Interpersonal Neurobiology
Can Lead to Healthier Communities

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When I was first introduced to interpersonal neurobiology (IPNB) 10 years ago it felt like the locked door to a secret room had been opened. As I stepped inside, I saw before me answers to help understand the science of what it means to be human and a way to make sense of our complex nature. Drawing on evidence-based studies across multiple disciplines, IPNB examines the evolution, the development, and the mechanisms of the nervous system, allowing a greater appreciation of our relationships, with others and with ourselves. Focusing on neural systems that organize attachment, emotion, feelings, attunement, and social communication, IPNB attempts to observe how neural structure and experience interact with one another. In other words, IPNB focuses on the importance of relationships, how we connect and are impacted by those connections, and how relationships change the architecture and functioning of the brain. In its essence, IPNB recognizes the brain as a social organ that is built through experience (Cozolino, 2014).

In the following article I will give an overview of neuroanatomy, illustrating both the inborn mechanisms that foster our drive to survive as well as the experience-dependent nature of our brains. I will also describe how feelings and emotions differ, and how they are valuable and inexorable parts of our nervous system, fundamentally linked to the behavioral tendency of all organisms to approach that which is life-sustaining and avoid that which is dangerous. Furthermore, the vast majority of what motivates us is generated below the level of our awareness; we are not nearly as grounded in conscious and compassionate decision-making as we might believe (Sapolsky, 2017). Last, but certainly not least, the particular way that an individual navigates their world depends upon their social connections. Relationships are our natural habitat and the qualities of our human community affects everything from our emotional and biological health to our intellectual abilities (Cozolino, 2017).

NEUROANATOMY

I first heard the statement "ontogeny recapitulates phylogeny" (Haeckel, 1892), when I was in college, and I found it fascinating. I became curious about the parallels between individual development and evolutionary history and found myself drawn to the sciences. While the theory of recapitulation is now considered largely defunct, there are aspects that are useful. Indeed, the development of the brain in utero reflects the development of the brain in evolution. In the 1960s, Paul MacLean, a physician and neuroscientist, first described the brain as a three-part system, and in 1990 he published a book called *The Triune Brain in Evolution* proposing the reptilian, the paleomammalian, and the neomammalian as the different parts (MacLean, 1990). This three-part structure is useful in giving an overview of neuroanatomy and illustrates the way we can observe aspects of our evolutionary history in the developing human being. In reality, this model is static because all three areas have continued to evolve. Nonetheless, it is helpful to look at this simplified view of the brain.

THE REPTILIAN BRAIN

The reptilian brain is the most primitive part and is the most activated area of the brain when we are first born. It is located at the base of the brain where the spinal cord first enters the skull. The reptilian brain, which contains the brain stem and cerebellum, is responsible for all of the things a baby can do at birth: cry, eat, sleep, wake, breathe, feel discomfort or pain, or empty its bowel and bladder. The brain stem, along with the hypothalamus (which sits just above the brain stem), work to promote homeostasis in the body through their influence on the nervous system, as well as the endocrine and immune systems, controlling the functioning of the heart and lungs and the energy levels of the body.

The cerebellum, which is included in the reptilian brain, is a perfect example of how MacLean's model is inadequate in explaining many of the brain's complexities. Indeed, the cerebellum helps with the very basic functions of balance and coordination of movement, as well as the control of muscle tone and the maintenance of equilibrium (Brodal, 1992). It contains cells responsible for mediating the body's reactions to threat. One could say that it is the seat of our "automatic pilot". However, the cerebellum also influences some higher order cortical operations by coordinating important aspects of memory formation and the integration of sensory perceptions (Inhoff, Diener, Rafal, & Ivry, 1989). The outer lobes of the cerebellum work with the association areas of the cerebral cortex, modulating mechanisms involved in motivation, emotional behaviors, and behavioral integration (Berntson & Torello, 1982).

THE PALEOMAMMALIAN BRAIN (LIMBIC SYSTEM)

The second area described by MacLean is the paleomammalian brain, also known as the limbic system. Sitting above the reptilian brain, its main structures include the hippocampus, the amygdala, and the hypothalamus. Every animal that lives in a group and nurtures their young has evolved to have these brain regions. Here, we experience emotions, seek connection, monitor for safety and danger, and appraise for meaning and importance.

The reptilian brain is truly designed for our survival. We come into this world with a beating heart and lungs that breathe all without our conscious effort. We have the urge to eat when we are hungry, to cry when we are not fed, or when we experience some other discomfort or pain. In contrast, the limbic system is shaped by our experience in conjunction with our inborn temperament and genetic predisposition. Together, these brain regions make up our "emotional brain" and monitor the world below the level of our awareness for signs of safety or danger.

THE NEOMAMMALIAN BRAIN (NEOCORTEX)

Lastly, the upper and outermost part of the brain is the neomammalian or neocortex, which means "new outer bark". It is because of the cortex that we can focus our attention, gain perspective, and plan our future. Four lobes are described—frontal, parietal, temporal, and occipital—which carry out different functions. Generally speaking, the back of the cortex carries out perception of the outside world (except for smell and the sense of position of the limbs) while the front half of the brain is responsible for motor, attentional, and thought-based processes. In humans, language and abstract thought take place in the frontal lobes.

It is safe to say that the social brain could not have evolved in human beings without the existence of the prefrontal cortex, which is central to the processes of creating meaning and emotion and enabling a flexibility of response. The prefrontal region of the brain can be said to include ventral areas, such as the insula, and medial areas, such as the orbitofrontal cortex, the ventromedial prefrontal cortex, and also the anterior cingulate cortex (Siegel, 2007). These regions sit at the interface between "lower" areas involved in receiving input from the body and the senses, as well as "higher" parts involved in integrating information and creating complex thoughts and plans for the future. Because of its ability to integrate information it receives, the prefrontal region is involved in stimulus appraisal (the meaning, value, or emotional valence given to a stimulus; Siegel, 2007), affect regulation (the brain's ability to modify its psychophysiological state; Davidson et al., 2003; Happaney, Zelazo, & Stuss, 2004), social cognition (the ability of an individual to perceive the mental state of another; Siegel, 2010), autonoetic consciousness (the ability to perform mental time travel; Happaney et al., 2004), response flexibility (Siegel, 2007), and empathy

(Cheng, Chen, Lin, Chou, & Decety, 2010).

While we may take the existence of relationships for granted, it is an evolutionary achievement that we can sustain social engagement. The brain regions described above touch briefly on the complexities of sociality. The social engagement system, involving the tenth cranial nerve (also called the vagus), illustrates this further. If you think about it, sustaining connection requires the regulation of our emotions in ways that support others as well as ourselves. The vagal system, which originates in the brain stem, is an integral part of the autonomic nervous system, working to enhance digestion, growth, and social communication in the absence of external challenge. When a challenge does arise, vagal activation decreases, facilitating sympathetic arousal and the fight-flight response. The vagus is capable of modulating arousal during emotional interpersonal exchanges, allowing us to maintain continued engagement (Porges, 2003).

The ability of this social engagement system to regulate affect appears to depend on the quality of attachment relationships in early childhood. We internalize what we learn from experience with caretakers into moment-to-moment somatic regulation (Porges, Doussard-Roosevelt, & Maiti, 1994). The vagal system also influences the muscles of our eyes, face, mouth, inner ear, and throat in the service of social and emotional communication (Porges, 2003).

FEELINGS AND EMOTIONS

As a family physician, I spent much of my career trying to make room for both the physical and emotional complaints patients brought to my office every day. I knew that both were real, but finding a balance was challenging. Furthermore, many of my colleagues were only interested in dealing with directly measurable and specific manifestations of disease; they found some of the intangible aspects of mental health to be a burden, or even a waste of time. In discovering and learning about IPNB, however, I began to appreciate something I had believed intuitively for a long time—that physical and emotional health are indivisible. Let's look at how this perspective made sense to me as a scientist; I hope it will help others as well.

IPNB, a consilient field of study that draws on truths identified across all scientific disciplines, elucidates the *objectivity of subjective experience*. When I was in medical school, we were understandably obliged to learn objective facts in order to gain understanding of the human body in states of health and of disease. Emotions and feelings were held to be subjective in nature and thus given less credence. I believe this comes out of the fact that emotions and feelings do not readily lend themselves to the rigors of the scientific method. With IPNB, we study the entire nervous system (that which is encased in the skull and extends throughout the body), its evolutionary history, and the ways in which the more primitive neural circuits influence our thoughts, feelings, and behaviors. With this broader lens, we know that despite their often-transient nature, feelings and emotions also occur on a cellular level throughout the entire nervous system, and that they cannot be discounted.

Let's consider feelings. Feelings are conscious mental experiences that originate in our bodies and help to direct homeostasis. Our every waking moment is accompanied by a feeling of some type. Most of the time, we are not even aware that the quality of an experience is laced with feelings, but without feelings, life would be just an objective chain of sensory episodes. The purpose of feelings is to help us to move toward positive and away from negative circumstances, thus promoting life. Feelings can be spontaneous or provoked. Spontaneous feelings arise from the background flow of life processes while provoked feelings are generated from *emotive responses*, the result of processing myriad stimuli or from engaging drives (such as hunger or thirst), or motivations (such as lust or play), or emotions in the more conventional sense of the word that are complex action programs (Damasio, 2018).

In this context, emotions differ from feelings. While the terms are often used interchangeably, here emotion describes an *emotive state*, a complex and constant interaction between the organism and the environment. Emotive responses originate in specific brain systems that are responsible for orchestrating the particular response, be that the secretion of chemical molecules, visceral changes, or active bodily movements, whatever is a part of a particular emotion (Damasio, 2018).

In *The Strange Order of Things*, Antonio Damasio (2018) artfully describes the complex actions included in the emotive response of delight upon hearing beautiful music. This includes the release of specific chemical molecules in the central nervous system and their transport to other regions of the nervous system and body. He describes the endocrine system's production of chemicals that can change bodily functions. As a result, there are changes in blood vessels, visceral organs, muscle fibers, and respiratory and cardiac rates and rhythms. Because the experience of delight is, well delightful, a state of harmony (no pun intended) is reached in metabolic changes, our imagination becomes more fluid, positive images are favored over negative ones, and even our immune system may be made stronger. Considerable relaxation is promoted, and we feel a minimal amount of stress. In short, this positive emotional experience is healthy.

In contrast, negative emotions are associated with more problematic physiological states that do not contribute to health and well-being. For example, in healthy individuals, stressful situations trigger the release of cortisol, which breaks down complex carbohydrates, creating useable energy for our muscles to take action and inhibiting protein synthesis to conserve energy and focus on the urgent task at hand. This regulatory system is designed for rapid delivery, response, and resolution. As humans, we have big brains and live in a complex environment, which increases the risk of chronic stress and elevated hormone levels that can impair neural growth and our immune system, thus impacting our ability both to learn and to remain healthy (Cozolino, 2017; Sapolsky, 1985). This regulatory system, also known as the hypothalamic–pituitary–adrenal (HPA) axis, is one example of the inherently indivisible nature of physical and mental health.

SOCIAL CONNECTIONS

Thus far, I have emphasized the anatomy and physiology of us as individual organisms. Indeed, there are vast regulatory mechanisms within our bodies constantly striving for homeostasis. Essential to understanding IPNB, however, is that the quality of our life experience, both subjective and objective, is inherently dependent on the quality of our relationships. We are conceived in relationship, born into relationships, and grow into our individual identity in the context of social connections. Indeed, natural selection favored those who banded together in groups because they could work together, enhancing their survival, and thus the social brain evolved. From the very moment that we are born, our survival depends on connection with those around us (Cozolino, 2017).

Since a significant portion of the human brain is not well developed at birth, it is experience that shapes the function of these areas; whatever happens to an infant or a child influences the emotional and perceptual construction of their developing brain. Simply put, experience means neural firing. In 1949, Donald Hebb postulated how neurons change during the learning process, essentially stating that neurons wire together if they fire together; this is the fundamental concept of neuroplasticity (Hebb, 1980).

Consequently, if a child feels safe and loved, their neuronal development will promote behaviors of curiosity and playfulness, and the courage to explore. Conversely, a child whose experiences are adverse will develop neural networks that are focused on survival—managing fear, preventing abandonment, and maintaining safety however she/he can. These early adverse experiences (known commonly as ACEs) have been shown to have negative impacts on physical health later in life (Felitti et al., 1998). This viewpoint provides valuable insight into the inherent difficulties of navigating and treating the human experience.

That the brain is a social organ constantly processing information regarding experiences of the past, the present, and even anticipating the future, cannot be over emphasized. Historically, Western science has studied individuals and neglected the notion that relationships are our natural habitat. When a patient enters the exam room, if I am wearing the lens of IPNB, I see the whole person and value the role of the relationship between us. Knowing that the brain is a social organ, I am aware of the impact I can have on the health and well-being of those in the room with me. I understand that my connection with them—how I talk and interact—can have a demonstrable effect on their health and willingness to engage in their own health care. All too often, not just in the practice of medicine, but in this culture, we tend to discount the importance of the quality of connection, and the impact we have on each other. Harnessing the principles of IPNB and applying them in our lives as we work to parent, to partner, to teach, and to supervise, can lead to a healthier community.

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