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Emotion and Learning

New Approaches to the Old Nature-Nurture Debate

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Traditional approaches to understanding the origins of social behavior tend to be hybrids of two venerable perspectives. One, a nativist approach, is that humans are biologically prepared to develop and behave in certain ways; on this view, the basic building blocks of emotions are hardwired into the brain. The other approach is empiricist or constructivist and focuses more on the roles of observation and modeling in shaping the schemas through which social interactions are interpreted. But most theories of socioemotional development end up in a nature-nurture gridlock of "easy" answers that attempt to accommodate both views and ultimately explain very little about exactly how it is that change in behavior occurs across development. In this chapter, I suggest that current advances in the neurobiology of learning are a fruitful way to examine the mechanisms that underlie children's acquisition of social skills.

While the old nature-nurture conundrum is always fun for impassioned debate, an exciting current perspective in socioemotional development concerns questions about how our brains instantiate behavioral change. How is it that our social experiences subsequently shape our thoughts, feelings, and behaviors? My own research has begun to integrate the neurobiology of learning into these questions. The history of psychology is rich with examples of the immediacy and power of basic learning processes. For example, we need only become ill once to create a strong food aversion, and changes in the frequency of reward schedules can quickly change behavior. Contemporary aspects of learning theory have enriched and even dominated some fields, such as the understanding of drug addiction and sensory perception. But this research has not yet infused the study of socioemotional development. This may be because the learning theories so dominant a half-century ago seem stale to psychologists interested in thoughts and feelings.

There is, however, compelling evidence that basic learning theories can uncover rich information about powerful sources of human motivation. My own interest in bridging the neurobiology of learning with the development of socioemotional behavior came from studies of parent–child bonding in rodents. As an example, experimental disruption of reward circuitry in the brain prevents mice pups from emitting vocalizations when removed from their mothers; interfering with brain reward systems also prevents mice from showing a preference for their own mothers (Moles, Kieffer, & D'Amato, 2004). This association also works in the opposite direction: When attachment to the parent is disrupted, other aspects of the animals' reward systems are also affected. For example, animals with disrupted attachments to their parents also have abnormal responses to novelty, altered appetitive conditioning, and unusually high sensitivity to dopamine antagonists and reactivity to other drug administrations (for review, see Matthews & Robbins, 2003). This type of data has led me to think of emotions like love and affection as operating on the brain in the same way—and perhaps through the same learning mechanisms—as drugs; after all, in different ways, both are rewarding.

LEARNING AND SOCIOEMOTIONAL DEVELOPMENT

My research has focused upon the emotional development of school-aged children who have had adverse early experiences as a way to better understand the processes of emotional development. We have learned a tremendous amount about the role of the social environment from

studying children who have been maltreated by the adults who ought to have been providing protection and security for them. Children who have suffered physical abuse are exposed to inconsistent or poorly conveyed emotional signals in their environments. The adults responsible for their care tend to vacillate between extreme emotional states and social withdrawal (Shackman et al., 2010). Yet these social interactions are the primary basis upon which these children begin to learn about their social environment. We hypothesized that this social context might affect the brain regions associated with learning which features of the environment lead to reward or punishment.

We have found that 4- to 6-year old children who are neglected have difficulty differentiating facial expressions of emotion—for example, perceiving that a facial expression is sad rather than angry (Pollak, Cicchetti, Hornung, & Reed, 2000). Conversely, children who have been physically abused appear to become very adept at recognizing cues of anger and hostility (Pollak, Vardi, Putzer Bechner, & Curtin, 2005; Shackman, Shackman, & Pollak, 2007). These patterns reflect ways in which the environment, through learning, directs children's attention to salient and meaningful information. A recent study suggests that these processes influence children's social cognition. Five- and six-year-old abused children in our study believed that almost any kind of interpersonal situation could result in an adult becoming angry; in contrast, most other children saw anger as likely only in particular interpersonal circumstances (Perlman, Kalish, & Pollak, 2008).

The results from these experiments raise new questions about how probabilistic information about other people's behaviors becomes instantiated in children's thinking about their social interactions. Given that children have a limited processing capacity and that there are limitless aspects of the world that can be attended to at any given moment, it may be the case that abused children prioritize negative social cues at the expense of positive cues. Consistent with this view, on a probabilistic reward task, most children respond more quickly as their chances of winning a reward increases. In contrast, maltreated children were not sensitive to the likelihood of reward (Guyer et al., 2006). And primate models also report that maltreated monkeys display less interest in rewards relative to control monkeys (Pryce, Dettling, Spengler, Schnell, & Feldon, 2004).

A potentially important implication of this focus on sensitivity to reward concerns the high rates of depression experienced by maltreated individuals. Although depression is frequently considered to be a problem involving sadness, one of the core symptoms is anhedonia, or reduced experience of pleasure. Indeed, depressed adults experience less pleasure and less reward-related brain activity than nondepressed individuals (Knutson, Bhanji, Cooney, Atlas, & Gotlib, 2008). Impairments in reward learning may lead to reduced engagement with positive stimuli in the environment; such deficits have been linked to problems in social functioning (Fareri, Martin, & Delgado, 2008; Finger et al., 2011). My own work has also suggested that in addition to overattending to threat, 10-year-old abused children underattend to positive cues, which may undermine feelings of safety and pose risk for aggression or depression (Pollak & Tolley-Schell, 2003).

CANDIDATE NEURAL SYSTEMS

There are some clues about which brain mechanisms are ripe for exploration about learning and social cognition. These include the basal ganglia (BG) and orbitofrontal cortex (OFC), which seem to represent the outcomes of situations that the organism has experienced. The BG is a diverse network of subcortical structures that work in concert to orchestrate and execute planned, motivated behaviors that require integration of movement, thinking, and feeling (Haber, 2003). The OFC is a rapidly flexible associative-learning area that is crucial for signaling outcome expectancies such as reward/punishment and the regulation of flexible behavior (Kringelbach & Rolls, 2004). Current thinking is that the BG guides learning based on assessments of the probability of a positive outcome, while the OFC represents gain–loss information and, together, these systems provide a robust way for the organism to learn from and adapt to the environment (Frank & Claus, 2006). As expected, impairments in these systems are associated with poor learning from environmental cues.

With regard to social cognition, it is especially interesting that OFC neurons do not stop firing in response to the reward after learning, suggesting that these neurons support predictions on the basis of afferent input and anticipation prior to other emotion-processing regions such as the amygdala (Schoenbaum, Roesch, Stalnaker, & Takahashi, 2009). Consistent with this view, damage to the OFC causes deficits in reversal learning, reduces the speed of reward learning, and is activated in humans during processes such as regret

and counterfactual reasoning (Honey, Kotter, Breakspear, & Sporns, 2007; Murray & Wise, 2010; Passingham, Stephan, & Kotter, 2002). Common to these examples is the need to signal, in real time, information about outcomes predicted by circumstances in the environment. Some emerging evidence suggests functional changes in the OFC and BG during reward processing in adolescents, further suggesting that these systems are a source of developmental changes in social behavior (Galvan et al., 2006).

There is also some evidence that functioning of these systems may account, in part, for how early-life stressors confer pervasive lifetime risks for children. Many kinds of early-life stressors (e.g., maternal separation, social defeat, chronic stress exposure, abuse) appear to alter neurotransmitters and receptors in the BG that are subsequently associated with impairments in learning (DeSteno & Schmauss, 2010). Child maltreatment has been associated with lower BG recruitment during a reward task (Mehta et al., 2010), and research from my own lab has found that children who experienced early-life stress have smaller brain volumes in the OFC (Hanson et al., 2010).

CONCLUSION

The concept of learning situates brain development within an environmental context. Integrating research and methods about the neurobiology of reward learning, in particular, may prove to be a powerful way to test novel hypotheses about children's developing abilities to understand social cues and regulate social behavior. Successful social adaptation reflects children's ability to learn from complex and varied interpersonal experiences. Children need to discern cues for approach versus withdrawal, which actions lead to punishments versus rewards, which behaviors lead to success in having their needs and desires met. These processes become increasingly intricate and fine-tuned as relevant neuroanatomical and neurobiological systems develop and as the range, complexity, and amount of social information increase for the developing child.

Although psychologists often like to see their subjects of study—emotion, language, social cognition, visual perception—as distinct from other domains of behavior, it may well be the case that general processes underlie many aspects of early learning. In this regard, there may be similarities in the neural processes that children use to track and encode features of their environments, parse and categorize these inputs into meaningful units, and begin to experience these interactions with the sensory world as rewarding or punishing. For this reason, the infusion of new perspectives and experimental techniques, such as those from the neurobiology of learning, can advance the study of social cognition.

A focus on learning processes allows us to formulate questions about which neural mechanisms we use to process socioemotional information, how these mechanisms are themselves shaped by social context, why adverse social environments confer risks for children, and, perhaps, what sorts of neurally informed interventions might remediate deficits in social cognition.

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