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Developments in Neurosociology

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Abstract

Neurosociology is a multilevel, integrative perspective that does not replace, but rather strengthens and is strengthened by, more established sociological traditions. It is a tract of common ground with the neurosciences and other “neuro friendly” social sciences, and so it heralds an exciting period of discovery through an unprecedented synthesis of ideas. To facilitate the continued progress of neurosociology, we address two pressing goals. First, we aim to help sociologists better understand and appreciate the unique and important benefits of thinking neurosociologically. We describe several programs of research in social psychology where the benefits of a neurosociological approach are already being delivered. We show how “interdisciplinarity” involving sociology and neuroscience can (i) contribute to answering nagging questions at the nexus of method and theory, (ii) stimulate theoretical progress by allowing us to take new angles on old problems, and (iii) help us develop useful practical applications. Second, we discuss the need to make the tools of the neurosciences more accessible to sociologists. Interdisciplinary trends are occurring that will take us part of the way, but much of the work is still left to us. We provide some suggestions to help interested colleagues access the means to conduct neurosociological research.

Introduction

Imagine an actuary contracted to improve our understanding of the various factors that contribute to automobile fatalities. Certainly factors at the individual level (driver characteristics), vehicle level (safety features), and “macro” level (traffic patterns, road maintenance, etc.) would all receive some consideration in the analysis. We would probably dismiss someone who, simply because of her or his background, insisted on examining one set of factors to the exclusion of all others. What we seem to be realizing now as we move deeper into an interdisciplinary age of science is that such single-track thinking can be just as counterproductive when it comes to the scientific understanding human behavior *in general*. During the 1990s—i.e. during the “decade of the brain” and with the emergence of social neuroscience—studies directed attention to the brain and how it matters for human social behavior. But even before then, neuroscience had begun to reveal that *environmental* factors matter too, particularly insofar as they matter for the brain (and thus behavior), and not just during the developmental years. And now as we enter the “new century of the brain” (Yuste and Church 2014), what is sure to increasingly guide the study of human social behavior is the developing multi-level, multi-disciplinary agenda between the neurosciences and the social sciences—an agenda that will bring sociology more and more into the fold.

With the rise of “neurosociology” over the last several years, it is clear that this progression is already underway. To help it along, one of the main tasks that must be accomplished is to help sociologists better understand and appreciate the unique and important benefits of thinking neurosociologically. Equally important, if not more important, is the need to make the tools of the neurosciences more accessible to sociologists. Even where intellectual interest exists, it is more often than not extremely difficult for sociologists to conduct research on

neurosociological topics, especially original empirical research, yet this may be about to change. We address both of these important issues below. Before turning to them, though, we begin by briefly discussing the relationship between social neuroscience and neurosociology. How did these fields arise? How are they unique? What is the common ground?

Social neuroscience and sociology

For most of the long history of the neurosciences, the prevailing belief was that the nervous system, including the brain, is fixed by the time an organism reaches maturity and that complex social phenomena are reducible to brain activity. This deterministic and reductionist position was, of course, anathema to sociologists. During the latter half of the 20th century, though, evidence had begun to show that environmental factors affect brain structure and function beyond the developmental years. Despite initial skepticism among neuroscientists, the view of the brain as an endogenous factor within a multi-level, reciprocally causal system gradually began to take hold. By the early 1990s psychologists had put forth a “doctrine of multilevel analysis” (Cacioppo and Berntson 1992), and this more or less officially marked the beginning of an interdisciplinary marriage between psychology and neuroscience. Thus was born the field of “social neuroscience,” the goal of which is to develop more comprehensive explanations of human behavior by examining factors within and across the neurobiological, psychological, and social psychological levels of organization.

Given these developments, it is not surprising that sociologists were next to enter the dialogue in a serious way. If levels of organization are complexly interactive, then what is the role of larger-scale social processes and elements of social organization, such as interaction, culture, and social structure? TenHouten and Kaplan (1973) had introduced the idea of “neurosociology” long before social neuroscience was even recognizable by name, but a comprehensive explication of the paradigm did not come along until years later. In his pioneering book on *Neurosociology: The Nexus Between Neuroscience and Social Psychology*, Franks (2010) details a sociological view of “the social brain,” traces the roots of the perspective across disciplines, provides examples of research consistent with a neurosociological approach, and lays out a research agenda that expands the doctrine of multilevel analysis to include higher levels of organization (see also Franks and Turner 2013).

In terms of meta-theoretical goals, we actually see little reason to differentiate between social neuroscience and neurosociology. Indeed, we think a strict demarcation between them would be counterproductive. While those working in these subfields usually have more expertise in one area than others (e.g. the typical neurosociologist will know a lot more about sociology than psychology or neurobiology), the unifying theme is that the challenges of multilevel analysis and interdisciplinary collaboration are well worth the effort. To spell out why, we now turn our attention to a description of some of the unique and important benefits of neurosociological analysis.

Some benefits of the neurosociological paradigm

Benefit 1: advancing theory with method

In the seminal BBC television documentary series, “The Ascent of Man,” the eloquent historian of science and program host, Jacob Brownowski, warned of the dangerous lure of epistemological certainty: “There is no absolute knowledge,” he said, “and those who claim it, whether they are scientists or dogmatists, open the door to tragedy. All information is imperfect. We have to treat it with humility.” Here Brownowski was not trying to suggest that there is no external

truth or that all knowledge claims are on equally shaky ground. Rather, the critical point he makes is that *knowledge is tightly bound with method*. He invites us to consider, for example, how differently we would describe the world if our eyes, as a “method” of knowing, were sensitive to the infrared range of the electromagnetic spectrum rather than the band we call “visible light.”

Indeed, one of the first things that new sociology students learn, as well they should, is that theoretical knowledge and method are inextricably linked. Our explanations of social organization and behavior are tied to the techniques and methods we use to collect information about phenomena, measure concepts, and test hypotheses. In other words, what we know is bound not only by theory itself, but also by the methodologies we use to test and develop our theories. This includes in no small way specific measurement techniques (Thye 2000). Neuroscientific methods, as we will see, allow us to observe both conscious and unconscious thought and emotional processes as they occur in real time, and without the always-looming possibility of intentional response bias (Laureiro-Martinez, Brusoni, Canessa, and Zollo 2015). As such, neuroscience methods have great potential to advance theory.

Description and comparison of methods

Here we overview two of the most commonly used research tools for studying brain activity: functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). These two methods have different strengths and weaknesses, and ideally the choice of whether to use one or the other or both is driven by the research question. If the goal is to “localize” the source (or sources) of brain activity in connection with a stimulus, then fMRI is typically the preferred choice. However, while fMRI can pinpoint activity in the brain with millimeter precision (i.e. it has excellent spatial resolution), there are some drawbacks to its use. First, fMRI is fairly invasive. Participants lie prone in a confined space inside a large, noisy scanner, and they must remain as still as possible during scanning. To the extent that participants find these conditions distracting and/or discomforting, the result may be poor-quality data. Second, fMRI is very expensive. Scanners with sufficient resolution for neurobehavioral research cost millions of dollars, not to mention the costs of permanent facility construction, installation, and regular maintenance. Most research universities rent scanner time for around 500 hundred dollars per hour, so it may be several years of full-time use before the machine pays for itself. Given the high costs associated with setting up an fMRI facility, the technology is simply not available at most universities. Third, fMRI does not directly measure brain activity. Instead, activity is inferred from changes in blood-oxygen levels over time. Increased blood-oxygen in an area of the brain is taken as an indication of greater activity in that area. Finally, while the spatial resolution of fMRI is very high, the temporal resolution of the method is low (3–6 s). Accordingly, fMRI is not fast enough to distinguish the *order* of activation patterns corresponding to the stages of stimulus processing, which may be critical information for testing a given neurosociological theory.

When high temporal resolution is the primary concern, EEG is generally regarded as the better option. With blazing millisecond resolution, EEG measures the electrical current of groups of neurons “firing” together in response to stimulus events. Unlike fMRI, then, another benefit of EEG is that it provides a direct measure of neural activity in the brain (Bunge and Kahn 2009). This activity is typically measured using a “net” of small electrodes placed at standardized locations across the scalp, often with the aid of specialized caps that make application relatively quick and easy. The electrodes in the cap are made of highly conductive metals (e.g. tin, silver, etc.), and after the cap is placed on a participant’s head, a non-irritating, non-staining, odorless, and water soluble conductive gel is applied within each electrode holder to maximize signal quality. From start of finish, a well-trained, experienced assistant can apply a 32-channel cap

such as the one shown in Figure 1 in about 15 min. During a study, electrical activity in the brain is monitored at a computer station, and recorded signals at each individual electrode are stored to hard disk for offline processing and analysis. After initial visual and software-aided processing to remove artifacts (e.g. eye blinks), analyses often involve looking at short segments of EEG data around repeated stimulus events, usually within one or more frequency bands (see below). Specific electrodes and bands of interest for analysis are chosen on the basis of past research. For statistical analyses, the data may be grand-averaged by experimental condition and then subjected to conventional tests (GLM, *t*-tests, etc.).

Again, one of the main benefits of EEG compared to fMRI is its high (millisecond-level) temporal resolution for studying the time course of cortical activity in association with stimulus events and behavior. This makes EEG ideally suited to the kinds of questions about dynamic processes that many sociologists study. EEG is also far cheaper than fMRI. Rather than costing millions of dollars, a research-grade EEG system may cost anywhere from thousands to tens-of-thousands to hundreds-of-thousands of dollars, depending on options (e.g. number of electrodes, whether commercial or open source analysis software is used, etc.).¹ Furthermore, EEG overhead costs (electrode gel, replacement electrodes, etc.) are very low. No regular maintenance plan is required. Finally, EEG is relatively non-invasive and tolerant of participant movement. Newer wireless and ambulatory systems have opened the door to exciting research applications for social scientists, including data collection in “walk around” 3-D environments and real-life field settings.²



Figure 1 Typical 32-channel EEG setup for research.

Despite these advantages, the downside of EEG compared to fMRI is its poor spatial resolution (5 to 9 cm as opposed to a few millimeters; Nunez et al. 1994; Babiloni et al. 2001). While “scalp power maps” (see below) can be used to track activity in gross regions of the neocortex, the consensus is that precise localization with EEG is simply not feasible. The electrical activity generated by neurons must pass through brain tissue, the meninges, bone, and skin before being diffused over the scalp, and this makes it very difficult to determine the origins of the activity with precision. That said, some relatively new analytical techniques such as low-resolution electromagnetic tomography (LORETA) show some promise for solving the vexatious “inverse problem” (i.e. what is the source of a measured electrical field?) and making EEG a contender for addressing source localization questions.

In practice, though, the “bread and butter” of EEG is not source localization but rather the analysis of “event-related potentials” (ERPs). ERP waves are defined as “changes in the scalp-recorded voltage over time” (Kappenman and Luck 2012:4). They are derived by averaging many short segments of EEG data collected from specific electrode positions on the scalp, usually on the basis of past research. Averaging segments from multiple trials cancels out background noise and reveals a distinct waveform that consists of a series of discrete ERP “components.” Each component can be described in terms of its latency relative to stimulus onset (in milliseconds), polarity (positive or negative), and magnitude/amplitude (in microvolts). Most importantly, different ERP components have been linked to specific brain processes (see Luck and Kappenman 2012 for an essential encyclopedic overview), and so they are very useful as direct measures of various emotional and higher-order cognitive reactions to different kinds of stimulus events, including aspects of social interaction. An example of the use of scalp power maps and ERP analysis will help illustrate the special capabilities of neurosociological analysis when it comes to advancing theory with method.

An illustration

While “identity” is one of the most important concepts in the social sciences, including in sociological social psychology, one of the most persistent questions in this area of research concerns how identity processes actually work (Schwartz, Luyckx, and Vignoles 2011). Do people desire social feedback that confirms their identities, or do they prefer feedback that makes them look good? In other words, are people motivated to verify or enhance self-views? For example, if you see yourself as a “good” student, do you want others to see you this way too, or would you happily welcome others to see you as a “brilliant” student?

While the verification/enhancement question seems simple enough, it has proved to be exceedingly difficult to resolve through empirical research. Perhaps the most important reason for this is that identity processes are not directly observable. Thus they are usually studied by focusing on more readily observed and measured “outward” responses that are assumed to be connected within the identity system. The problem, however, is that it is not always clear what is producing these responses, which complicates theory testing. For example, in a series of laboratory experiments designed to test basic predictions of identity theory (Burke 1991), Stets and her colleagues (Stets 2003, 2005; Stets and Asencio 2008) did not find support for the theory’s self-verification principle. Participants placed in a “worker” identity reported positive rather than negative emotions when they were over-evaluated by a confederate enacting a “manager” role. But according to identity theory, people are supposed to feel bad when they receive any kind of non-verifying feedback, even when it is over-evaluative. Because identity-related responses to the feedback that participants received in these studies was not (and usually is not) more directly measured, it is unclear whether the predictions of identity theory truly failed. As Stets (2005) explained, “[P]articipants may have been responding rather

immediately to the positive feedback, without considering whether it was consistent with their own [identity] standard” (p. 51). How do we know whether participants even thought about the feedback in terms of an identity? It is difficult to say, and this is an impediment to theoretical progress.

In an effort to shed light on this problem, Kalkhoff et al. (forthcoming) advanced a neurosociological account of identity processes and used EEG to measure brain responses to self-relevant feedback. Specifically, Kalkhoff and his colleagues fleshed out the neural architecture of the identity system and advanced several hypotheses linking identity verification and non-verification to specific, well-established EEG measures. Using a within-subjects design, college student participants were presented with a series of 50 adjectives related to the “student” identity (motivated, hard-working, etc.). They were asked to indicate the extent to which each adjective/identity meaning applied to them. Subsequently they received verifying feedback for half of the meanings (at random) and non-verifying feedback for the remaining half. By employing EEG, Kalkhoff and his colleagues were able to measure theoretically relevant conscious and unconscious processes more directly and without the usual uncertainty that comes with participant self-reports. Consistent with their elaborated neurosociological account of identity theory, scalp power mapping revealed that neural activity proximate to the midline of the brain increased during an “early” processing phase (around 150 ms) when feedback is unconsciously compared against the internal identity standard. As predicted, this occurred whether the feedback was verifying or non-verifying. Also as predicted, the dorsolateral prefrontal cortex (DLPFC)—an area of the brain thought to be a critical node for conscious processing—erupted with activity during a “late” processing phase (around 300 ms), *but only for trials where participants were presented with non-verifying feedback*. The video clip in Figure 2 shows this result in vivid, real-time detail.

To address the verification/enhancement question in particular, Kalkhoff and his colleagues employed event-related potential (ERP) analysis (described above). Specifically, they focused on what is known as the “feedback-related negativity” (FRN) component. The FRN occurs 200 to 300 ms after an unexpected and unfavorable feedback stimulus, and the magnitude of the FRN is related to the *degree* to which the stimulus is unexpected and unfavorable. In the

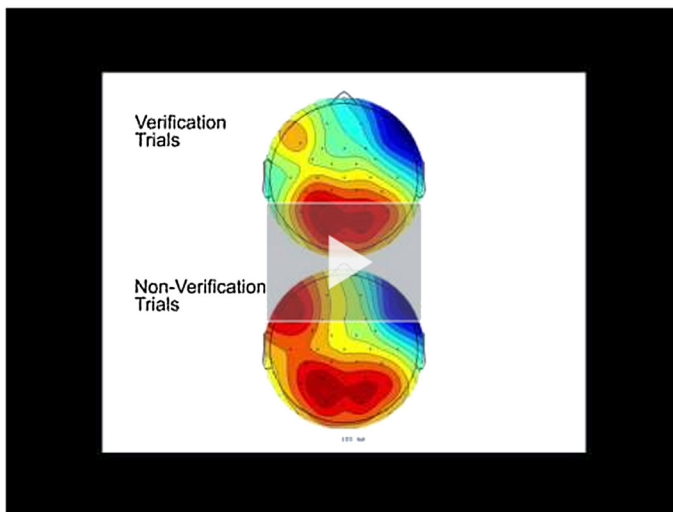


Figure 2 EEG of verifying versus non-verifying identity-relevant feedback (see Supplementary Video S1, available online).

study conducted by Kalkhoff and his colleagues, the FRN was significantly greater for socially undesirable, under-evaluative feedback than it was for comparably over-evaluative feedback. Yet according to identity theory's self-verification principle, comparable amounts of over-evaluation and under-evaluation are equally aversive. To borrow a famous expression from Georgia O'Keefe, criticism and flattery may not "go down the same drain" after all.

At least in terms of neural responses, these data suggest that self-enhancement rather than self-verification characterizes immediate reactions to identity-relevant feedback. While this does not completely resolve the larger verification/enhancement debate, the findings are important insofar as they demonstrate the utility of neurological measurement in neurosociological theory testing. Methods from the neurosciences like EEG and fMRI can offer "valuable additional information from which to draw inferences about social and psychological processes" (Cacioppo 2002:821). Perhaps even more importantly, the findings here suggest that identity processes may be supported by a general neurological system for "favorable-unfavorable" assessment (Zajonc 1984). From a theoretical standpoint, it may prove useful to think about identity processes as existing within a larger multilevel system spanning the neurological and interpersonal levels.

Benefit 2: new angles on old problems

In addition to helping advance theory, the tools of neuroscience can also help us take new angles on old problems, which is another related way by which progress can occur in a research program. Here we consider the case of research on solidarity. As Shibutani (1964) pointed out, explaining group solidarity is one of the "perennial problems" in sociology (p. 144). In sociological social psychology, one of the most rigorous accounts of solidarity is the program of research encompassing relational cohesion theory (Lawler, Thye, and Yoon 2000; Lawler and Yoon 1993, 1996) and the affect theory of social exchange (Lawler 2001, 2006). At the core of each of these theories is a three-step endogenous process that connects structural conditions to behavioral outcomes. According to the basic assumptions of the model, "favorable" structural conditions (e.g. high and equal levels of dependence among group members) lead to repeated successful exchanges of valued behaviors, goods, or outcomes, and these repeated exchanges produce positive emotions followed by perceptions of relational cohesion and, in turn, behavioral commitment to the group.

Together relational cohesion theory and the affect theory of social exchange provide a very useful sociological account of the process by which solidarity emerges in groups (see Thye, Vincent, Lawler, and Yoon 2014 for an overview). Where do we go next? We share the view that while analyses carried out at a single level of analysis are important and can often stand on their own, there is much to be gained from a multilevel analysis of behavior—one that considers both the context of human behavior (e.g. structural conditions) and the simpler, lower-level biological components that support it. Among the benefits of this approach are improved precision and the development of more comprehensive theoretical accounts (Cacioppo and Berntson 1992). Furthermore, adherence to the so-called "doctrine of multilevel analysis" ushers in the opportunity to take new angles on old problems. The simultaneous consideration of levels of analysis allows each level to inform the other(s), and this brings fresh perspective on theoretically relevant issues and paves the way for continued progress in a research program.

For instance, Lawler and his colleagues have most recently begun to pursue development of a multilevel (neurosociological) account of relational cohesion that draws on recent theoretical and methodological advances from social neuroscience. Specifically, they use EEG to experimentally investigate how "brain coordination" (Kelso, Dumas, and Tognoli 2013) represents and supports the emergence of relational cohesion and commitment during dyadic exchange

(Kalkhoff et al. 2015). Using a task adapted from Lawler and Yoon (1996), two-person teams engaged in 24 rounds of bargaining using ExNet 3.0, a web-based software system used to test exchange processes in simple (dyadic) to complex networks. The expected profit from agreement in the dyadic relation was 120 points. Each dyad was randomly assigned to either a “high total power” condition or a “low total power” condition. In the high total power condition, participants could expect to earn 50 points from a standing alternative if they failed to reach agreement with one another on any given round. In the low total power condition, participants could expect to earn 100 points from the alternative. Accordingly, there was greater incentive to reach agreement in the high total power setting than in the low total power setting. EEG data was collected simultaneously from both participants throughout the bargaining task.

As mentioned above, EEG measures electrical activity of the brain diffused across the scalp. The complex brain waves measured by EEG and displayed on a monitor in real-time during recording do not reveal much about any cognitive and/or emotional processes that may be occurring. However, decomposing brain waves measured at different scalp locations into frequency bands and comparing signal power and the similarity of wave oscillations within bands and *across participants* provides a fascinating multilevel picture of how structure fosters “coupling” across levels of analysis.

For the purposes of interpretation, EEG analyses are typically carried out within specific frequency bands: theta (4 – 7 Hz), alpha (8 – 12 Hz), beta (13 – 30 Hz), and gamma (>30 Hz) (see Figure 3). When the frequencies in the alpha band have a “weak” presence, this is an indication of greater brain activity (Coan and Allen 2004). Alpha activity is usually representative of inhibitory processes, and so decreases in alpha power over a particular brain area indicate a release from inhibition, which allows for activity in that area (Klimesch 1999). In general, good performance on cognitive (and memory) tasks is associated with a decrease in alpha power as well as an *increase* in theta band power (see Klimesch 1999 for an overview). Furthermore, high beta band power has been linked to active attention (Sanei and Chambers 2007), and high gamma band power has been linked to emotional reactions (Keil et al. 2001; Muller et al. 1999) as well as attention (Jensen, Kaiser, and Lachaux 2007). EEG band power can be computed by focusing on specific electrode locations, as guided by past theory and research. Among other functions, areas along the cortical midline of the brain subserve the creation of shared social experience (Uddin et al. 2007) as well as the coupling of attention with affect and reward (Cohen 2014:361). The frontal lobes of the brain, among other functions, subserve cognitive

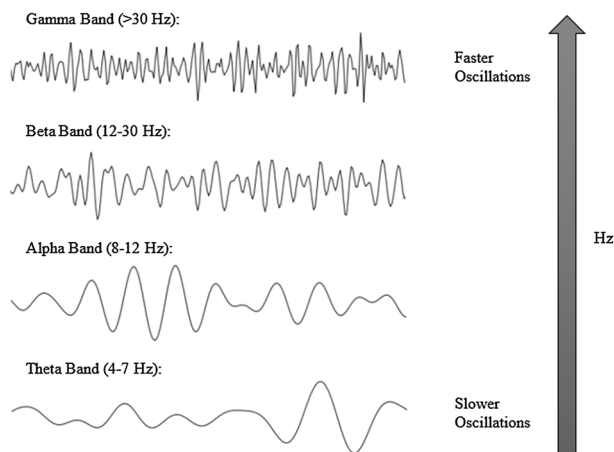


Figure 3 EEG bands.

processing and active attention (alertness, concentration, etc.) (see Stuss and Knight 2013 for an overview). Thus researchers interested in these functions would focus on electrode locations proximate to these areas. Finally, in comparing two EEGs, the “coherence” of oscillations within bands is one of several measures that may be used to measure the extent of “coupling” of areas across brains (Burgess 2013).

Putting all of this together, Lawler and his colleagues reasoned that because high total power produces a synchronization of cognition (namely goal-directed attention) and emotions over time, the resulting development of social cohesion (i.e. the bidirectional coupling of two individuals) would be represented and supported by an emergent between-person coupling of relevant brain areas (see Figure 3). Consistent with this argument, they found that inter-brain synchronization (as measured by the phase coherence of EEG signals across brains) increased over time in the (1) theta and beta bands at frontal electrode sites, and (2) alpha and gamma bands at central electrode sites (Kalkhoff et al. 2015). In line with the above discussion of the substantive interpretation of such findings, high structural power produced increased synchronization over time of cognition and emotions. Interestingly, there were no significant increases in inter-brain coherence for participants in the low total power condition, which is exactly what we would expect to find in contexts such as this where the development of social cohesion is structurally impeded (Figure 4).

This research takes a new (neurosociological) angle on an old sociological problem (solidarity). Most importantly, it allows us to begin thinking about solidarity in expanded micro-macro terms. Of course, micro-macro and multilevel theorizing are not new. They are not new in the neurosciences; they are not new in psychology; and they are not new in sociology. Indeed,

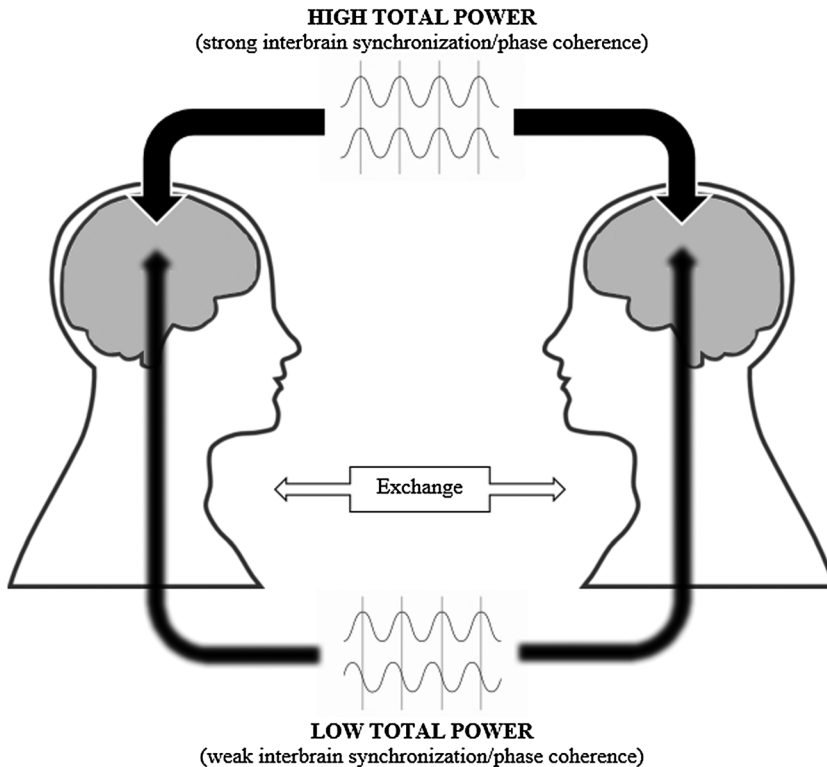


Figure 4 The multilevel relationship between structural power and interbrain synchronization.

interest in the micro-macro linkage and multilevel modeling has been one of the most important developments in sociology over the last several decades. What is relatively new, though, is the call to enlarge the integrative picture by bridging the sociological and the neural. We have already discussed some of the benefits of taking this approach, but we should emphasize that doing so does not entail biological reductionism or determinism, nor does it mean that we have to prioritize one level over another. In line with the general framework put forth by Kelso and his colleagues (Kelso et al. 2013), the approach we advocate is neither top-down nor bottom-up. It is both. In terms of the research we have described above, neural coupling derives from social structure, and social structure is supported by the bodily processes of interaction rituals, generally speaking (Collins 2004). To develop a richer, fuller, and more detailed account of the latter, we have only just begun to theorize and explore the deeper bodily processes (i.e. coupling between relevant brain areas) that represent, support, and contribute to the emergence of social organization in exchange relations. And as we develop more comprehensive and precise neurosociological accounts of human behavior and organization, sociology's relevance to "practice" will only be enhanced. This brings us to another benefit of neurosociological thinking.

Benefit 3: practice and translational science

As Durkheim ([1895] 1982) observed in *The Rules of Sociological Method*, "For what good is it to strive after a knowledge of reality if the knowledge we acquire cannot serve in our lives?" (p. 85). Despite the increasing efforts of sociologists to engage with the public through "public sociology" (see Burawoy 2004; Gans 1989), the field is still missing a well-organized engineering division. There are a number of reasons why this may be the case, but whatever they are, it is ever more pressing that we overcome them (Turner 2001). Along with the rise of the era of integrated science, we are seeing increasing emphasis placed on the importance of "translational science." The goal of translational science is to bridge the gap between basic science and applied science by facilitating the "translation" of scientific knowledge into useful applications that promote human well-being. While the focus here is usually on the health sciences (see Fang and Casadevall 2010), there is no fundamental reason why sociology should be excluded. For successful translation to occur, though, greater emphasis must be placed on the development and testing of *precise and comprehensive* sociological theories (Turner 2001). As improved precision and developing more comprehensive theoretical accounts are, as we have seen, among the benefits of approaches that combine ideas from the social and neurosciences, the prospects for successful translation may be especially promising for neurosociology. Next we briefly consider a few illustrative examples of how this is already occurring.

In the early 1980s, Gregory (1983) pioneered a set of voice analysis techniques for revealing the extent to which people adapt to one another and become "in sync" during social interaction. Unlike others who had focused on consciously controllable vocal indicators of this process (e.g. overall loudness), Gregory found that people's voices tend to become more spectrally similar during interaction, particularly in the lower registers. In other words, the amplitudes (or intensities) of the lower frequencies in people's voices tend to align as an interaction unfolds. And because this is not something over which interactants have conscious control, the technique is an especially useful one for non-invasively measuring and monitoring interpersonal accommodation and convergence during social interaction.

Gregory and his colleagues (Gregory and Webster 1996) later established how interpersonal accommodation, as evidenced in the lower vocal frequencies, is affected by social status. They argued and found that lower-status interactants are the ones who unconsciously "do the work" in changing the lower frequencies of their voices to become more like those

of their higher-status conversation partners. A follow-up intervention study validated the social importance of the lower vocal frequencies by filtering them out of the voices of participants who worked on a task over an audio-visual communication system (Gregory, Dagan, and Webster 1997). Compared to a “control” condition where the lower frequencies were left intact, participants in the treatment condition were judged by outside observers to have significantly poorer communication. The voice analysis techniques that Gregory and colleagues developed in these studies were later applied to the final debates preceding eight separate U.S. presidential elections. The results revealed which candidate came out on top in each debate (i.e. which candidate changed his voice the least), and most importantly, they accurately predicted the popular vote outcome for all eight of the elections (Gregory and Gallagher 2002).

The most recent studies in this program of research have taken a neurosociological direction. In line with our assertion that such work facilitates translation, these studies have led directly to the development of patented technology and an agenda for continued applied work. First, Gregory and his colleagues (Gregory, Kalkhoff, Harkness, and Paull 2009) conducted a laboratory experiment designed to test hypotheses about the lateralized role of the brain in the processing of the lower vocal frequencies. They developed a “dichotic” method of routing the lower and higher frequency ranges of interactants’ voices directly to the theoretically appropriate right and left hemispheres of the brain, respectively. This is accomplished by means of headsets and an audio filtering system that sends the higher vocal frequencies directly to the left hemisphere of each participant’s brain by way of the right ear, and the lower frequencies directly to the right hemisphere of each participant’s brain by way of the left ear. Compared to a “control” condition where communications were unaltered, participants were able to complete a task more quickly and with greater accuracy when their communications were dichotically “enhanced.” The applied promise of this intervention was established in a related study of simulated driving where dichotic enhancement significantly reduced crash risk among participants who interacted with an experimenter via an audio communication system (Kalkhoff, Gregory, and Melamed 2009). In line with the type of engineering applications envisioned by Turner (2001), these studies led to a US non-provisional patent for “A Device and Method for Improving Communication Through Dichotic Input of a Speech Signal” (Gregory and Kalkhoff 2011).³ Among its possible uses, the invention might provide a means of mitigating safety problems and improving performance in situations where individuals carry out complex tasks while interacting with others via headset communication systems, such as pilots interacting with other pilots and air-traffic controllers while taking off and landing in crowded airspace.

Finally, Leveto and Kalkhoff (2012) have recently advanced an understanding of how autism spectrum disorders (ASDs) might be improved by combining neurology’s knowledge of the brain with the knowledge that has been gained from Gregory’s extensive program of research on communication and interaction. They explain that the social difficulties faced by individuals with autism may be rooted in problems associated with the cerebral processing of the lower vocal frequencies, and they propose using the device and method developed by Gregory and Kalkhoff (2011) to counteract these problems. This particular application may enhance the lives of individuals with autism and those with whom they interact by facilitating communication and, therefore, social bonding. It is another example of how neurosociologists are in a good position to take theoretical ideas developed and tested through basic research and put them to work with translational efforts.

Increasing access to neuroscience

While we hope that the above discussion will contribute to furthering agreement among sociologists about the unique and important benefits of neurosociological analysis, having the *means*

to carry out such analyses is another matter. A big part of the problem here is that neurosociology is still more precariously situated within sociology than social neuroscience is within psychology. In psychology departments, it is not altogether uncommon for faculty and students to have access to the training, equipment, and collaborative opportunities that facilitate research involving techniques and insights from the neurosciences. In sociology, by contrast, these resources are currently very scarce. We know of only one sociology department in the country that has its own neuroscience laboratory.⁴ Thus while many sociologists may have a strong intellectual interest in the social brain, how are they to go about studying it *empirically*?

To some extent this problem will be taken care of over time by larger trends in science and higher education. We are, after all, still at the beginning of an exciting era of integrated science. Studies of trends in higher education point to an increase in interdisciplinary research, teaching, and degree programs (Jacob 2015). Furthermore, research commissioned by the National Science Foundation's National Center for Science and Engineering Statistics has shown that interdisciplinary research accounts for a significant proportion of dissertations (Millar and Dillman 2012). There has also been an increase in federal funding for interdisciplinary research (Resnick 2011). Insofar as these trends reflect a "real transition" to interdisciplinarity within research universities (see Rhoten 2004), the relative lack of opportunity that stands as perhaps the main barrier to the empirical progress of neurosociology will gradually be lifted.

But even now empirical work in sociology that incorporates techniques and insights from neuroscience can be done, and, as we have shown, *is* being done. Models do exist for collaborative arrangements and even for specialized laboratories where sociologists are conducting research on neurological topics (see below). Universities seem ready and willing to support such efforts. Furthermore, as suggested above, sociology's ability to change with the times will be supported by continued increases in interdisciplinary research, teaching, degree programs, and funding as we move deeper into an era of integrated sciences. This will make it easier for sociologists to acquire what is needed to do their own empirical and translational research that draws on the neurosciences.

For those interested in getting started now, we offer several suggestions from experience. Step one, of course, is to develop some fluency in neuroscience, including both its methods as well as relevant concepts, theories, and findings. An excellent place to start is *The Student's Guide to Social Neuroscience*, by Jamie Ward. This text provides readers with an introduction to the field of social neuroscience, including its history, common methods, and several burgeoning areas of research that are sure to pique the interest of sociologists. We also especially recommend two seminal works on neurosociology by David Franks and his colleagues: (1) *Neurosociology: The Nexus Between Neuroscience and Social Psychology*, and (2) *The Handbook of Neurosociology*.

Armed with a basic understanding of techniques and insights from neuroscience and with an agenda for empirical research, the simplest and most expeditious next step is to avail oneself of existing infrastructure. While most sociology departments do not have neuroscience laboratories, one or more faculty in other university programs or departments may use EEG and/or other physiological methods, and some universities operate their own fMRI facilities. A few Internet searches and email exchanges will usually uncover local labs and possible willing collaborators. As discussed above, there are costs associated with operating neuroscience laboratories (especially when it comes to fMRI), and so those who run them are often willing to collaborate on grants in order to pay down large investments in scanners and help cover various overhead expenses.⁵ Well-articulated collaborative arrangements between sociologists and neuroscientists who can contribute infrastructure and expertise are required for the success of funding applications.

For those so motivated, the road to building one's own EEG laboratory or fMRI facility is likely to be a long and difficult one that will take many unanticipated twists and turns, but it can be done and has been done. Given the exorbitant costs of fMRI, attempting to build an

fMRI facility from the ground up is a Herculean task. The best strategy here would be to form (or join) a multi-department group of colleagues and then work with relevant colleges and one's university to develop and submit an instrumentation grant. At the time of this writing, the National Science Foundation's "Major Research Instrumentation Program" is among the more attractive opportunities.⁶ One potential drawback of the NSF's MRI program, though, is that it currently requires Ph.D.-granting institutions to cost-share at the level of 30% of the total amount needed to accomplish the proposed project. This figure will not be small for a new fMRI facility, but given the growing importance of the neurosciences and related fields such as neurosociology, a strong case can be made for acquiring one of the most powerful tools for studying the brain. As time goes on, providing access to a research-dedicated fMRI system may be required for major research universities to remain among the most competitive of them.

Major Research Instrumentation grants through the NSF are also an excellent way to acquire EEG and other systems for examining brain activity (e.g. fNIRS). Given that EEG equipment is much less costly than fMRI, does not require expensive regular maintenance, and is usually easily accommodated by existing lab space, it may be possible to acquire it with internal funds. For example, Kent State University purchased a 64-channel EEG system with \$65,000 in funding from an "Innovative Research Seed Award" provided by the College of Arts and Sciences (but see Endnote 1). The creation of a small consortium of faculty from sociology, psychology, and biology quickly followed. Most critical to the success of the laboratory, though, was the addition of a post-doctoral fellow. The post-doc rounded out the interdisciplinary team with formal training and expertise in the acquisition, processing, and analysis of electrophysiological data. Acquiring EEG equipment is not exceptionally difficult, but it may often require the creation of at least one staff position for the investment to be bear any fruit. University-sponsored post-doctoral positions are an excellent way to get started, but the creation of a lasting full-time position (e.g. a research NTT position) would be better yet. At universities where EEG is not available, it is very likely that more than one faculty member wishes they had access to it. So, after determining that EEG is not available on campus, the next step is to contact colleagues who would be likely to want it for their research. For those who do want it, forming an interdisciplinary neuroscience research group and developing several promising lines of fundable work will go a long way to convincing a dean that it would be academically and financially profitable to purchase an EEG system and create a staff position for someone who would help with all aspects of the planned research. With more and more universities investing in neuroscience-related programs and technology, collaborating with colleagues to develop plans for an interdisciplinary neuroscience laboratory is a timely endeavor, though one that requires quite a bit of time, effort, and patience to succeed.

Conclusion

There is a "new kind of social science" emerging in the 21st century—a kind of social science that will have to navigate the "biological hurricane" that is upon us (Edge Video 2015), including all of the relevant knowledge that is rapidly cumulating in the neurosciences. In the context of this trend, we have attempted to supply some reasons why (more) sociologists may want to give consideration to doing neurosociological research. That said, we feel the need to emphasize one particularly important caveat. That is, just because one *can* do research that incorporates insights and techniques from neuroscience does not mean that one *should* do so. We agree with Willingham and Dunn (2003) that we must be careful not to fall prey to the alluring "charm" of brain imaging methods and the like (p. 668). We agree with the overall thrust of their recommendations—that neuroscientific methods such as neuroimaging are put to best use where the main goal is to develop theoretical knowledge. In short, the method, in and of itself, should never drive the research.

Where neurosociological analysis is “appropriate,” we have given some suggestions to help interested colleagues access *the means* of doing such research. As we have argued, interdisciplinary trends are underway that will do some of the heavy lifting here, and what is left to do can be taken up by sociologists who devote time to educating themselves and others and to learning more about existing programs of neurosociological research, including how to go about building the infrastructural resources that support it. As it becomes increasingly possible for sociologists to actually *do* their own neurosociological research, we expect intellectual and professional interest in the area to grow in kind. We are hopeful for such change, as the benefits of studying the complexly interactive nature of social and neurological forces are many. Indeed, we see a bright future for neurosociology.

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Short Biographies

Will Kalkhoff is an associate professor of sociology at Kent State University. He is also a co-director of the Kent Electrophysiological Neuroscience Laboratory (<http://kenl.kent.edu>) and serves as a deputy editor for *Social Psychology Quarterly* and as a Council member for the Evolution, Biology, and Society section of the American Sociological Association. His research interests include neurosociology and social psychology. His most recent authored and co-authored publications in these areas appear in *New Directions in Identity Theory & Research* (Oxford University Press), the *Handbook of the Social Psychology of Inequality* (Springer Press), the *Handbook of Neurosociology* (Springer Press), and several peer-reviewed outlets, including *Advances in Group Processes, Emotion, Laterality: Asymmetries of Body, Brain, and Cognition, Perceptual and Motor Skills, Social Psychology Quarterly*, and *Social Science Research*. He also recently guest-edited a special volume of *Advances in Group Processes* “Biosociology and Neurosociology” with Stanford W. Gregory, Jr. He was awarded a US Non-Provisional Patent for “A Device and Method for Improving Communication through Dichotic Input of a Speech Signal” (No. 8,000,958, August 16, 2011). Current research projects focus on the multi-person dynamics of relational cohesion (with Shane R. Thye, Edward J. Lawler, and others) and on the neurodynamics of social status (with David Melamed, Joshua Pollock, and others). The latter project is supported by a grant from the Department of the Army, US Army Research, Development and Engineering Command, Army Research Office (proposal No. 67034-LS). He holds a B.A. in sociology from Marquette University and both an M.A. and Ph.D. in Sociology from the University of Iowa.

Shane R. Thye is a professor of sociology at the University of South Carolina. He is the series co-editor (with Professor Edward J. Lawler) of *Advances in Group Processes*. He recently completed a book with Edward J. Lawler and Jeongkoo Yoon on *Social Commitments in a Depersonalized World* (Russell Sage Foundation, 2009) and works primarily in the areas of group dynamics and experimental sociology. His work has appeared in outlets such as the *American Sociological Review*, the *American Journal of Sociology*, *Social Forces*, *Sociological Methods and Research*, and *Social Psychology Quarterly*. He is currently conducting research on status processes in bargaining relations, the neurodynamics of status, and the social psychological bases of micro social order. Over the years, his research with colleagues and students has been generously funded

by nearly a dozen grants from the National Science Foundation. He holds a B.S., M.A., and Ph.D. in Sociology from the University of Iowa and was a postdoctoral fellow at Cornell University.

Joshua Pollock is currently a postdoctoral fellow at Kent State University. His research interests include neuroscience, developmental psychology, cognitive processes, quantitative methodology, and meditation. His most recent authored and co-authored publications appear in *Frontiers in Integrative Neuroscience*, *PLoS One*, and *The Encyclopedia of Adulthood and Aging*. Current projects focus on analytical meditation (with David Fresco, Marieke van Vugt, Marcel Bonn-Miller, and Bryce Johnson), the neural processing of social status (with Will Kalkhoff and others), emotional regulation in clinical samples, and cognitive mediators of fearful responses. He holds a B.A. in Psychology from The University of Akron and both an M.A. and Ph.D. in Adult Development and Aging from The University of Akron.

Notes

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¹ For many purposes, a 32-electrode (i.e. 32-channel) EEG system will be sufficient. Oftentimes data are analyzed from a single electrode or small group of electrodes. Past research is the most important guide. For a general discussion of issues surrounding the number of electrodes required for different kinds of studies and analyses, see Lau, Gwin, and Ferris (2012). In terms of software, the free EEGLAB add-on for MATLAB is an excellent choice, especially given that commercial software packages for EEG processing and analysis tend to be quite expensive.

² While our focus here is on EEG and fMRI, another emerging technology with exciting implications for investigations in ecological settings is functional near-infrared spectroscopy (fNIRS). Like fMRI, fNIRS measures hemodynamic changes in the brain for source localization, but it cannot image deep brain structures and has comparably low spatial resolution (20–30 mm). And like modern EEG, fNIRS is non-invasive and portable and can be used in more natural situations, but it does not have the high temporal resolution of EEG. In short, fNIRS takes some of the strengths of both fMRI and EEG and combines them, but it also has some of their disadvantages too. For an excellent overview and comparison of the three methods for social neuroscience and neurosociological applications, see Liu and Pelowski (2014).

³ See Gregory and Kalkhoff (2013) for a thorough overview of the program of basic and applied research, including the important “neural milestones” (p. 378).

⁴ <http://kenl.kent.edu>.

⁵ That said, unless otherwise indicated, do not expect potential collaborators to carry out research *for you*. This is a surefire way to have your introductory email ignored. It would be unwise, for example, to email a colleague and ask her or him to collect and analyze some pilot data for a grant that you would like to submit. In our experience, most who run neuroscience labs expect those from other disciplines to have paid their dues to a reasonable extent—i.e. to have some spent some time learning about neuroscience knowledge and methods. They learn to recognize those who have adequate preparation, can “talk the talk,” and can actually contribute to a collaborative endeavor. A better strategy, then, is to first put in the effort to really understand a topic and come up with a tentative plan for research. Next, in making initial contact, very briefly describe the research plan, emphasize shared substantive interests and ostensive mutual benefits, include a relevant grant opportunity for collaborative research, and list whatever existing resources that you can contribute to a pilot project (e.g., incentive money, research assistance, etc.). The last thing laboratories want to do is tie up limited resources with unknowledgeable freeloaders drawn in by the novelty and glamour of brain imaging.

⁶ There are many examples of successful Major Research Instrumentation (MRI) proposals available through the NSF’s awards search engine (<http://www.nsf.gov/awardsearch/>). Visit the following link to view the abstract for a recent successful application: http://www.nsf.gov/awardsearch/showAward?AWD_ID=1531616. Full proposals must be requested directly from PIs.

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