CHAPTER 1

SOCIAL NEUROSCIENCE AND ITS APPLICATION TO EDUCATION

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"I've had three friends die of gang violence, and they weren't even from a gang... I cried for two of them, and then the third one, I was just like, in shock. I was like... I can't believe that just happened again."

(as heard on KPCC Southern California Public Radio, story by F. Stoltze, 5-22-08)

Fifteen-year-old Alan's story is one of fear and sadness, of turning from compassion and embodied, tearful awareness to numbness and "shock." It is a story of empathy come and gone, of emotion felt and lost, of consciousness altered by engagement changed to disbelief. Alan speaks of his life in Los Angeles, but he could be telling the story of many young people caught in zones of urban violence worldwide.

As many young people do, in talking about their experiences, Alan gives away what social and affective neuroscience is just beginning to understand, namely, that the body and mind are linked and that our very consciousness, the biological mechanisms that make possible our subjective sense of self, form the sounding board for our understanding of other people. Alan cries for the deaths of his first two friends, innocent bystanders caught in gang violence. He feels the sadness of their loss as an emotion that changes his body through crying as well as other physiological changes, which typically include a decrease in overall activity level, lowered heart rate, a sad facial expression, and restricted bodily posture. His friends' deaths and the ensuing emotions he feels also alter his mind in uncharacteristic ways, most likely causing him to dwell on and re-experience the event, shattering his focus and concentration, and perhaps even causing trouble in his relationships with loved ones due to the fear that he will lose them.
Beyond the emotions that Alan reports for his first two friends' deaths, Alan's experience exemplifies another recent neuroscientific discovery about the relationship between the mind and body. When his third friend dies, Alan’s reaction moves past his former extreme sadness to induce a state that he cogently describes as “shock.” From a neuroscientific perspective, Alan is describing the altered state of consciousness he experienced at such an overwhelming event, and alluding to a disjunction between his previous experiences and this new occurrence by stating that he could not “believe” what had just happened. Unable to reconcile the events he knows are true with his knowledge about what ought to be true based on his past experiences, his emotion and sense of self are temporarily dampened. Alan is unable to cry for his third friend's death, because he simply cannot connect his current knowledge to his past experiences in order to properly engage his body and mind to foster an appropriate emotional reaction. Instead, the resulting state is “shock,” or the emotional numbness and disembodiment that many people feel during traumatic events that would otherwise trigger overwhelming emotion.

To sum up the discussion of Alan, what have we learned? The answer forms a conceptual outline for the rest of this chapter, and leads us into a discussion of the neuroscience of emotion, social interaction, and their implications for learning and education. First, Alan's tearful reaction to his first two friends' deaths highlights the relationship between the cognitive and emotional aspects of Alan's experience. Alan's emotions and thoughts are intertwined, not separate. What he feels influences and is influenced by what he thinks, and in fact his thoughts and emotions are two aspects of the same process (Fischer & Bidell, 2006), a concept that we have previously termed “emotional thought” (Immordino-Yang & Damasio, 2007).

Second, emotions involve an interdependency of the body and brain, and both the body and brain are involved in the induction of an appropriate response to Alan's tragic news. Alan learns of his friends' deaths, a circumstance that automatically triggers the emotional reaction of sadness; and this reaction modulates basic physiological life-regulatory processing in the body. Alan manifests bodily changes through crying, and if we measured, we would expect to see changes in heart rate, blood pressure, and breathing pattern as well. In turn, these physiological changes are sensed by the brain, and used to shape the contents of Alan's mind. In this way, Alan's "cognitive" knowledge triggers an "emotional" response that involves bodily changes as well as the accommodation of Alan's thoughts to the feeling of these changes. In this body ↔ brain/mind cycle, emotions and cognition are intertwined, and together influence and are influenced by changes in the state of the body.

Third, Alan's reaction to his third friend's death demonstrates how the relationships between the body, brain, and mind are connected to neuropsychological mechanisms of consciousness. When Alan is unable to assimilate the knowledge of his third friend's death, he cannot mount an appropriate emotional response in his body and mind. The result is a change or void in his consciousness level, experienced as "shock," "disbelief," and, although Alan does not directly say this, a perceived detachment or disembodiment, as evidenced by a lack of crying or emotional reaction.

Fourth, and perhaps least obvious but most important, all of the reactions that Alan describes involve his own body and mind, and yet they are induced by events that happened to other people. Here, Alan reveals that, from a neuroscientific perspective, the mechanisms involved in the feeling and control of the body form a platform for the social mind. In essence, we understand and mount reactions to others' situations by feeling the response of our own viscera or "gut" as our mind
perceives and deliberates on the situation at hand. Related to the third point above, the feeling of our own “self” appears to involve the organized recruitment of brain networks for feeling and regulating the body, connected to memories for experiences within the social and physical worlds. In summary, affective neuroscience is discovering and describing the interrelatedness of the body and mind in processes of emotion, thinking and consciousness. Further, the neuroscientific evidence is increasingly demonstrating that we understand, evaluate, and react to the situations of other people by vicariously imagining them on the substrate of our own self.

What Is Emotion?
As an entry point to the discussion of educationally-relevant advances in affective and social neuroscience, it is useful to lay out a neuroscientific definition of emotion. Although lay views of emotion abound, here we understand emotion as a set of cognitive and physiological processes that constitute a person’s automatic evaluative reaction to a perceived, remembered, or imagined circumstance. As such, emotions involve both the body and mind, and utilize brain systems for body regulation (e.g., for blood pressure, heart rate, respiration, or digestion) and sensation (e.g., for physical pain or pleasure, or for stomach ache) (Damasio et al., 2000). Emotions also influence brain systems for cognition, changing thought in characteristic ways—from the desire to seek revenge in anger, to the search for escape in fear, to the receptive openness to others in happiness, to the ruminating on lost people or objects in sadness. In each case, the emotion is played out on the face and body, a process that is felt via neural systems for sensing and regulating the body. And in each case, these feelings of the body interact with other thoughts to change the mind in characteristic ways, and to help people learn from their experiences.

It is important to understand that in this view, emotion and thinking are never truly separated, and learning always involves both emotional evaluation and cognitive processing (see Figure 1-1, from Immordino-Yang & Damasio, 2007). Even solving the driest academic problem involves emotional as well as cognitive processing. For example, what neurocognitive processes are required for Amy, a typical 10th grade student void of any particular learning condition, to solve a typical mathematical equation? It is readily apparent that the initial steps to engage in successful problem solving are more emotional in nature. For instance, to apply problem-solving skills usefully in math, Amy must first motivate and engage herself sufficiently, recognize the degree of complexity required to tackle the equation and make a value judgment as to whether or not her efforts are worthwhile, identify
the type of problem that is before her, and retrieve the necessary neurocognitive and academic information and strategies that will steer her toward a correct solution. Emotion plays a critical role in all of these stages of problem solving, helping Amy to consciously or non-consciously evaluate which sets of knowledge, skills, and abilities are likely relevant, and which will lead to the correct solution based on previous learning experiences. As she begins the cognitive journey of thinking through the solution, Amy is emotionally evaluating whether each cognitive step is likely to bring her closer to a correct solution, or whether it seems to be pointing her down an incorrect path.

From a neuropsychological perspective, the brain systems for emotion form the “rudder” that steers a student’s thinking toward the development and recruitment of an effective skill or solution (Immordino-Yang & Damasio, 2007), in this case for the solving of math problems. Through regulating and inciting attention (Posner & Rothbart, 2005), motivation, and evaluation of possible outcomes, emotion serves to modulate Amy’s recruitment of brain networks that support the mathematical skills she is developing. These same mechanisms would be at play in the solving of most other academic endeavors, thereby blurring the oft artificial distinction between cognition and emotion.

**Figure 1-1**

![Diagram showing the relationship between Emotion and Cognition](image)

Figure 1-1. The thought processes that educators care about, among them learning and memory, involve both emotional and cognitive aspects, and the body as well as the mind. In the diagram, the solid ellipse represents emotion; the dashed ellipse represents cognition. The extensive overlap between the two ellipses represents the domain of “emotional thought.” Emotional thought can be conscious or non-conscious, and is the means by which bodily sensations influence the mind during learning. High reason is a small section of the diagram, and refers to the most abstract and logical of thought processes, which are nevertheless informed by emotional thought. Reprinted with permission from Immordino-Yang and Damasio (2007).
From “Self” to “Other” and Back Again

Many emotions are social, and anyone involved in educating children, from teachers and parents to coaches, counselors and beyond, realizes all too well that social learning is a major force in children’s development. Typical children watch and engage with other people, imitate other people’s actions (including mental actions and beliefs), and look to trusted adults and peers for emotional and other feedback on their behavior. They imagine how other people feel and think, and those thoughts in turn influence how they feel and think.

Educators have long known that thinking and learning, as simultaneously cognitive and emotional processes, are not carried out in a vacuum, but in social and cultural contexts (Fischer & Bidell, 2006). A major part of a child’s decision-making process involves previous social experiences, moral and ethical boundaries, and cultural history. For example, Alan and Amy clearly utilize past experiences to guide their current behavior, thoughts, feelings, and ultimately their learning. In Alan’s case, experiencing the emotional connection involved in friendship leads him to an appreciation of the emotional implications of losing them. Furthermore, knowing and empathizing with the feelings of being physically and emotionally hurt helps him to understand what his friends must have experienced during their deadly encounter. With respect to the emotional interplay of solving a mundane mathematical problem, Amy’s reasons may include the desire to please her parents, the intrinsic reward of finding the solution, the avoidance of punishment or the teacher’s disapproval, or the desire to attend a good college. From a neuroscientific perspective, we do not usually think of math problems as emotional; nevertheless, each of these reasons involves an implicit or explicit social or emotional value judgment. As Amy imagines how it would feel to solve the mathematical problem, she engages feedback loops between neural systems supporting memories, sensations, and cultural values, including how she may have benefited from previous learning situations. This emotional chain of processing eventually comes together to help steer Amy’s current thinking and behavior, while at the same time giving her a context in which to interpret and learn from her new experiences. Despite the differences in Alan’s and Amy’s experiences, both adolescents’ behavior is guided at every step by their ability to make social and emotional evaluations and predictions, and by their ability to use their own selves as a platform for decision-making.

The Neuroscience of Self and Other: “Mirror Neurons”

Social neuroscience is revealing some of the basic biological mechanisms by which such social and
KEY LEARNING POINTS:
Emotional Predictions

Many emotions are social in nature, and fueled by feelings toward others. Such emotions play an important role in helping to guide students’ and teachers’ behavior and thinking, because they enable educators to formulate predictions about how students may react to decisions and actions. These predictive processes form a basic mechanism for social learning, as they enable educators to learn from the behavior of their students, while also guiding their own behavior in directions that will lead to positive outcomes. These processes also underscore the subjective nature of social processing, as predictions and evaluation are made in relation to a person’s own culture mores, memories, biases, and preferences (Immordino-Yang, 2007).

emotional processing takes place (Frith & Frith, 2007; Mitchell, 2008), although applications to classroom practice are only just beginning (Immordino-Yang, 2009). According to current evidence, social processing and learning generally involve internalizing one’s own subjective interpretations of other people’s feelings and actions (Uddin, Iacoboni, Lange, & Keenan, 2007). We perceive and understand other people’s feelings and actions in relation to our own beliefs and goals, and vicariously experience these feelings and actions as if they were our own (Immordino-Yang, 2008). This processing allows us to empathically experience the emotional and cognitive effects of another person’s circumstances, be they about urban violence or about math problems, and to use these empathic experiences to guide our own behavior and learning.

Notably, empathically experiencing another person’s feelings and actions involves neural systems relating actions with their resulting perceptions. Bringing this discussion to the level of neuroscience explanations, recent research findings regarding empathetic behavior in the brain has led researchers toward further exploring the “mirror neuron” systems (Oberman & Ramachandran, 2007; Rizzolatti, Fogassi, & Gallese, 2001; Umiltà et al., 2001). The “mirror systems” are essentially networks in the brain where systems for perception, and systems for action, converge and feed into one another (Damasio & Meyer, 2008). What are the implications of this relatively obscure brain system for school-based educators? Simply put, in order for these convergence areas to be activated in an observer watching another person, the observer must have some context in which to understand the purpose or goal of the action being observed. Furthermore, in order for an action to be perceived as goal-directed or purposeful, the observer must have some sense of the change in circumstances that the action will produce, i.e., “the goal.” In turn, the change in circumstances the action produces will be perceived, and then fed back into motor systems to inform the planning of future actions. (For a more complete treatment of the role of mirror systems in the production of meaningful skills, see Immordino-Yang, 2008.)

To understand how this process is invoked in empathically assessing other people’s actions, think, for example, of the last time you were in a quiet meeting, when suddenly someone began frantically groping for a ringing cell phone. Everyone in the room instantly knew why this person was searching their pockets in order to avoid further embarrassment. Furthermore, everyone in the room likely felt some of the accompanying emotions this hapless person felt while searching. Why? Because everyone in that room shared a common cultural understanding of the appropriate use of technology in a meeting, and of the embarrassment that results from a breach of conduct. Lastly, what did several people in the room do after watching this unpleasant predicament? Of course, they turned off or muted their own cell phones!
Emotional Disorders: A Neuropsychological, Psychopharmacological, and Educational Perspective

To understand what this means for education, think about a typical classroom, with students engaged in problem-solving activities while the teacher demonstrates and explains a myriad of concepts. Beyond the obvious linguistic and visual necessities, what is required for a student to understand and learn from a teacher? And, conversely, what can the teacher do to facilitate a student's comprehension of the information presented? Clearly, for students to accurately perceive, understand, and conceptually grasp the information offered the student and teacher must implicitly understand each other's goals. In essence, to perceive another person's actions as meaningful, a process which involves empathic activation of motor planning systems (via sectors of these systems known as "mirror neuron" areas) and many other neural systems for various aspects of emotional thought, requires that the perceiver have some background in addition to some prior experience with the topic at hand. Despite the teacher's best efforts, if the students are not in tune with the purposes of the lesson and consequently not able to empathically internalize the aim of the teacher's actions and words, they may overlook the features of the lesson that the teacher intended to convey. To them, the teacher's words and gestures may seem irrelevant, meaningless, or pointless. Additionally, the students may impute the wrong goal to the teacher's actions and misinterpret the social exchanges of the learning situation. Consequently, an erroneous conclusion is reached as students may feel the teacher is only interested in boring them, or in making them feel unintelligent, or in making them learn something that is entirely different from what the teacher intended.

SUMMARY
Just as affective neuroscientific evidence links our bodies and minds in processes of emotion, social neuroscientific evidence links our own selves to the understanding of other people. From a neuroscientific standpoint, understanding other people's actions, and hence learning from others, is a process that involves an observer imagining another person's actions as if they were his own. This process is inherently subjective and biased, as the observer imputes goals to the other person's actions based on their own experience within similar contexts. In educational settings, this suggests that if students do not understand the teacher's goals, they may not perceive the teacher's lesson as intended, and the content may be lost. In other words, the social exchanges of learning are paramount before the sharing of knowledge can take place. Therefore, teachers should strive to learn about the culture, mindset, mores, and values of their students to forge a strong social connection that can then lay the foundation for a successful learning experience. Further, teachers should work to make their goals as explicit as possible for students, rather than hidden underneath the veil of the subject matter.

To conclude, social emotions and their associated thoughts and actions are biologically built but culturally shaped; they reflect our neuropsychological propensity to internalize the actions of others, but are interpreted in light of our own social, emotional and cognitive experiences. These social, emotional, and cognitive experiences, in turn, can be interrelated under the heading of "emotional thought," which can originate in the mind but involves interplay between the body and brain. Social and affective neuroscience, while it cannot directly show teachers how to interact with students, can inform educators' knowledge of why and how students learn, especially in social contexts. Incorporating this new information into traditional models of teaching and learning may lead to innovative, effective methods for engaging students in meaningful learning experiences.
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