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SOCIAL NEUROSCIENCE AND ITS RELATIONSHIP TO SOCIAL PSYCHOLOGY

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Social species create emergent organizations beyond the individual. These emergent structures evolved hand in hand with neural, hormonal, cellular, and genetic mechanisms to support them because the consequent social behaviors helped these organisms survive, reproduce, and care for offspring sufficiently long that they too reproduced. Social neuroscience seeks to specify the neural, hormonal, cellular, and genetic mechanisms underlying social behavior, and in so doing to understand the associations and influences between social and biological levels of organization. Success in the field, therefore, is not measured in terms of the contributions to social psychology per se, but rather in terms of the specification of the biological mechanisms underlying social interactions and behavior—one of the major problems for the neurosciences to address in the 21st century.

Social species, by definition, create emergent organizations beyond the individual—structures ranging from dyads and families to groups and cultures. These emergent social structures evolved hand in hand with neural, hormonal, cellular, and genetic mechanisms to support them because the consequent social behaviors helped these organisms survive, reproduce and, in the case of some social species, care for offspring sufficiently long that they too reproduced thereby ensuring their genetic legacy. Social neuroscience is the interdisciplinary field devoted to the study of these neural, hormonal, cellular, and genetic mechanisms and, relatedly, to the study of the associations and influences between social and biological

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levels of organization. Humans are a somewhat unique social species in that our social institutions, civilizations, and cultures are highly developed and our territorial reach knows few boundaries (Gazzaniga, 2008). Our biology has helped shape the social environments we have created, and our social environment has helped shape our genes, brains, and bodies. Social neuroscience can be viewed as a single, overarching paradigm in which to investigate human behavior and biology, and to investigate where we as a species fit within the broader biological context.

Social psychology is a science of social behavior, as well, but the emphasis is on how thought, feeling, and behavior of individuals are influenced by the actual, imagined, or implied presence of others. Social perception and social cognition—intrapersonal level psychological processes, and social interaction and influence—interpersonal and group processes, are both vital aspects of social psychological analyses of behavior. Although investigations of the role of biological factors can be found in social psychology (Cacioppo, Petty, & Tassinary, 1989), the field has emphasized the role of situational factors and, in collaboration with personality theorists, the role of dispositional factors. Because the focus of both is social behavior, social psychology and social neuroscience have the potential to be aligned and thereby potentially inform constructs and theories in each (Berntson & Cacioppo, 2008). The emphasis in each is sufficiently different that neither field is in danger of being reduced to or replaced by the other, but articulating the different levels of analysis can provide a better understanding of complex social phenomena.

BACKGROUND

During much of the 20th century in the neurosciences, the individual was treated as the fundamental unit of analysis, and the brain was treated as a solitary information-processing organ. This is an entirely understandable starting point. The brain, the organ of the mind, is housed deep within the cranial vault, where it is protected and isolated from others, as are the neural, hormonal, and genetic processes of interest to most biological scientists. Even cognition, emotion, and behavior can be thought of as beginning with the neurobiological events within individual organisms, events that can be isolated and examined. It should be no surprise, therefore, that the study of human behavior by neuroscientists, and many cognitive and behavioral scientists, in the 20th century tended to focus on single organisms, organs, cells, intracellular processes, and genes.

Further contributing to this backdrop is the premise in the neurosciences that investigation of the mechanisms upon which behavior are based is best addressed at as small a scale as possible. As Llinás (1989) noted: . . . the brain, as complex as it is, can only be understood from a cellular perspective. This perspective has been the cornerstone of neurosciences over the past 100 years (p. vii).

An erroneous extrapolation drawn from this perspective is that the contributions of the social world are largely irrelevant with respect to the basic development, structure, or processes of the brain and behavior, and, therefore, social factors are of little interest. To the extent that social factors were suspected of being relevant, their consideration was thought to be so complicated that they should be considered at some later date, if at all, once the basic mechanisms underlying the human brain and behavior had been determined.

The approach of social psychologists throughout most of the 20th century was no less focused than that of neuroscientists. World wars, a great depression, and civil injustices made it amply clear that social and cultural forces were too important to await the full explication of cellular and molecular mechanisms (Allport, 1947). Moreover, from the perspective of social psychology, social factors ranging from mother-infant attachment to culture defined and shaped who we are as a species. As a consequence, neural structures and processes were routinely ignored.

THE QUESTION OF CONTRIBUTIONS

Human social behavior is complex, and many behaviors can be ambiguous as to their origins. One may eat because one is hungry, but often it is a habit to eat at a particular time of day, or a social occasion in which the consumption of food is the norm. The identification of which genes, gene transcripts, proteins, cells, cell assemblies, brain regions, and neural networks are relevant to a given behavior is advanced by the empirical isolation of the underlying psychological component processes. Social psychology is rich in theoretical models that specify conceptual structures and processes underlying a variety of social behaviors, and behavioral paradigms exist that permit the isolation of posited structures and processes for empirical analysis. These theoretical specifications and paradigms are important for understanding the biological bases of social psychological and behavioral processes because the brain and genes are sufficiently complex that the identification of their operation is likely to be fostered by theories of the mind and behavior to guide the process of empirical exploration and discovery.

Social neuroscience, therefore, has much to gain from the extant work in social psychology. This is not the contention in this special issue, but rather the question is whether social psychology has anything to gain from social neuroscience. In one sense, it wouldn't undercut social neuroscience if the answer to this question were "no." Social neuroscience seeks to specify the neural, hormonal, cellular, and genetic mechanisms underlying social behavior, and in so doing to understand the reciprocal associations and influences between social and biological levels of organization. Success in the field, therefore, is not measured in terms of the contributions to social psychology per se, but rather in terms of the specification of the biological mechanisms underlying social interactions and behavior—an objective Frith and Wolpert (Frith & Wolpert, 2004) characterized as one of the major problems for the neurosciences to address in the 21st century.

Social neuroscience is also grounded in the premise that there are lawful relationships among biological, psychological, and social processes. This notion dates back at least to the third century B.C.E., when the Greek physician Erasistratos used his observations of peripheral physiological responses, such as the appearance of an irregular heartbeat and pallor in a young man when his stepmother visited, to identify the cause of the individual's malady—lovesickness (Mesulam & Perry, 1972). As this historical example suggests, as the fields of social psychology and social neuroscience become aligned—that is, as the mapping between measures and constructs across these levels of organization is specified –data and theory from social neuroscience can contribute to empirical tests and theoretical developments in social psychology. In addition, new theoretical insights and testable hypotheses in social psychology may be suggested by structures and processes identified, and the theories developed, in social neuroscience—as exemplified in the extant social psychological literature on emotional contagion (Hatfield, Cacioppo, & Rapson, 1994), empathy (Yamada & Decety, 2009), embodied cognition (Cacioppo, Priester, & Berntson, 1993; Niedenthal, 2007), health and well being (Cacioppo & Patrick, 2008), self-regulation (Ochsner, Hughes, Robertson, Cooper, & Gabrieli, 2009), and the heterarchical organization of evaluative processes (Berntson & Cacioppo, 2008; Cacioppo, Berntson, Norris, & Gollan, in press).

IMAGING THE WORKING HUMAN BRAIN

For most of the 20th century, investigations of the brain mechanisms underlying social psychological processes were limited in animals to methods such as brain lesions, electrophysiological recording, and neurochemistry and in humans to postmortem examinations, observations of the occasional unfortunate individual who suffered trauma to or disorders of the brain, electroencephalography and event related brain potential recording in response to specific cognitive or behavioral tasks (Raichle, 2000; Sarter, Berntson, & Cacioppo, 1996). Developments in multimodal structural, hemodynamic, and electrophysiological brain imaging acquisition and analysis techniques; more sophisticated specifications and analyses of focal brain lesions; focused experimental manipulations of brain activity using transcranial magnetic stimulation and pharmacological agents; and emerging visualization and quantitative techniques that integrate anatomical and functional connectivity—in addition to information about neural processes at different scales of organization—are creating new opportunities for scientific investigations of the working human brain. Despite the increased sophistication and data yield from recent advances that make it possible to observe the operation of the working brain at various levels of analysis, however, an atheoretical exploration alone is not likely to yield many major discoveries of the working social brain and behavior. Our understanding of the neural basis of specific social processes may be informed by well-designed tasks that isolate those processes:

> . . . the task of functional brain imaging becomes clear: identify regions and their temporal relationships associated with the performance of a well-designed task. The brain instantiation of the task will emerge from an understanding of the elementary operations performed within such a network. (Raichle, 2000, p. 34)

HUMAN NATURE AND THE NEED FOR SOCIAL CONNECTION

The emergent structures that define social species are not simply late tangential add-ons, but rather they are shaped by and in turn shape basic neural, hormonal, cellular, and genetic mechanisms, and they are important for normal mental and physical development and functioning. For instance, individual members of social species do not fare well when living solitary lives. Social isolation decreases the lifespan of social species ranging from *Drosophila* (Ruan & Wu, 2008) to Homo sapiens (House, Landis, & Umberson, 1988). Humans, born to the longest period of total dependency of any species and dependent on conspecifics to survive and prosper across the lifespan, fare poorly both mentally and physically when they are socially isolated or they perceive they are socially isolated (Cacioppo & Patrick, 2008). The mechanism suggested initially for the association between social isolation and mortality in humans was that isolated individuals engage in poorer health behaviors (House et al., 1988). This hypothesis is not strongly supported by the data in humans and cannot account for the effects of social isolation in nonhuman social species, but instead evidence is accruing in humans that social isolation, and especially perceived isolation, has deleterious effects on health through its effects on the brain, hypothalamic pituitary adrenocortical axis, vascular processes, blood pressure, gene transcription, inflammatory processes, immunity, and sleep (see review by Cacioppo & Hawkley, 2009).

Hominids have walked the earth for approximately 7 million years, with Homo sapiens having evolved within approximately the last 1% of that period, only the last 5 to 10% of which is characterized by human achievements and civilization we now take for granted. The attributes of *Homo sapiens* responsible for our success as a species are debatable, but the number of genes and the size of the human brain are themselves insufficient explanations. Estimates among biologists a decade ago were that 100,000 genes were needed for the cellular processes responsible for human social behavior, but humans have only about a quarter that number of genes (see review by Cacioppo et al., 2007). The prefrontal cortex is thought to be particularly important for critical behaviors such as executive function and working memory, yet the ratio of prefrontal to total cortical gray matter is no greater in humans than it is in nonhuman primates. Although humans may have more cortical neurons than other mammals, they have barely more than whales and elephants. The specialized capacities of humans may result from the increased number and processing capacity of synapses in the brain, greater cell-packing density, greater connectivity, and higher neural-conduction velocities, raising the brain's overall information-processing capacity. Other specialized capacities of humans range from hands with fingers and thumbs to theory of mind and language. Together, these properties support complex and coordinated collective enterprises. In short, our brains have evolved to connect to other minds, and our remarkable accomplishments as a species reflect our collective ability rather than our individual might. Accordingly, there is a growing potential for social neuroscience to inform social cognition, emotion and behavior, as illustrated for instance by the growing literature on oxytocin and trust (e.g., Norman et al., in press) and on brain, genes, and culture (Chiao & Blizinsky, 2010).

BUT WAIT

Social neuroscience emerged in the early 1990s as an interdisciplinary field devoted to understanding how biological systems implement social processes and behavior, capitalizing on biological concepts and methods to inform and refine theories of social processes and behavior, and using social and behavioral concepts and data to inform and refine theories of neural organization and function (Cacioppo & Berntson, 1992). Social neuroscience as an approach has faced skeptics representing two diametrical positions in the social and biological sciences.

The first is the view that social neuroscience deals in dualistic reasoning:

> Historically, the question of the relation of the body to the mind was, at best, opaque; the mental attributes of humans were only vaguely related to the attributes of the brain. Despite the increase in our knowledge of brain morphology and function at the end of the nineteenth century and the beginning of the twentieth century, there was still a feeling among many scholars that the nature of human reason might be related to some new and wonderful knowledge totally alien to that which is accessible through the scientific method. (Llinás, 1989, p. vii)

The scientific study of the brain mechanisms underlying social processes and behavior is premised on the rejection of René Descartes' contention that because the body existed in time and space and the mind had no spatial dimension, the body and mind were made of completely different stuff. Chemists who work with the periodic table on a daily basis use recipes rather than the periodic table to cook not because food preparation cannot be reduced to chemical expressions but because it is not cognitively efficient to do so. The scientist who uses theoretical constructs is no more a dualist than a chemist who uses both culinary and chemical levels of analysis to understand what it takes to develop fine cuisine.

A second set of skeptics has argued that any reductionistic account of mental or behavioral phenomena provided by the neurosciences eliminates the essence of the psychological level of analysis (e.g., Coltheart, 2006; Kihlstrom, this issue). However, social neuroscience is not a substitute for the behavioral or social sciences, it is an interdisciplinary field that draws on these sciences as well as on the neurosciences to provide an integrative paradigm in which to investigate complex human behavior across levels of organization, from the molecular to the molar. The brain is the organ of the mind, and psychological analyses are important if we are to understand how the brain functions to produce mental processes (Cacioppo & Decety, 2009). As we understand brain function better, opportunities for reciprocal insights arise. For instance, studies of the conceptual organization of emotion have suggested that affective space is organized around two basic dimensions: a bipolar valence dimension and an orthogonal arousal dimension (Russell & Carroll, 1999). Based on neuroscientific as well as behavioral evidence that appetitive and aversive stimuli activate separable underlying mechanisms, we have developed a model of the affect system in which the bipolar valence dimension is a derived rather than a basic dimension (Cacioppo, Gardner, & Bernston, 1999; Cacioppo et al., 2010).

In a second example, Waytz and colleagues (2010) reasoned that people anthropomorphize, in part, to satisfy *effectance motivation*—the basic and chronic motivation to attain mastery of one's environment. Five behavioral studies demonstrate that increasing effectance motivation by manipulating the perceived unpredictability of a nonhuman agent or by increasing the incentives for mastery increases anthropomorphism of that agent. Were participants thinking about the mental states of the gadgets or were they simply thinking about the unpredictability of the gadgets? Based on the extant literature in cognitive and social neuroscience, Waytz et al. (2010) derived competing hypotheses about which areas of the brain should show changes in hemodynamic response if the participants were thinking about the mental states versus the unpredictability of the gadgets. Following hypothetico-deductive logic (no reverse inferences were necessary; see Cacioppo & Tassinary, 1990), the hypothesis that participants were focusing on the unpredictability of the gadgets could be rejected based on the inconsistency between the predicted and observed hemodynamic brain responses.

One might argue that the behavioral evidence in each of these examples was sufficient, and whether or not this is the case depends on your point of view. We can all agree, however, that converging evidence, especially from disparate sources, makes a stronger empirical case for a proposition than evidence from a single source.

DOCTRINE OF MULTILEVEL ANALYSIS

Whether or not social psychologists choose to draw from fields outside their own is a personal choice, but we would contend that comprehensive theories of social behavior ultimately will require that scientists also consider biological factors. Indeed, from the outset the field of social neuroscience has been grounded in three principles (Cacioppo & Berntson, 1992). The first, the principle of *multiple determinism,* specifies that a target event at one level of organization can have multiple antecedents within or across levels of organization. On the biological level, for instance, researchers identified the contribution of individual differences in the endogenous opiod receptor system in drug use, whereas on the social level investigators have noted the important role of social context. Both operate, and our understanding of drug abuse is incomplete if either level is excluded. Similarly, immune functions were once considered to reflect specific and nonspecific physiological responses to pathogens or tissue damage. It is now clear that immune responses are heavily influenced by central nervous processes that are affected by social interactions. It is clear that an understanding of immunocompetence will be inadequate in the absence of considerations of social and behavioral factors. The implication is that major advances in the neurosciences and the social sciences can result from increasing the scope of the analysis to include the contributions of factors and processes from both perspectives.

An important corollary to this principle is that the mapping between elements across levels of organization becomes more complex (e.g., many-to-many) as the number of intervening levels of organization increases. One implication is that the likelihood of complex and potentially obscure mappings increases as one skips levels of organizations. This is one reason that going from the genotype to endophenotypes and from endophenotypes to phenotypes has proven to be more productive than going directly from the genotype to phenotype. Similarly, mapping neural regions of activation to social behavior should prove more tractable if the intervening social information processing computations and operations are considered, as well. For instance, the question of the self has been the target of various neuroimaging investigations during the past decade (e.g., D'Argembeau et al., 2010; Decety, & Sommerville, 2003; Mitchell et al., 2005). A number of concepts have been used including but not limited to the present self, distant self, experiential self; prereflexive self, mental self, core self, minimal self, spatial self, emotional self, autobiographical self, and narrative self. A similarly large number of regions have been associated with the self including the medial prefrontal cortex, ventro- and dorsolateral prefrontal cortex, lateral parietal cortex, bilateral temporal poles, insula, and subcortical regions such as the brain stem, colliculi, and periaqueductal gray (see Northoff et al., 2006 for a meta-analysis). It may be futile to seek a correlation between the "self" and brain processing without breaking down the concept of self into component processes that are plausibly implemented in specific brain regions. (See Decety, 2010, for a component analysis of empathy and the corresponding brain regions associated with each of these components.)

The second principle is of *nonadditive determinism*, which specifies that properties of the whole are not always readily predictable from the properties of the parts. Consider an illustrative study by Haber and Barchas (Haber & Barchas, 1984), who investigated the effects of amphetamine on primate behavior. The behavior of nonhuman primates was examined following the administration of amphetamine or placebo. No clear pattern emerged between the drug and placebo conditions until each primate's position in the social hierarchy was considered. When this social factor was taken into account, amphetamine was found to increase dominant behavior in primates high in the social hierarchy and to increase submissive behavior in primates low in the social hierarchy. A strictly physiological (or social) analysis, regardless of the sophistication of the measurement technology, may not have revealed the order that existed in these data. These data, then, illustrate how the combination of neural and social variables can produce emergent phenomena that would not be predictable from a neuroscientific or social psychological analysis alone. More specifically, given a neurochemical explanation at one level, we require a further social-behavioral explanation at another level to explain the effects of amphetamines on behavior.

The third principle is of *reciprocal determinism*, which specifies that there can be mutual influences between biological and social factors in determining behavior. For example, not only has the level of testosterone in nonhuman male primates been shown to promote sexual behavior, but the availability of receptive females influences the level of testosterone in nonhuman primates (e.g., Rose, Gordon, & Bernstein, 1972). Accordingly, comprehensive accounts of these behaviors cannot be achieved if the biological or the social level of organization is considered unnecessary or irrelevant.

In sum, merely observing social behavior in context may not neatly reduce to a neurophysiological account in terms of a total explanation of the same phenomenon. A complete explanation of social behavior is enabled by the multi-level integrative approach of social neuroscience.

CONCLUSION

It is the mounting evidence for the importance of the relationship between social events and biological events that has prompted biological, cognitive, and social scientists to collaborate more systematically, with a common belief that the understanding of mind and behavior could be enhanced by an integrative analysis that encompasses levels of organization ranging from genes to cultures. Indeed, there has been a dramatic growth in social neuroscience over the past two decades. Subareas within the broad perspective of social neuroscience include social cognitive neuroscience, social affective neuroscience, cultural neuroscience, computational social neuroscience, social developmental neuroscience, and comparative social neuroscience.

One can question whether social constructs, once reduced to their neural, hormonal, and genetic components, will be relegated to the junk pile of excess theoretical baggage. There is no precedent in the history of science for such an outcome. Biochemistry did not replace biology or chemistry but rather as an interdisciplinary perspective that drew on both biology and chemistry it has benefitted from and, in time, contributed to both fields. The constructs developed by social psychologists provide a means of understanding highly complex social processes and behavior without needing to specify each individual action by its simplest components, thereby providing a cognitively efficient approach to describing complex systems. By analogy, chemists who work with the periodic table on a daily basis use recipes rather than the periodic table to cook, not because they think the recipes couldn't be expressed as chemical equations but because it would be cognitively inefficient to do so. The efficiency of expression is not the only issue: The concepts defining fine cuisine are not part of the discipline of chemistry. The theoretical terms of the behavioral and social sciences are similarly valuable in relation to those of the neurosciences, but can be informed and refined through integration with theories and methods from the neurosciences. The field of social neuroscience, therefore, represents an interdisciplinary perspective that embraces animal as well as human research, patient as well as nonpatient research, computational as well as empirical analyses, and neural as well as behavioral studies.

Like any new field, social neuroscience faces problems and challenges that must be acknowledged and addressed. Doing so facilitates efforts in the field to provide more comprehensive accounts for the basic structures, processes, and behaviors of humans and other complex social species. The value of a special issue such as this is its stimulation of just such considerations by articulating the distinct yet complementary objectives of social psychology and social neuroscience, acknowledging contemporary problems and challenges in the field, providing a review of research in social neuroscience that has affected research and theory in social psychology, and identifying some of the most fertile paradigms and areas of future inquiry.

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