1 Introduction

Co-constructing Culture, Mind, and Brain

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Introduction

The last two decades have seen the emergence of a body of work in the social and cultural neurosciences that is beginning to illuminate the ways in which the nervous system reconfigures itself, in response to diverse sociocultural contexts and lifeworlds, through ongoing dynamic processes of adaptation, plasticity, and learning. This innovative work has benefited from major advances in brain imaging, genomics, and other biotechnologies that are contributing to new ways of studying and thinking about human minds, brains, and cultures. Older brain-centric views are giving way to more integrative pictures, in which the cultural world shapes and reshapes our neural circuitry even as our brains cooperate to produce the social world.

The brain is an adaptive system that is constantly reorganizing itself through dynamic interactions with the larger systems in which it is embedded (the body and the social world), to respond to the challenges and opportunities presented by the environment. In the case of humans, the environments we occupy are always already shaped by culture. All of the adaptive tasks, challenges, and opportunities that we face are organized and made meaningful, both personally and socially, by cultural conventions, practices, traditions, and institutions. We live our lives in and through socially constructed worlds that vary widely in their architecture, sensory qualities, social order, values, ideologies, and aspirations – all of which reflect different histories, institutions, and visions of the future. Human nature, therefore, although grounded in our evolutionary history, is also inescapably cultural and undergoing constant revision. Coming to grips with who we are and who we are becoming requires that we consider not only our biology, but equally the culturally diverse social worlds that shape our experience, psychology, and imagination.

On this view, the brain is the organ of culture; mind and experience are processes located in loops of active engagement of the brain and the body with the social world. This engagement occurs on multiple scales, from evolutionary and coevolutionary adaptation, through the cultural history of communities, to individual developmental trajectories, and moment-to-moment engagement

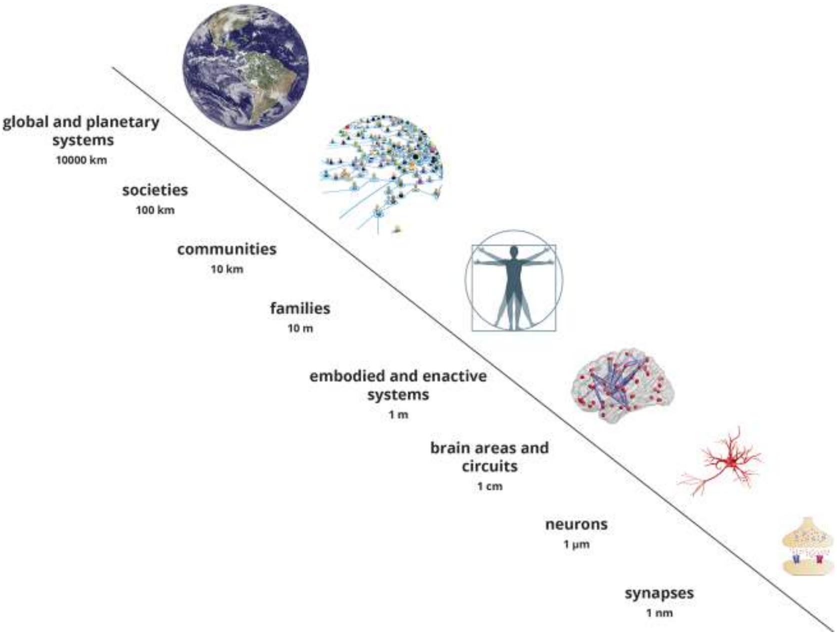

Figure 1.1 Networks constitutive of human experience across multiple spatial scales. The networks that contribute to human behavior and experience are hierarchically organized across multiple spatial scales. Integrating these networks requires a multilevel perspective that includes the brain in its local environment and culturally constructed niche, and extends to family, community, and larger social networks.

with social contexts. Different disciplines have focused on processes at specific spatial and temporal scales. Exciting new work is being done that both reveals the unique dynamics that occur on each of these timescales and captures the interplay among them, allowing us to begin to see the interactions between brain, body, and environment as a complex system that gives rise to our individual experiences and psychological interiority, as well our social worlds. Network theory has emerged in recent years as a valuable tool for describing and quantifying interactions of complex systems that occur across multiple scales (Clauset et al., 2008). In Figure 1.1, these networks are hierarchically organized, and each level (e.g., "whole brain") further subdivides into networks-within-networks. Integrating these networks requires a multilevel perspective that includes the brain in its local environment, cultural niche, and larger social networks, which constitute a kind of ecological system. In this introductory essay, we outline some conceptual building blocks for such an ecosocial view on the co-construction of mind, brain, and culture.

Cambridge University Press & Assessment
978-1-108-70596-7 — Culture, Mind, and Brain
Edited by Laurence J. Kirmayer , Carol M. Worthman , Shinobu Kitayama ,
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Brain, Mind, and Culture

This book is built around a set of questions about the interplay of three constructs: *brain*, *mind*, and *culture*. Although these are words we all use casually, it is worth pausing for a moment to consider their various meanings.

The brain is an anatomical entity – a three-pound organ, comprised of some 100 billion neurons, nestled within the human skull – that extends its reach throughout the body and into the larger world. Through the autonomic, endocrine, and immune systems, the brain regulates all the other physiological systems of the body. The body, in turn, influences the brain through peripheral neural, endocrine, immune, and circulatory systems, as well as interactions with the trillions of microorganisms that constitute the microbiome of the gut, which itself has upwards of 100 million neurons. Interoception, the perception of the body's internal milieu, is crucial to the regulation and maintenance of healthy functioning, or homeostasis. Through exteroceptive sensory organs and the motor system, the brain and nervous system engage with the world in ways that allow us to survive, meet our basic needs, reproduce, respond to the challenges of a changing environment, and even, at times, to flourish. In addition to these vital regulatory and adaptive functions, which we share with other animals, the human brain subserves consciousness, subjectivity, and agency – our sense of being alive, aware, and able to articulate and pursue our goals. At the same time, the brain is also a discursive object, something we talk about – indeed, references to the brain are increasingly present in the ways we think about ourselves as persons. New ways of talking about human functioning and experience in terms of the brain – which sometimes oversimplify or else go far beyond what neuroscience has actually shown – are having profound impacts in many domains of life including childrearing, education, healthcare, and the law (Choudhury & Slaby, 2012; Rose & Abi-Rached, 2013; Vidal & Ortega, 2017).

The term "mind" stands for our fundamental nature as thinking, feeling, acting beings. The grammar of the English language tends to make us speak of *the* mind as a thing and thus confronts us with the hoary mind–body problem, in which we struggle to explain how to get from the physical machinery of the brain to the complexity of goal-oriented behavior and the qualia of conscious experience. Mind is better thought of not as a thing but as a set of processes. Indeed some philosophers have argued that the mind is what the *brain* does; that is, they argue that what we call the mind can be demystified and ultimately naturalized by identifying it strictly with specific neural processes, all of which are localizable in the brain (e.g., Churchland, 1989). This kind of neuro-reductionism is challenged by evidence for the embodied, enacted, socially embedded, and extended nature of mental processes discussed in many of the

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contributions to this volume (e.g., see Chapter 5). The term "mind" then remains an important placeholder for the many complex, meaning-centered processes that are the focus of psychology. Taking the social embedding of the person seriously means that mind extends out into the world in ways that include our tools, our social environments, and, crucially, the minds of others, past and present.

The term "culture" stands for the cooperatively constructed, socially shared, transmitted, and enacted knowledge, institutions, and practices that are central to human development and functioning. Culturally shared developmental experiences shape the architecture of our brains, and cultural knowledge and practices stock our minds with the language, models, and metaphors that we use to navigate the world. Culture itself is a hierarchical system with its own dynamics, co-existing in a landscape of diversity with other cultures, and constantly reconfigured in response to new technologies, social processes, and ways of life.

Approaches to studying the role of culture in human experience also are changing to reflect new dynamics. Earlier models analyzed culture and ethnicity (that is, the groups with which people identify, or the particular historical groups, communities, or peoples to which they are assigned by others) in terms of traits or characteristics that were viewed as consequences of particular patterns of childrearing and specific social, ecological, or historical conditions. The focus on shared or collective characteristics has been complemented by work on how individuals make use of culturally mediated and mandated strategies to respond to particular contexts or situations. More recently, both group and individual levels of cultural analysis have been refined by examining how local social contexts interact with global, historical, and ecological conditions. Despite the forces of globalization, humanity continues to exhibit a remarkable efflorescence of cultures and hybrid forms. The great diversity of cultures and ways of life holds keys to understanding human nature and our collective future.

Each of these concepts of culture, mind, and brain has its own social, intellectual, and disciplinary history. While at any point in time, our notions of culture, mind, and brain often are presented as givens, they also can be understood as constructions. The metaphor of construction seems apt when describing social phenomena that we have set in place deliberately through creative invention, cooperative actions, and collective agreement. There are rich traditions of social and cultural constructivism, which study the changing constructs that constitute our social worlds (Hacking, 1999, 2002). Many socially and culturally constructed processes reside in shared discourse, institutions, and practices. But the metaphor of construction can also be applied to the ways that mind, brain, and culture give rise to each other through mutually constitutive processes on multiple timescales.

The Encultured Brain: Genetics, Epigenetics, and Neuroplasticity

The mapping of the human genome was expected to yield immediate insights into how the brain functions. However, behaviors are not produced directly by genes, but instead reflect dynamic, recursive, and multi-layered interactions among genes, cellular machinery, neural circuitry, and the environment over time (Lock & Palsson, 2016). The genome itself is a complex regulatory system, with a large portion of its DNA devoted to its own modulation (Davidson, 2006). A burgeoning field of epigenetics examines the ways in which environmental interactions turn genes on and off through a variety of biochemical mechanisms (Champagne, 2018). The functional genome, then, is not merely given through genetic inheritance but emerges through interactions with an environment – through epigenetic and indeed, *extragenetic* inheritance of cultural and other reliably recurrent environmental factors as well (Griffiths & Stotz, 2013). Brain structures and circuits emerge in neurodevelopment through dense interactions among genetic networks, local regions of tissue, and the larger social and cultural environment. As anatomical structures and circuits emerge, they interact with each other, introducing further levels of complexity.

In current theory, the human brain is viewed as a large-scale network with various, more specialized or modular subnetworks for processing and integrating information at multiple scales (e.g., the synaptic, neuronal, and neural-circuit levels), as well as across distant brain regions. Neuroanatomical connectivity is partially inscribed in our genes, which interact with the environment to produce the brain's basic architecture during early development (Collin & van den Heuvel, 2013), but brain connectivity is also highly dynamic, plastic, and adaptable, shaped by each brain's history of functional activity (Sherwood & Gómez-Robles, 2017; Sporns, 2011), and continuously interacting with the rest of the body (together comprising the *neurome*; Hahn et al., 2019). Neuronal plasticity occurs at many levels: synaptic connections between neurons are modified by their co-activation, allowing neurons to be recruited to join cell assemblies, local networks, or subsystems; neural subnetworks are wired and rewired in response to environmental contingencies; and multiple subnetworks may be recruited to form larger functional assemblies to meet ongoing adaptive challenges (Anderson, 2014).

Recognition of the crucial roles of brain plasticity in structure and function throughout life stands in contrast to earlier views according to which, once developed, brain anatomy remains static, like the hardware of a computer (Martin et al., 2000; Merzenich et al., 2013). Fundamental functions, such as learning and memory, proceed through changes in neuronal structure and connections (e.g., through the formation, strengthening, and pruning of synapses; Tononi & Cirelli, 2014). Previous functions can be restored after trauma and compensatory functions elaborated after sensory loss (e.g., blindness) by rewiring or repurposing cortical areas (Doidge, 2007; Merabet & Pascual-Leone, 2010). The brain is modified by how we use it: for example, occupation (e.g., London taxi drivers; Maguire et al., 2006), skill training (e.g., juggling; Draganski et al., 2004), physical activity (Hillman et al., 2008), rumination or thinking too much (Hamilton et al., 2015), and meditation or attentional practices (Muehsam et al., 2017); all have been associated with shifts in brain structure and function.

Two points merit emphasis here. First, though there are limits to brain plasticity, we now know that the brain's anatomy and activity are dynamically shaped by use and experience from infancy through old age. Second, it follows that brain plasticity represents a critical dynamic through which humans are encultured, not just during early development but throughout the life course. The culturally mediated worlds in which we grow up and live are integral to how our brains achieve their functional capabilities. Culturally informed skills and "habits of mind" reflect neurodevelopmental processes as well as ongoing dynamics of interaction with local environmental niches and the larger social ecologies we inhabit. As a consequence, through everyday activities and social interactions, our individual brain networks become uniquely tuned to aspects of our particular social-cultural niche. It is because of our human capacity to be shaped by, enact, and transmit knowledge, skills, and attitudes – through language, shared intentionality, and other distinctively human attributes (Tomasello, 2019) – that the collaborative workings of many individual brains can achieve the feat of creating, navigating, and reproducing cultural systems (Veissière et al., 2020).

Windows on the Brain

This book is prompted by new theory and findings in neuroscience that have wide implications for the social and behavioral sciences, and for our understanding of what it is to be human. These advances have been stimulated by a range of new technologies that have made it possible to visualize brain activity, connectivity, and dynamic functioning in powerful ways. Earlier generations of research relied on animal models or the study of human brain injury to identify anatomical correlates or localization of particular kinds of brain function (Bennett & Hacker, 2008). This animal work was limited because nonhuman animals do not possess many of the features that define human culture – including language, stories, complex artifacts and technologies, social conventions, institutions, values, and ideologies. At the same time, human research was limited by ethical constraints and by the fact that while studies of brain injury or pathology can shed light on basic processes, the pathology also may obscure normal functioning. The injured brain must jury-rig new ways of functioning, while the person coping with affliction adopts new strategies for adaptation.

Human brain research has benefited enormously from the development of noninvasive neuroimaging techniques at multiple spatial and temporal resolutions, especially electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). EEG techniques involve the use of electrodes attached to the scalp to measure the electrical activity of the brain, particularly the outer cortical layers. The main advantage of this technique is its temporal resolution: it can capture rapid changes (in milliseconds) in brain activity. Its spatial resolution is less impressive. Originally, it could give only a rough measure of cortical activity over a wide area; thanks to new analytic techniques, underlying activity deeper in the brain can be inferred, although still not with extreme precision. That said, EEG is inexpensive and can be done with small, portable equipment allowing studies of activity in more ecologically valid, real-world settings. It can detect synchronous activity among brain networks in the form of specific rhythms that may be associated with particular aspects of brain functioning. EEG can be used to measure event-related potentials (ERPs). ERPs measure electrical activity triggered by specific stimuli and thus can indicate sensory, orienting, attentional, and decision-related responses to a stimulus over the scale of milliseconds. In suitable experimental setups, this allows investigators to unpack the sequence of steps in processing particular kinds of information and build models of attention and cognition.

Magnetic resonance imaging (MRI) can produce detailed pictures of an individual's brain. These can be used to study anatomical differences in the brains of people with different developmental histories, psychological characteristics, or forms of pathology. Functional magnetic resonance imaging examines changes in blood flow to specific regions of the brain, which provides an indirect measure of local metabolic and processing activity. In experiments, fMRI can be used to study dynamic global (whole-brain) and regional neural activity associated with experiential states such as self-related thinking or particular cognitive tasks. Newer methods, such as forms of diffusion MRI, allow us to reconstruct anatomical pathways, taking us a step closer to a comprehensive map of the brain's neural circuitry or "connectome" (Shi & Toga, 2017). This has given rise to a rapidly growing body of work that explores how circuits of the brain subserve particular cognitive functions or behaviors and how neurodevelopment, learning, and experience reconfigure the connectivity of the brain.

The neurodevelopmental processes that give rise to human capacities for language, thought, and creativity extend beyond the brain to include interactions with the environment and, especially, with other people. On a small scale, we can study these interactions in the laboratory by examining brain function in response to socially and ecologically meaningful stimuli. Methods

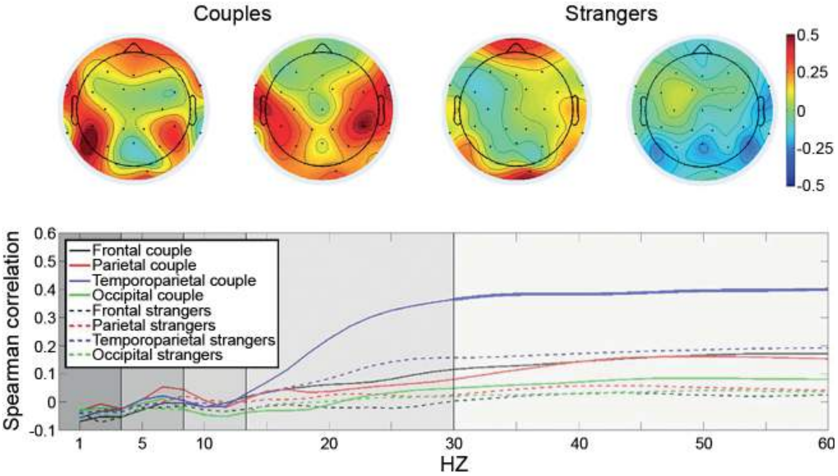

Figure 1.2 Brain-to-brain synchrony in a couple and a dyad of strangers. Kinreich and colleagues simultaneously measured the EEGs of romantic couples and pairs of strangers while the dyads were engaged in a free conversation about a "positive theme." The study found greater neural synchrony in the form of gamma-rhythm correlations in temporal-parietal areas (blue line in graph) among the couples than among the strangers. From "Brain-to-Brain Synchrony during Naturalistic Social Interactions," by S. Kinreich, A. Djalovski, L. Kraus, Y. Louzoun, and R. Feldman, 2017, *Scientific Reports, 9,* 17060 (https://doi.org/10.1038/s41598-017-17339-5). https://creativecommons.org/licenses/by/4.0/

of hyperscanning, for example, imaging the brains of two or more people while they interact with each other in naturalistic settings, can reveal the processes of coordination, synchrony, and mutual regulation that may underlie crucial aspects of social behavior and help account for aspects of our feelings of empathy and mutual understanding or of strangeness and hostility (Babiloni & Astolfi, 2014; Bilek et al., 2015; Hirsch et al., 2017; Kinreich et al., 2017; Saito et al., 2010). Figure 1.2 illustrates how brain correlates of dyadic interactions can be explored in the laboratory. These new technologies allow us to move beyond theory construction to begin to explore the functional links between the brain and the social world.

4-E Cognitive Science and Predictive Processing as Unifying Frameworks

In each generation, neuroscience has used models and metaphors drawn from contemporary technologies and social arrangements to think about the brain

(Borck, 2012). For Descartes (1649/1989; see also Hatfield, 2007), the brain was the mediator between an immaterial soul and a biological machine. For nineteenth and early twentieth century physiologists such as Sechenov (1863/1965), Sherrington (1906), and Pavlov (1928), the brain was a hierarchy of reflex arcs. The dense forest of neurons revealed under the microscope by the anatomist Ramón y Cajal (1909) was thought to account for the complexity of behavior, but the organizational principles of neural networks have only slowly yielded their secrets (Sporns, 2012). At any historical moment, our most complex artifacts provide us with models and metaphors for brain functioning. Over the course of the twentieth century the brain was successively likened to a telephone switchboard, a cybernetic control system, and a digital computer (Ashby, 1952; Pickering, 2010; Von Neumann, 1958; Wiener, 1948). Each analogy contributed to advancing theory and research, but none is adequate to capture the brain's complexity.

While early work in computational neuroscience revealed that even simple idealized neurons suitably arranged could, in principle, constitute a Turing machine, capable of computing any computable number (McCulloch & Pitts, 1943), the brain is not a single general-purpose digital computer, but a bundle of more specialized mechanisms, organized to enable specific kinds of ecologically meaningful action. The peculiar strengths and limitations of human cognition suggest that brain structures and circuits that emerged for specific adaptive purposes are recruited for new tasks. For example, our visual and linguistic systems did not evolve to read, but have been recruited to serve this cultural practice (Dehaene, 2009).

The reflex arc picture of the brain fits a stimulus–response view of learning and behavior that could be adapted to model the processes of Pavlovian (classical) conditioning and operant (reinforcement) learning. However, during the last century it became increasingly clear that the brain is not usually sitting idle, waiting for environmental stimuli to provoke its response, but is ceaselessly active. Our brains are restless, constantly anticipating potential events, scanning our bodies and the world for news, seeking out novelty, and elaborating imaginative scenarios. Current models of the brain draw from work in artificial intelligence to depict the brain as networks of neurons that are engaged in *active inference*: working constantly to predict their input. On this view, the brain is a prediction machine, anticipating its environment, noticing discrepancies between expectation and reality, and working to refine its predictions to make them more accurate or acting on the environment to make it conform to predictions (Clark, 2015; Friston, 2010; Hohwy, 2013).

Predictive processing models generally propose that the brain is not a diffuse network with neurons interconnected to each other willy-nilly, but is instead structured into layers, with connectivity within each layer distinguished from connections to the layers above and below (Kaiser et al., 2010;

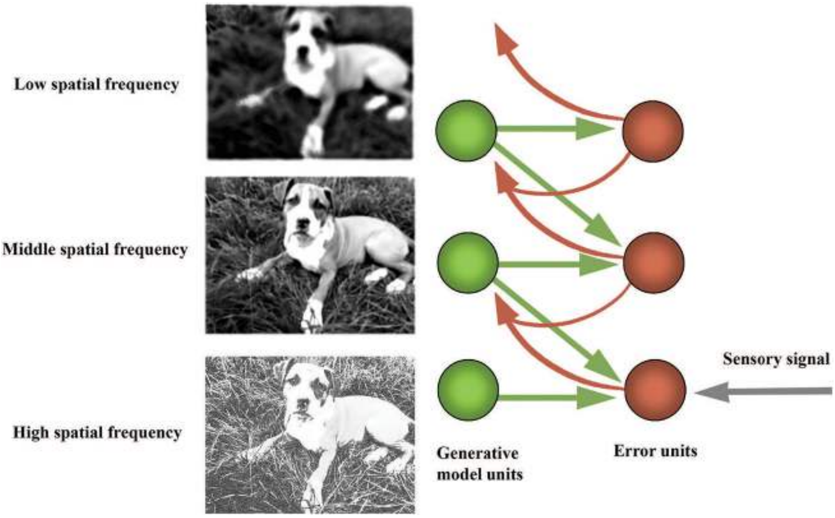

Figure 1.3 An illustration of hierarchical predictive coding. Predictive processing of visual perception involves multiple levels of spatial-temporal resolution. On the left, we see the same image (of a dog) decomposed into high, medium, and low spatial frequency information. High spatial frequency information changes faster than low spatial frequency information (e.g., lips and eyes change more over the course of a conversation than do larger facial features). On the right is a representation of the layers of predictive processing by the brain's neural networks. Layers closer to the sensory periphery (or bottom of the hierarchy), encode fast-changing phenomena that unfold over small spatial ranges. Layers near the top of the hierarchy, encode slower-changing phenomena. In predictive processing models, predictions flow from top to bottom; discrepancies between predictions and what is sensed at any layer ("prediction errors") are sent up the hierarchy. This organization endows the brain with a functional anatomy that enables it to embody context and leverage that context to guide its behavior.
From "Cultural Affordances: Scaffolding Local Worlds through Shared Intentionality and Regimes of Attention," by M. J. D. Ramstead, S. P. L. Veissière, and L. J. Kirmayer, 2016, *Frontiers in Psychology, 7*, 1090 (https://doi.org/10.3389%2Ffpsyg.2016.01090). https://creativecommons.org/licenses/by/4.0/

Park & Friston, 2013). This allows hierarchical processing, in which each layer successively encodes regularities at larger scales (that is, phenomena that extend over longer spans of time and/or larger regions of space) than the layers below, and the brain re-represents the causes of its sensation at all these different scales with dedicated layers (Badcock, Friston, & Ramstead, 2019; Badcock, Friston, Ramstead, Ploeger, et al., 2019; see also Figure 1.3). The