Bridging neuroscience of consciousness and education: Part II

The neuroscience of consciousness is providing teachers with a new perspective on how to understand and address educational challenges and opportunities in the classroom.

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Executive summary

- Sensitivity to information outside the world (perceptual sensitivity) is a type of implicit knowledge involving consciousness without self-reflection. The "first-order" neural networks associated with sensitivity behave much like a thermostat by being sensitive to the temperature and adjusting it automatically. Hence, perceptual sensitivity does not require conscious awareness, although it does not exclude it and, in many cases, is followed by it.
- Emotion involves innate, powerful, and mostly unconscious feelings which can be considered as types of perceptual sensitivity, alerting us to danger or opportunity. Emotional arousal activates attentional and problem-solving processes that develop a "solution" response.
- However, emotions can also be learned and elaborated, and they can involve conscious awareness.
- *Conscious awareness* always seems to carry the ability of *knowing that one knows*. This "second-order" knowledge depends on *learning*.
- Since implicit feelings can become explicit (conscious) and be in part controlled, students should be encouraged to talk about their emotions, listen to their classmates' feelings, and think about others' motivations through metacognitive activities in the classroom.
- Curricular applications that incorporate emotional recognition and cognitive control include: aesthetics and the integration of arts and culture, activities that promote play, and a social skills curriculum grounded in collaborative classroom management.

Introduction

As it is studied in neuroscience, consciousness involves our brain's arousal systems as well as the unconscious and conscious abilities to recognize important challenges, dangers, and opportunities. It is only part of all the things the brain does or can do. However, it is very relevant for successful teaching and learning. The *neuroscience of consciousness* gives educators a new perspective on how to understand and address educational challenges and opportunities in the classroom, especially in regards to students' and teachers' emotions. This is undoubtedly one of the most important contributions of current neuroscience to possible applications in education. Surprisingly, there have been very few attempts to bridge the two fields. This brief has the goal to fill this gap. I will overview the links between consciousness and learning. Especially, I will describe the processes responsible for *knowing that we know* (and that we feel).

I begin with key concepts that tie consciousness and practical application to emotional states. I use examples of educational and curricular issues that are common from early to middle childhood.

Neuroscience of consciousness: Knowing that we know

A thermostat can turn a furnace on or off depending on whether the current temperature exceeds a set value. Thus, the thermostat is *sensitive* to temperature. But is it *aware* of temperature? No, because the thermostat does not have any knowledge of being sensitive to temperature. Also, the thermostat does not *care* about whether its environment is hot or cold. As we have seen in Part I, C-conditions show that knowledge of one's own internal states and the emotional value associated with such knowledge make up what we call consciousness. Adding to Part I, in this brief, I will show that consciousness is not just an innate faculty; we learn to be conscious through stages of elaboration of information coming from implicit feelings.

The isolated neural networks I have described in Part I work like the thermostat. For example, consider the speech network. It is fair to say that a network that learned the basic sounds (phonemes) of English will be sensitive to English phonemes. Also, it will not respond to French phonemes. However, it will not know anything about the cultural context that makes English a language different from French. In other words, it will not really know anything about what a language is. It will only respond to regular patterns of sounds. Such patterns or maps are "first-order" *representations* to the extent that they are ***in** a network* rather than ***for** the network*. That is, such maps are not accessible to the network *as something that stands for something else* (that is, representations). They only process information in terms of *codes*, which are different from representations. In other words, an isolated (first-order) network *can never know that it knows*. It simply lacks the appropriate machinery. This is the key difference between sensitivity and awareness. Sensitivity merely is the ability to respond in specific ways to certain states of affairs. Sensitivity does not require consciousness, although it does not exclude consciousness, and in many cases, conscious awareness follows sensitivity.

Conscious awareness always seems to carry the ability of *knowing that one knows*. This "second-order" knowledge depends on *learned* representations. It forms our experience, provided that we *care* (that is, we have *emotional feelings*) about certain things more than about others. This ability is the source of verbal reports, which are the most direct sign of awareness. Not only consciousness requires learning about the state of one's own representations, but also it requires that the resulting knowledge shows our dispositions and preferences. Therefore, to make the thermostat conscious, we would need to set it up so that it *cares* (has emotions) about certain temperatures more than about others. These preferences are the result of learning.

To know about things, we must be able to access, inspect, and manipulate our own images, symbols, or maps that stand for things—that is, the representations of such things. The latter requires describing again and again to ourselves our own representations of things in various formats. This continuous **representational redescription** (Karmiloff-Smith, 1992) makes an individual aware of the internal states of learning he/she goes through. This same process applies to the elaboration of feelings into emotions. Indeed, a school of thought within neuroscience (for example, see Pessoa, 2013) pretty much argues that there is no difference between cognition and emotions.

Post-Piagetian scholars who also work in neuroscience, such as Karmiloff-Smith (and others), proposed a series of stages that children and learners follow before being capable of expressing their knowledge, regardless of whether the content of this knowledge is cognitive or emotional. Initially, the child learns how to do something indirectly by responding to information available in the environment. Learning is stimulus-driven and based on imitation. The child learns to respond in set ways. Knowledge is inflexible and tied to particular situations and experiences (**implicit**). Each new bit of information is stored as a separate procedure, a particular response to a particular task. Nevertheless, the child masters more complex procedures for more complex tasks. After mastery is established, the child begins to make more connections in the brain; as the knowledge becomes stronger, distinctive, and stable, it becomes **explicit** and globally available in the brain and to consciousness. Once the knowledge has reached consciousness, it can be manipulated and controlled through the uses of symbolic tools such as language allowing for the child to make sense of the information and eventually express what has been learned by **verbal report**.

Next, I examine key concepts from neuroscience research that illustrate how educators can assist children during these stages of re-description.

Unconscious attentional and emotional processing

Neuroscience research grounded on evolution has emphasized that some key aspects of emotions, also referred to as ***feelings*** (Damasio, 2010), are innate, powerful, and mostly unconscious (implicit). These aspects alert us and drive our attention to focus on challenges that are important for survival. Therefore, unconscious emotions are designed to promote arousal only if necessary. Similarly, these unconscious emotions arouse us and drive the deployment of teachers' and children's attention in the classroom. A sudden event that elicits an emotional response can thus easily and immediately stop classroom activity. For example, the sound of a fire alarm may trigger arousal, which would prevent students from focusing on what they are currently doing and shift their attention to this new challenge. Even after they are reassured by the teacher that there is no problem and that it was a false alarm, it is then difficult for students to control their emotional arousal and resume working on the task at hand. According to evolutionary neuroscience, this is because our brains are programmed to linger until the issue which induced the emotional arousal is dealt with, as a more sophisticated version of homeostasis, the process according to which we keep all vital functions at a stable optimal level (see Damasio, 2018).

How students emotionally respond to the problem in part depends on their temperament. **Temperament** refers to the innate emotional response that unconsciously drives an individual towards danger or opportunity. Temperament is a useful trait since it permits quick and resolute action towards a response or not. An individual temperament typically varies along a range between bold/uninhibited (i.e., behavioural activation system, BAS) and anxious/inhibited (i.e., behavioural inhibition system, BIS) (Kagan, 1994). When children are emotionally aroused, those who are bold are more likely to be curious about potential opportunity, whereas anxious children tend to be wary of potential danger (Sportel et al., 2011). Using our previous example, in response to the sound of a fire alarm, students with a bolder temperament are more likely to want to explore the school for a potential fire and put it out, whereas students with a more inhibited temperament would be more likely to want to run out of the classroom and escape the threat. Both approaches result in a solution to the problem and may be viewed as effective coping strategies. In terms of teaching, students should be encouraged to follow their tendency but also given opportunities to practice the other, nonpreferred approach. Projects that effectively team bold/uninhibited students with anxious/inhibited students can create a cooperative opportunity where the best elements of both approaches work together to reach solutions. Furthermore, educators can get to know their students' tendencies and emotional responses to problems. In this context, since body language also implicitly shows current emotional states, it makes a lot of sense for teachers to be apt at reading and adapting to their students' body language, for example, recognizing the subtle body language associated with the beginning of a problem until it suddenly becomes a challenge.

Daydreaming, is it always bad?

Much of the brain's energy expenses are dedicated to an enormous functional system. Just a small amount is used for some "emotional or cognitive moments" which need consciousness. We can use the analogy of the *tip of the iceberg* to describe these "consciousness moments."

However, most of the time the brain is in a state of idling using the *default mode network* (DMN). The DMN seems to be related to mind wandering and daydreaming. Teachers are well familiar with these states. They observe it first hand in their students at one point or another. And there is some merit when students need to initially pay attention to create a "code" for new information they are being taught. Many studies, however, show that DMN activity predicts aspects that usually help comprehension and what is called reflective "deep" learning (as opposed to just pay attention), such as mental imagery generation, creativity, and problem-solving (Beaty, Benedek, Kaufman, & Silvia, 2015). Mental imagery is the ability to draw from memory to form an image "in your mind" using sensory information. Mental imagery can be represented in a variety of ways, for example, as a visual picture or through the sound of a melody.

Therefore, in appropriate circumstances, daydreaming may not be that bad after all. Neuroscience may be able to demonstrate that certain types of daydreaming may actually be beneficial for some types of learning and should be incorporated into class time, exactly as we do with physical activity, to support some phases of learning. For example, it is a common observation that when students are asked a question, they will zone out for a few minutes and come up with a response only after a relatively long period of elaboration (that teachers may find uncomfortable and difficult to be patient to). The DMN may be involved in that type of processing when children and students need the time to activate remote associations and connect them to what they are listening to. Indeed, very recent evidence shows that DMN while is always activated as a whole with different intensity (less during attentive tasks but more during reflective, self-oriented tasks) reorganizes itself after a cognitive task to reflect a long-term learning condition that "remembers" and can anticipate the old task in future circumstances (Lin et al., 2017).

Conscious appraisal of emotions and other attended contents

Damasio (2010) suggests that feelings emerge in our brain when we become conscious of our emotional arousal to potential danger or opportunity. Although others can often observe emotions, our feelings remain a private mental experience. Identifying and understanding our emotions allows us to go beyond automatic behaviors to create solutions to a variety of present-day challenges. Emotions and our understanding of them take us beyond how we were "programmed" in early evolution. Evidence from evolutionary neurobiology suggests that, similarly to cognitive processes, emotional representations (or affective, feeling imagery as discussed by Feinberg & Mallat, 2016) also undergo re-descriptions which reflect the level of the brain systems involved during the process from when the affective content is implicit to when it may become explicit and then it may become fully conscious.

Emotional awareness and self-regulation in the classroom

The feelings we experience from emotions simply exist. That is, they have a pervasive character that does not allow us to ignore them, deriving from evolutionary survival adaptation, as mentioned earlier. We do not learn what we are feeling in the same way we learn telephone numbers, and we cannot easily change it. But just for the same reasons, we should not ignore these sensations; rather, we should be encouraged to enhance our awareness of what we are feeling by expressing them explicitly in symbols so that they can be controlled. Once students can identify what they are feeling and why, they can learn how to engage in self-regulation to address a problem constructively.

Two important aspects of self-regulation are emotional recognition and cognitive control. Self-regulation is implemented by executive functions which can be viewed as *hot* when behavior is driven by emotion or *cold* when behavior is controlled by cognition. A way to help students and teachers self-regulate in the classroom may be by enhancing emotional awareness. This would help when they are experiencing disruptive emotions, or *hot* feelings (i.e., anger, frustration), by allowing them to work on implementing *cold* responses (i.e., reason, focus)—we must first be aware of what we are feeling before attempting to control our reaction. Emotional awareness may assist with controlling impulses, delaying fulfillment from rewards, and preventing inappropriate actions. This metacognitive approach has helped learners with attentional and hyperactivity deficits (Tamm and Nakonezny, 2015). Students should be given opportunities to express what they are feeling in a nonjudgmental, nondisruptive environment.

Integrating emotional expression in classroom life is difficult; however, it is possible by promoting the stages of learning from implicit conscious emotion to making it explicit for conscious awareness—then, by enabling students to learn to regulate and control symbols (for example, words and language) that are associated with the explicit expression of the feelings into complex emotions.

Most students know quite a bit about emotions and how they are experienced (Saarni and Harris, 1991), although they may not be able to articulate their understanding. Schools can improve students' ability to express their knowledge of emotions by incorporating metacognitive activities. Students should be encouraged to talk about their emotions, listen to their classmates' feelings, and think about others' motivations.

Curricular applications

Aesthetics

Unconscious feelings and conscious emotions alert us to important dangers and opportunities. Similarly, the arts may play an important social role to drive collective attention and interest to culturally important dangers and opportunities that may potentially arise or are hard to recognize and express explicitly. Unlike traditional school systems which have an assigned visual art class or music class, this suggests that arts and culture should be naturally integrated into the curriculum as seen in the Reggio Emilia approach. Under this school of thought, the environment is considered a "third teacher" promoting children's curiosity through active exploration. Much thought goes into providing tools and materials that stem from children's interests, which are often inspired through walks in the community. An expert in the arts, known as the *atelierista*, is invited to work with children on self-directed projects and educate them on the essential skills of creation. Arts are recognized as a necessary means for nurturing learning through reflection and communication.

Field trips, interactive projects, physical education, and the arts are all possible examples of aesthetic experiences. Although we have long known that such activities enhance student learning, we tend to think of them as special rewards and so withdraw them when students misbehave. When budgets are tight, we eliminate them altogether.

Play

Extended consciousness (the understanding of past experience combined with our expectation for the future) requires a large cortex and a complex brain. Humans are born with a very immature brain which develops over a long-sheltered childhood. In contrast, most animals are born with a substantially developed brain, equipped with many neural systems that respond automatically to the dangers/opportunities their species typically confront.

Play allows children to safely explore solutions to pretend problems by simulating any situation—typically childhood versions of adult problems they will later confront—without the danger of being in the real situation. More specifically, good games engage extended consciousness at a simulation level. Much of children's motor, language, and social development progresses with the support of play, and in many instances, without much adult instruction. Play sparks emotional arousal which then activates attention, problem-solving, and behavioral response systems. Children engage in pretend play to make sense of what is taking place around them and test threatening situations.

Play and games are intrinsically rewarding activities that can enhance a child's extended learning. The early childhood theorist Vygotsky proposed that play not only allows children to freely express their thoughts but also has the advantage of creating thoughts. It is only in school that we refer to learning as work. In an era obsessed with assessment and standards, educators must rediscover the power of play for learning. Teachers have often used learning games, but emerging electronic technologies create new instructional possibilities for the learner to address danger and opportunity. For example, the Fast ForWord program (http://www.scilearn.com/products/fast-forword) uses video game technology to eliminate specific attentional problems related to hearing that negatively affect language development in young children.

Metacognitive tools

Finally, knowing about the neuroscience of own learning (meta-learning or meta-cognition) is a tool that can be used with students and educators. They are both learners, although their learning is applied to different objects of enquiry (the very object of learning and the learner's mind, for educators; how to learn and the particular topic, for the student). Hence, both types of learners are very engaged and interested to know at the metacognitive level the nature of the mechanisms and processes underlying their abilities and preferences. Acquiring such knowledge can then change habits or strategies that do not work and could inform the willingness to attempt new approaches. The metacognitive process could be used as feedback to explain why we need to go through some steps and processes to learn in the way we do. Many educators already engage in self-reflection regarding their approach to learning, but children may require some support to come to understand the neuroscience of their own learning.

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