perception* of actual and illusory physiological changes, that would involve the *awareness* of the emotional experience, comprising a process of category attribution according to culturally-relative conceptions. He states that "first-level experience thus refers to non-reflective phenomenology, whereas second-level experience refers to awareness" (Wiens, 2005, p. 444). In his understanding of "awareness", it entails a process of cognitive categorization of the affective experience as such and such emotion or mood[8]. This distinction may help us to understand the difference between what we may call a "purely felt" level of interoception underlying putatively all affective states, and the additional layers of cognition and awareness that plausibly give rise to the wide spectrum of diverse affective experiences, ranging from the diffuse but ubiquitous feeling of simply

[8] Although it could not be claimed to be a universal usage, 'awareness' is easily associated with a more cognitively-loaded process in which the subjectively felt quality of experience is de-emphasized or may even be completely absent (Chalmers, 1996). In broad terms, and akin to how Wiens seems to use the term, 'awareness' can be understood as the functionally describable process of making felt experience cognitively available for reporting, thinking, voluntary control, comparation with another experiences, etc. Chalmers (1996) for instance, insists that we should use the term 'consciousness' to denote the 'what-it-is-likeness' of experience, how experience feels for the subject (Nagel, 1974), and reserve the term 'awareness' for the more functional conception. Also, to a great extent, Chalmers' distinction coincides with Block's differentiation between 'phenomenal consciousness' and 'access consciousness' (Block, 1995), where the former refers to the felt, qualitative and subjective aspect of experience while the latter expresses the more cognitively-charged functional conception. Here we follow Chalmers and use 'consciousness' and 'conscious' to denote the phenomenological, subjectively felt aspect of any experience, for instance the felt dimensions of pleasantness/unpleasantness and energization/deactivation integral to many, if not all, affective episodes. We also use 'sentience' to denote the experiential aspects of affective states.

being an embodied, living creature (Cea & Martínez-Pernía, 2023; Damasio, 1994; Fuchs, 2012; Seth, 2021), to sublime emotions of aesthetic beauty (Damasio, 2021)

Related to the bodily localization of interoceptive sensations in emotional experience, a group of researchers studied the degree in which participants (n=701) felt an increase or decrease in activation in different parts of their bodies, in comparison to baseline, for each of the so-called basic emotions (i.e. anger, fear, disgust, etc.) and other, non-basic ones (e.g. anxiety, contempt, shame, etc.) (Nummenmaa et al., 2014). Using a computationally-based, topographical self-report method, researchers found consistent emotional bodily maps across West European and East Asian participants, that were associated with statistically separable emotions. These different maps were further distinguished using statistical classifiers. The results are shown in Figure 2. It is very telling how, for instance, depression is typically felt as a significant de-energization of the limbs, which is arguably associated with the tendency towards inertia and demotivation that, among other things, characterizes this condition (Fuchs, 2013); while happiness in contrast, is felt with the greatest energization in the face and upper chest, and also a slightly lower but still significant energization in the limbs, which is coherent with that emotion being related to a generalized feeling of being energized, that comes with a disposition to engage with pleasant activities and other people.

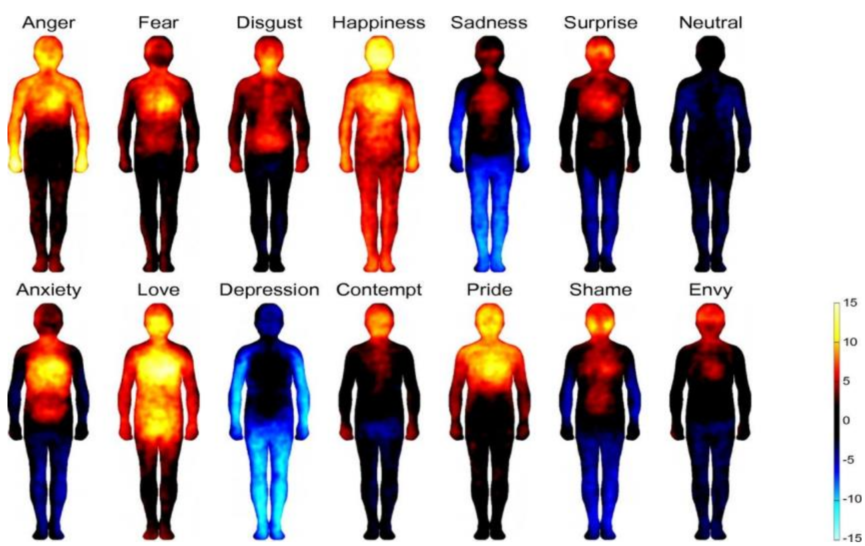

Figure 2. Bodily maps of emotions. Extracted from Nummenmaa et al., (2014), p. 647.

Importantly, all accounts of affective experience in which bodily feelings play a crucial part, have as major historical antecedents the perspectives of William James and Carl Lange, who independently of each other both posited that emotions are fundamentally constituted by the feelings of the physiological changes occurring in one's own body (e.g. increased heart rate and muscle tension), typically triggered by salient events in the environment. In other words, the phenomenological dimension (i.e. first-person lived experience) of emotions would be nothing but the interoceptively felt bodily sensations that are triggered by a perceived event in the environment (James, 1884, 1890). Although the James-Lange theory has received important criticisms (Cannon, 1927; Northoff, 2008), and is commonly held to be probably unplausible in its original form (Seth, 2021), there is currently strong evidence for the central place of interoceptive bodily feelings in emotional experience (Barrett, 2017; Craig, 2018; Critchley & Garfinkel, 2017; Damasio, 1999, 2021; Lindquist et al., 2012; Seth, 2013; Seth & Friston, 2016; Seth & Tsakiris, 2018).

Anil Seth (2021; 2013; Seth & Friston, 2016; Seth & Tsakiris, 2018) and Lisa F. Barrett (2017; Barrett & Bliss-Moreau, 2009; Barrett & Simmons, 2015), for instance, have both offered similar (but not identical) proposals about the specific role of interoception in moods and emotions. In broad terms, they both assert that empirical evidence supports the hypothesis that affective experience arises from the brain's predictions about the interoceptive consequences of homeostatic motor signals aimed at controlling the interior of the body, based on previous experiences, and under the imperative of securing the continuity of life in the organism in its relation to the environment[9,10].

This anticipatory complex machinery that would give rise to affect is another way of approaching what seems to be an essential link between affectivity and the imperative to preserve life's integrity. Importantly, this would entail the organism's need to efficiently summarize its own homeostatic state regarding its energetic resources, what Barrett refers to as "body-budgeting". Moreover, this moment-to-moment interoceptive summary would be nothing less than what we experience as (core) affect: "Your affective feelings of pleasure and displeasure, and calmness and agitation, are simple summaries of your budgetary state. Are you flush? Are you overdrawn? Do you need a deposit, and if so, how desperately? (Barrett 2017, p. 73). This is complemented by Anil Seth, when he states that the interoceptive feelings that constitute the basic ingredients of moods and emotions, "are not merely about registering the state of the body, whether from the outside or from the inside. They are intimately and causally bound up with how well we are doing, and how well we are likely to do in the future, at the business of staying alive" (Seth 2021, 193)

3.4. The social dimension of interoception, homeostatic regulation and affect

[9] Note that both Seth and Barrett give especial emphasis to *allostasis* instead of *homeostasis*, which is the *predictive control* of the interior of the body aimed at securing the viability of life (homeostasis), based on models that allow the brain to infer how the internal environment of the body will probably change if this or that action were implemented, and the probable causes of interoceptive signals.

[10] As mentioned in section 2.1., according to Barrett, in the case of emotions like fear or sadness there are also in play socially constructed emotion *categories* (i.e. concepts of "fear", "sadness", "joy") that the brain uses to make sense of the interoceptive signals it receives from the body in the context of present circumstances.

Crucially, the importance of interoceptive feelings for homeostatic regulation and affective experience is not restricted to the individual. In a groundbreaking paper, Fotopoulou and Tsakiris (2017) argue that the very capacity to feel our internal homeostatic state is crucially mediated by the early social interactions with our caregivers, and thus, the very building blocks of our affective life would be, at least partially, socially constituted. As well as Seth and Barrett, Fotopoulou and Tsakiris (2017) frame their proposal within a predictive processing approach in which interoceptive feelings arise from the brain's continuous task of inferring the inner physiological causes of the interoceptive signals it receives, as well as the interoceptive consequences of the actions it commands to secure inner physiological balance. The key point of Fotopoulou and Tsakiris (2017) is that, given the strong dependence of the human infant on her caregivers to preserve and restore her inner physiological balance (e.g. by being fed, hydrated or warmed by a parent), the interoceptive predictive models that purportedly underlie the emergence of the infant's bodily feelings would be, necessarily, shaped by the caregiver's sensitivity in reading out the infant's homeostatic needs and the actions he or she may perform to fulfill them. As summarized by the authors, "the origins of interoceptive active inference are always, by necessity social, and thus core subjective feelings such as hunger and satiation, pain and relief, cold or warmth have actually social origins" (Fotopoulou and Tsakiris, 2017, p. 19).

Importantly, this social dimension of our bodily feelings and physiological regulation extends towards adulthood, as evidenced by studies showing, for instance, that the experience of pain is strongly influenced by the presence or absence of social support: "our perception of pain, and of bodily threat more generally, may vary not only according to how much tissue damage is communicated by nociceptive, peripheral pathways, but also according to how much social support we predict is available to us in a given situation" (Fotopoulou and Tsakiris, 2017, p. 17). The social dimension of homeostatic regulation is further supported by a recent review of decades of psychological and physiological research in attachment and social loss in both human and non-human animals (Sbarra & Hazan, 2008). It asserts that in close relationships (e.g. parent-infant, long-term mate relationships, etc.), physiological (and psychological) homeostasis in each individual is coregulated to a large extent by the presence of the other individual (Sbarra and Hazan, 2008). A prominent example is the increase in parasympathetic tone (i.e. relaxing, calming response) in infants when they synchronize gazes with a parent (Feldman & Eidelman, 2007). Sbarra and Hazan (2008) synthetize their main conclusion:

> social regulation provides the most efficient and metabolically cost-effective means of regulating affect. Coregulated physiology describes the underpinnings of this process and can provide adaptive value by enabling individuals the ability to quickly regulate affective distress by synching their physiological systems to their attachment figure. (p. 157)

From a more phenomenological perspective, the simultaneous coregulation of affect and physiology between individuals can be described as *interaffectivity* and, following Merleau-

Ponty, *interbodily resonance* or *intercorporality* (Fuchs 2013). This refers to the recursive cycle of mutual affective and bodily influence between interacting subjects during emotional experience, in which the *bodily resonance* (i.e. interoceptive feelings and sensations, along with kinesthetic and proprioceptive elements) constituting the emotional *affection* of one person, entails an emotional *expression*, which in turn, affects the second person who consequently experiences her own bodily resonance and expresses her emotion, which then recursively affects the bodily resonance of the first one, with an expression that again, affects the second, and so forth. Interestingly, a recent study in experimental phenomenology studying empathy for pain in a non-interactive setting[11], shows that although the experimental subjects are not interacting with the individuals experiencing pain, a fundamental aspect of their empathic experiences is nonetheless their bodily resonance, which is constituted by a multiplicity of interoceptive, affective and kinesthetic components elicited by the other person's pain; presumably reflecting the subject's embodiment of a history of previous experiences of interaffectivity and intercorporality (Martínez-Pernía et al., 2023).

Conclusions

Throughout this chapter, we have developed an argument made up of two main premises: 1) Affective experience plays a fundamental role in learning (Section 2); and 2) Affective experience is rooted in the homeostatic self/co-regulation of living bodies (Section 3). Hence, the main conclusion of our argument and chapter is that

Homeostatic self/co-regulation in and between living bodies plays a fundamental role in learning.

Therefore, if we want a fuller and deeper understanding of learning to improve teaching practices and the students' learning processes, we need to focus more on the ongoing self-/co-regulation of life within and between learners' bodies. With this new comprehension in mind, the following remark by Mark Brackett makes perfect sense:

> Children learn what they care about… research shows that when students feel deeply engaged and connected in the learning process, and when what they learn is relevant and meaningful to their own lives, there is activation in the same brain systems (for instance, the medulla) that keep us alive. (Bracket, 2019, pp. 431-2)

[11] Namely, a setting in which the experimental subject is watching a prerecorded video of people experiencing painful falls while practicing extreme sports. Afterwards, systematized phenomenological interviews and analyses are implemented by the researchers to transform the subjects' lived experiences into rigorous qualitative data (Martinez-Pernía et al., 2023).

Learning is an extension of life and should be oriented as such. In consonance with the autopoietic proposal that cognition is an inherent property of life itself (Maturana & Varela, 1980), learning, affect and our living, bodily nature are not separate aspects of ourselves but interdependent constituents of the multifaceted whole that we are. Education would be greatly benefited if we overcome the current computer-based conception of the human mind as essentially a complex information-processing phenomenon being run by a brain-computer, controlling an otherwise blind and insentient body-machine. Nor are we immaterial ghosts giving life and mentality to brute physiological machinery. We are living, sentient, thinking and acting bodies, intertwined with other living, sentient, thinking and acting bodies. Socially shaped interoception and (inter)affectivity provide the missing link between our minds and bodies; between our felt, lived corporalities and our physiological, life-supporting coregulations. Cognition and learning are not abstract, computational and disembodied faculties; they are capacities of interdependent, living, sentient, human organisms, in which the “affective dimension of organismic regulation… constitute the organism’s feeling of self” (Thompson & Varela, 2001, p. 424), underpinning “a strong continuity between life, mind, and consciousness” (Seth and Tsakiris, 2018, p. 11).

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Brief CV of IC:

Ignacio Cea is currently an ANID-Fondecyt postdoctoral fellow and full-time research associate at the Center for Research, Innovation and Creation at Catholic University of Temuco, Chile. Before, he was an ANID-Fondecyt postdoctoral fellow at the Center for Social and Cognitive Neuroscience, School of Psychology, Adolfo Ibanez University, Chile. Currently he is also a lecturer in Philosophy of Science and Philosophy of Artificial Intelligence at Alberto Hurtado University. He earned a Master's degree (2014) and PhD in Philosophy (2019) at Alberto Hurtado University, Chile. His main areas of research are the philosophy of mind and philosophical problems in the cognitive and affective sciences, especially interdisciplinary issues about consciousness.