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“This is Your Brain on Rhetoric”: Research Directions for Neurorhetorics

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“This is Your Brain on Rhetoric”: Research Directions for Neurorhetorics

Jordynn Jack & L. Gregory Appelbaum

Neuroscience research findings yield fascinating new insights into human cognition and communication. Rhetoricians may be attracted to neuroscience research that uses imaging tools (such as fMRI) to draw inferences about rhetorical concepts, such as emotion, reason, or empathy. Yet this interdisciplinary effort poses challenges to rhetorical scholars. Accordingly, research in neurorhetorics should be two-sided: not only should researchers question the neuroscience of rhetoric (the brain functions related to persuasion and argument), but they should also inquire into the rhetoric of neuroscience (how neuroscience research findings are framed rhetorically). This two-sided approach can help rhetoric scholars to use neuroscience insights in a responsible manner, minimizing analytical pitfalls. These two approaches can be combined to examine neuroscience discussions about methodology, research, and emotion, and studies of autism and empathy, with a rhetorical as well as scientific lens. Such an approach yields productive insights into rhetoric while minimizing potential pitfalls of interdisciplinary work.

At a time when cultural critics lament declining popular interest in science, neuroscience research findings are only gaining in popularity. Highly persuasive neuroscience-related findings are touted for their potential to transform advertising, political campaigns, and law (for example, through new brain-based “lie detectors”).¹ Those hoping to improve their own brains can read self-help books, play “brain training” computer and video games, listen to specially designed meditations, and train their children’s brains with Baby Einstein, Beethoven for Babies, and similar devices.²

¹For a rhetorical-cultural analysis of brain-based lie detectors, see Littlefield.

²The scientific evidence for these devices varies considerably. For instance, one 2006 study suggested that each hour of television or video viewing (regardless of type) was actually associated with a 16.99-point decrease in MacArthur-Bates Communicative Development Inventory CDI score, an indicator of early language proficiency. See Zimmerman et al.

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Neuroscientific research findings are reported in mainstream news outlets with striking regularity. Through scientific and technical developments, researchers can now track active neural systems and document the relationship between brain chemistry, human behavior, and mental activities. These undertakings seem to offer concrete, material proof of concepts previously considered ephemeral, especially when claims are supported with showy, multicolored brain scan images.³

In rhetorical studies, there seem to be two main approaches to studying this burgeoning attention to all things *neuro-*. One area of study under the rubric of neurorhetorics might be *the rhetoric of neuroscience*—inquiry into the modes, effects, and implications of scientific discourses about the brain. To take up a recent example, on 3 February 2010, a Reuters news report featured the following headline: “Vegetative patient ‘talks’ using brain waves” (Kelland). According to reports carried in nearly every major news outlet, British and Belgian researchers used functional magnetic resonance imaging (fMRI) to demonstrate that a comatose man was able to think “yes” or “no,” intentionally altering his brain activity to communicate with the researchers. Newspapers and magazines reprinted the dramatic images of brain activation that appeared in the original scientific report in the *New England Journal of Medicine*, with “yes” answers featuring orange and “no” answers showing blue spots. The findings immediately prompted debates in popular venues. As is often the case with widely reported neuroscience findings, this announcement reinvigorated public arguments about medical care, governmentality, and the politics of life itself. Rhetoric scholars should certainly pay attention to how scientific appeals function in these debates.

A second approach might be *the neuroscience of rhetoric*, drawing new insights into language, persuasion, and communication from neuroscience research. Findings such as this study of noncommunicative patients can prompt us to broaden our very definitions of rhetoric to include those with impaired communication (such as autism, aphasia, or “locked-in syndrome”), asking how communication occurs through different means, or how brain differences might influence communication. Cynthia Lewiecki-Wilson argues that “we need an expanded understanding of rhetoricity as a potential, and a broadened concept of rhetoric to include collaborative and mediated rhetorics that work with the performative rhetoric of bodies that ‘speak’ with/out language” (157). Surely, cognitive neuroscience findings can play an important role in such an endeavor. Neuroscience findings might also add new insights to longstanding rhetorical issues, such as the relationship between *pathos* and *logos*, or emotion and logic, or other cognitive dimensions of rhetoric (Flower; Arthos; Oakley). Indeed, Mark Turner goes so far as to suggest that “If Aristotle were alive today he would be studying this [neuroscience] research and revising his work accordingly” (10).

³See, for instance, Mooney and Kirshenbaum; Specter.

In this article, we, a neuroscientist and a rhetoric-of-science scholar, argue that the rhetoric of neuroscience and the neuroscience of rhetoric should be intertwined. In other words, to work with neuroscience research findings one should carefully analyze that work with a rhetorical as well as a scientific lens, paying attention to the rhetorical workings of accounts of cognitive neuroscience research. Rhetoricians who would like to do work in neurorhetorics should understand how knowledge is established rhetorically and empirically in the field of cognitive neuroscience, how to interpret scientific findings critically, and how to avoid pitfalls of interpretation that could lead to misleading arguments about rhetoric. Here we demonstrate the kinds of considerations rhetoric scholars should use to examine neuroscience research. First, in order to highlight the complex methodological choices that go into neuroscience research studies, we introduce a contentious debate concerning common analytical practices for functional magnetic resonance imaging. To give rhetoric scholars a set of tools for understanding these complex arguments, we highlight key *topoi* scientists use to negotiate methodological argument, such as accuracy, efficiency, and bias. Second, we examine how neuroscience researchers define key concepts that may also be of interest to rhetorical scholars, such as emotion, reason, and empathy, considering whether those definitions square with traditional rhetorical concepts of *pathos*, *logos*, and identification. In the third section, we consider how a single research article in neuroscience is framed rhetorically, including how decisions about terminology, research questions, and research subjects are rhetorical as well as empirical decisions. In the final section we identify common tropes used in popular accounts of neuroscience research findings. We offer guidelines in each section for rhetorical scholars who would like to work with neuroscience findings, and conclude by offering a set of suggested topics for future research that can constitute what we call neurorhetorics.

Accuracy, Bias, and Efficiency: Methodological *Topoi* in Human Brain Imaging

As scholars in the rhetoric of science have demonstrated, research findings are shaped rhetorically to fit with scientists' shared expectations. As Lawrence Prelli has argued, scientists use “an identifiable, finite set of value-laden topics as they produce and evaluate claims and counterclaims involving community problems and concerns” (5). Some of these topics (or *topoi*) include accuracy (200), quantitative precision (195), and bias. The accuracy *topos* focuses on the degree to which methods, procedures, and statistical calculations match what is being measured, while the precision *topos* focuses attention on the degree of reliability of the experimental method. Bias refers to the potential for the results to be influenced by factors unrelated to the variable being tested.

In the case of neuroscience, researchers use these three *topoi* to argue for methods that can usefully extend existing knowledge of the brain's structures

and functions. One approach involves using case studies of individuals with brain deficits to draw inferences about normal brain functions. A second approach requires careful, statistical analysis of digitized data generated through imaging technologies such as fMRI or positron emission tomography (PET) (Beaulieu “From Brainbank”). As Michael E. Lynch explains, this data becomes visible through various technologies that transform specimens (animal or human brains) such that “[t]he squishy stuff of the brain becomes a subject of graphic comparison, sequential analysis, numerical measure, and statistical summary” (273). The methods used to accurately extract data from squishy brains are rhetorically negotiated through ongoing debates.

In order to understand these debates, a brief overview of neuroimaging research techniques is important. Through recent advancements in fMRI capabilities, researchers have been able to gain advanced understanding of the activity, structure, and function of the human brain on a fine spatial scale (Bandettini; Poldrack et al.). In most instances, the primary objective in acquiring fMRI data is to infer information about the brain activity that supports cognitive functions (such as perception, memory, emotion) from local changes in blood oxygen content. Increases in neural activity cause variations in blood oxygenation, which in turn cause changes in magnetization that can be detected in an MRI scanner. While these changes (called Blood Oxygenation Level Dependent or BOLD activity) offer a somewhat indirect measure of neural activity, they are widely accepted as a close proxy for the synaptic activity assumed to underlie neuronal communication, brain function, and ultimately cognition (Logothetis and Wandell; Logothetis et al.; Bandettini).⁴

In the hands of cognitive neuroscientists, an fMRI experiment is typically carried out by presenting a subject with a stimulus (such as an image, word problem, or even scent) and a task that requires some kind of response (answering a simple multiple choice question, choosing yes or no, etc.). Neuroscientists analyze the resulting data with regard to specific experimental contrasts designed to isolate, in a meaningful way, specified cognitive functions (e.g., subtraction between remembered and forgotten items from a list). As a result of a single experimental session, researchers can identify minute, specific regions of BOLD activation that correlate with the task at hand in one individual’s brain.⁵ However, given the inherent variability between individuals in brain anatomy, these activations can not easily be generalized across individuals. The activation patterns may not land consistently in the same place in different brains, nor can they be defined by any

⁴Scholars hoping to work with fMRI research findings might wish to consult a textbook explaining basic methodological procedures, such as Scott A. Huettel’s *Functional Magnetic Resonance Imaging*.

⁵While this is typical, not all fMRI experimental designs test hypotheses about the specialization of localized regions of the brain. For example, a large number of recent papers have focused on decoding the information that is represented across the whole brain at a particular point in time to a particular class of stimuli.

set of standard anatomical co-ordinates (see Saxe et al. 2006). In order to draw conclusions about brains in general, and not about single individuals, neuroscientists need to establish some basis of comparison across brains, even though they differ in anatomy, size, and arrangement. This is where methodological arguments come in, since neuroscientists must argue for the accuracy and efficiency of their preferred techniques for addressing this challenge.

One approach involves acquiring information from separate "localizer" scans in each subject. Neuroscience researchers Rebecca Saxe, Matthew Brett, and Nancy Kanwisher argue such an approach can "constrain the identification of what is the same brain region across individuals," allowing researchers to more easily "combine data across subjects, studies, and labs" (1089). In rhetorical terms, these researchers argue from the accuracy topos. By identifying regions that function similarly across subjects, they claim that localizer scans allow for more accurate representations of how the brain works. In addition, Saxe, Brett, and Kanwisher argue from efficiency and bias, claiming that the functional regions-of-interest (fROI) approach allows researchers to "specify in advance the region(s) in which a hypothesis will be tested," which "increases statistical power by reducing the search space from tens of thousands of voxels to just a handful of ROIs" (1090). In contrast, the authors claim that whole-head comparisons will "produce an explosion of multiple comparisons, requiring powerful corrections to control false positives" (1090). In this way, they position the fROI approach as more accurate, more efficient, and less likely to lead to biased results (such as false positives). By bias, they mean statistical bias (not personal bias), which can result simply from taking multiple measurements of the whole head. Given the complexity of the brain and the sheer number of neurons it contains, some voxels might indicate brain activity that appears to correlate with the task in question, but that is actually due to sheer chance. In debates about fMRI methodology, the accusation that one technique or another might lead to more false positives serves as a way to position that technique as less sound than the preferred technique.

Using functional localizers, or fROIs, represents a dramatic shift away from more traditional analytical approaches that take into account all measurements from the whole recorded volume, so-called whole-head measurements. Notably, those who support a whole-head approach argue from the very same topos as those who argue for the fROI approach. For instance, Karl Friston is a vocal proponent of the whole-head approach, which he claims allows for greater accuracy precisely because it does not pinpoint a region of interest *a priori* (Friston et al.; Friston and Henson). Friston points out that the only way to guarantee one has not overlooked potentially interesting activations is to test every voxel (the 3-D unit of measurement in fMRI), a tactic that cannot be done by limiting analysis to only those areas pre-defined in a localizer scan. Drawing on the efficiency topos, Friston et al. argue that whole-brain approaches provide "increased statistical efficiency," making it possible to report results for all locations in the brain while statistically accounting for the multiple tests performed across the whole volume

(Friston et al. 1086). In their defense of the whole-head approach, Friston et al. also argue from the topos of bias, claiming that in the whole-head approach, “the test for one main effect cannot bias the test for other main effects or interactions” (Friston and Henson 1098).

As is the case with any scientific method, claims based on fMRI data rely on chain of inferences that link the data to the psychological function or construct of interest. Each step of this chain raises potential questions about the inferences that can be garnered from the data. The nature and meaning of data are in turn shaped by a series of methodological and conceptual choices made by scientists. This ongoing debate regarding the appropriate tactics to use in fMRI data analysis highlights the fact that neuroscientists have not yet established consensus on these underlying assumptions. It is therefore up to the author to adequately communicate their methodology (Poldrack et al.) and to the reader to be versed in the meaning, trends, and nuances of the methodologies employed.

For researchers hoping to discover new insights into rhetoric and communication from brain studies, it might be tempting to lump together a number of research findings on a topic (such as desire or reason). Yet, each of those studies, individually, might use a different technology (such as PET vs. fMRI), employ a different methodology (such as fROI or whole-brain analysis), and use different kinds of stimuli to evoke a given mental state (images, sounds, smells, etc.). To draw conclusions from such a disparate group of studies requires significant technical knowledge. While rhetoric scholars might find neuroscience methods difficult to understand, they can start by paying attention to these topoi. By looking for terms such as “false positive,” “bias,” or “assumptions,” rhetoric scholars can ferret out places where neuroscientists argue for their methods (or argue against others).

Same Words, Different Meanings: Neurorhetorics of Reason and Desire

Rhetorical scholars have long held a principal interest in reason, emotion, and how they work together to achieve persuasion. These fundamental aspects of human behavior have recently emerged into a rapidly growing branch of empirical neuroscience, called neuroeconomics. As the name implies, neuroeconomics employs both neuroscience techniques and economic theory to test how desire, reason, and choice are represented in the human mind, and, ultimately, why humans make the choices that they do. Neuroeconomics may therefore hold a particularly promising avenue for rhetorical scholars to explore questions that have traditionally been tied to verbal appeals: how people are ultimately persuaded toward a particular course of action.

Rhetoric scholars might be particularly interested in how terms like emotion and reason (which evoke the ancient rhetorical proofs, *pathos* and *logos*) can be studied experimentally in neuroeconomics. In this way, we might gain a deeper

understanding of what parts of the brain are activated by emotional stimuli (such as memories of events that signal threat) or by reasoning tasks (such as decision/reward tasks involving the anticipation of gains and losses) (Labar; Carter et al.). Nevertheless, neuroeconomics must be approached with care, since reason and emotion can be difficult concepts to pin down. In this section, we examine how researchers in neuroeconomics understand reason and emotion, how they operationalize those qualities in experiments, and how those understandings do or do not line up with how rhetoricians understand reason and emotion.

Of course, the word “neuroeconomics” itself suggests that the field draws on a specific understanding of human action, one that frames such issues primarily in economic terms. The assumption underlying much of this research is that humans make decisions according to calculations of rewards, risk, and value, and that these are represented in concrete and testable psychological and neural terms. If the brain is responsible for carrying out all of the decisions that humans make, understanding the physiological functions of the brain will help explain why people make specific choices and why they often fail to make optimal decisions.

The interplay between such theory and neurobiology has led to productive insights. Over the past several years, neuroscientists have begun to identify basic computational and physiological functions that explain how reasoning works. One common model is a compensatory one, where individuals make decisions based on calculations of positive versus negative outcomes (Rangel). In this model, decision makers must first form mental representations of the available options, and then assign each option some value according to a common currency (such as monetary gain). Next, the organism compares the values of different options and chooses a specific course of action. After the action is completed, the organism measures the benefit gained, and this information is fed back into the decision mechanism to improve future choices.

A growing body of neuroscientific evidence supports this framework. For example, researchers have found that some neurons in the brain adjust their firing rate with the magnitude and probability of reward (Platt and Glimcher). Similarly, researchers have shown that neurons in the monkey orbitofrontal cortex encode the value of goods (Padoa-Schioppa and Assad), while others have suggested that the frontal cortex neurons represent decision variables such as probability, magnitude, and cost (Kennerley et al.). Collectively, this evidence suggests that subjective value is represented in the nervous system, and that individuals make choices by weighing these values. In this model, decisions are made primarily through rational calculations of value, with the goal being for organisms to maximize their reward (whether it be money, food, or something else).

But does this understanding of reason and emotion line up with the assumptions rhetorical scholars might make about those concepts, which since Aristotle’s *Rhetoric*, have been associated with logos and pathos? We might be tempted to take these studies as outside proof that such concepts exist, or to suggest the possibility of someday teasing out rhetorical appeals scientifically

(an idea being implemented in the field of neuromarketing). Yet, rhetorical scholars should be careful to distinguish our own understandings of emotion and logic from those supposed by neuroscientists. Daniel Gross argues that Aristotle understands the passions as a sort of a “political economy,” but the emotions in this theory are decidedly public and rhetorical (6). Anger, for Aristotle, “is a deeply social passion provoked by perceived, unjustified slights,” presupposing “a public stage where social status is always insecure” (2). According to Gross, emotions that were at one time treated as “externalized forms of currency” have been folded into the brain, where they are now understood as hardwired and biological, not political and rhetorical (8). While the notion of an emotional economy might appear in both fields, then, the nature of that economy varies significantly.

To determine how, exactly, neuroscientific understandings of reason and logic might match up with rhetorical ones, we searched PubMed for articles that contained the terms *reason*, *emotion*, and *fMRI*. Out of 83 articles, we chose 20 that attempted to track individuals’ response to emotional stimuli and/or reasoned judgments. For each article (see Appendix), we tracked whether or not definitions were provided for the terms *reason* and *emotion*, noted what definitions were given, and determined how those fuzzy concepts were *operationalized*, or rendered scientifically measurable. The studies we selected focused on such topics as gender differences in cognitive control of emotion, the “neural correlates” of empathy, and the recruitment of specific brain regions in inductive reasoning. Obviously, direct comparison of these articles is impossible, and that is not our intent. Our aim was not to conduct an exhaustive study of how scientists operationalize these concepts, but simply to get a preliminary sense of how scientific understandings of reason and emotion might square with rhetorical conceptions.

In many cases, researchers did not define what was meant by key terms such as *emotion* or *reason*—only six of the articles in our sample did so. Perhaps the writers assumed that their readers already shared a common, disciplinary definition. For non-neuroscientists, then, this poses a challenge: what do the authors mean by a term like *emotion* if it is not defined? Is there a standard definition or understanding about this term as it is used in the field? And might these definitions differ between sub-fields?

When definitions were given, they varied in format and content. For instance, studies of reason usually offered provisional definitions, as in these four:

- reasoning “combines prior information with new beliefs or conclusions and usually comes in the form of cognitive manipulations . . . that require working memory” (Schaich Borg et al. 803)
- “a combination of cognitive processes that allows us to draw inferences from a given set of information and reach conclusions that are not explicitly available, providing new knowledge” (Canessa et al. 930)

- “By ‘reasoning,’ we refer to relatively slow and deliberative processes involving abstraction and at least some introspectively accessible components” (Greene et al. 389)
- “Inductive reasoning is defined as the process of inferring a general rule (conclusion) by observation and analysis of specific instances (premises). Inductive reasoning is used when generating hypotheses, formulating theories and discovering relationships, and is essential for scientific discovery.” (Lu et al. 74)

Anyone hoping to draw conclusions about reason as an element of rhetoric would need to take into account these differing definitions, weighing whether or not they are similar enough to warrant generalizations to rhetorical study. While rhetoricians may wish to associate reason with *logos*, none of these articles considers how individuals are persuaded by logical arguments. In these studies, participants are usually presented with logical puzzles or problems they must solve individually. It would be difficult for a rhetorical scholar to draw clear inferences about logical persuasion from these studies, since they do not focus specifically on how the brain responds to logical appeals.

In the studies mentioning empathy, one cited *Encyclopedia Britannica*’s definition of empathy—“the ability to imagine oneself in another’s place and understand the other’s feelings, desires, ideas, and actions”—along with criteria from a previous study (Krämer et al. 110). A second defined empathy as “the capacity to share and appreciate others’ emotional and affective states in relation to oneself,” drawing on previous work by other researchers (Akitsuki and Decety 722). While these definitions are similar, in the first one, empathy involves propelling oneself outward into another’s “place,” while the second involves the opposite movement of considering another’s emotions “in relation to oneself”—the first is outer-directed, the second inner-directed.

For rhetoric scholars, the next step might be to consider how these definitions compare to rhetorical ones. Both of the definitions cited here envisioned empathy as an ability or capacity, something one presumably either has or does not have. On the face of it, these definitions might square with Quintilian’s notion that the most effective rhetors possess a capacity to feel the emotions they seek to evoke (Quintilian 6.2.26). For Quintilian, though, empathy is a distinctly performative skill, since orators who can “best conceive such images will have the greatest power in moving the feelings” (6.2.29). In his formulation, empathy represents a capacity to conjure for oneself the emotional states that move the feelings, and to project those emotional states to an audience. Alternately, we might be tempted to line up these fMRI studies with Kenneth Burke’s concept of identification, which suggests that “You persuade a man only insofar as you can talk his language by speech, gesture, tonality, order, image, attitude, idea, *identifying* your ways with his” (Burke 55, his emphasis). In any case, both Quintilian and Burke add a dimension to empathy that is lacking in the scientific accounts—the capacity not only to put oneself in another’s shoes, but then to *take on* or

perform that person's emotions, to "talk his language," as Burke suggests, or to paint an image that evokes those emotions, in Quintilian's conception.

In order for an fMRI study of empathy to map neatly onto these definitions, the study would have to operationalize this specific, rhetorical definition of empathy—not just any study of empathy will necessarily apply. The choice of stimulus would also be significant. In our sample, emotion was evoked using images of neutral or emotional faces (Kompus et al.), faceless cartoons in emotional or neutral situations (Krämer et al.), negative olfactory stimulation (by means of rotten yeast) (Koch et al.), and angry or neutral voices reading nonsense utterances (Sander et al.). Only in a few cases did studies focusing on emotion involve subjects reading or listening to meaningful text—usually a few lines only (Harris, Sheth, and Cohen; Ferstl and von Cramon; Schaich Borg et al.). To date, no fMRI studies that we could find studied individuals' neuronal responses to explicitly rhetorical stimuli—there have been no "this is your brain on Martin Luther King's 'I Have a Dream' speech" studies (although perhaps it is only a matter of time before such a study appears).

In the remaining articles, the terms *emotion* or *reason* were either taken as given, or were implicitly defined. For instance, in Harris et al., a study of belief and disbelief, participants were asked to rate phrases as "true" or "false" while their brain activation was measured with fMRI. Because this is how the authors chose to operationalize belief and disbelief, we can surmise that they defined those values, implicitly, as being akin to truth and falsity (as opposed to some other definition of belief emphasizing faith, trust, or confidence). While our survey was not exhaustive, it does suggest that rhetoricians seeking to incorporate neuroscience findings must do considerable work to unpack the assumptions underlying any single study, to put those in the context of other studies, and then to compare neuroscience understandings with those common to our own field. This preliminary survey suggests that we need to be careful not to assume that terms like "reason" or "emotion" have stable definitions, that they are defined in the same way across studies, or that they necessarily align with the preferred rhetorical definitions.

Empathy and Neurological Difference

As we have shown, neuroscience research is replete with methodological and terminological variability, so that writers of research articles must make careful choices about the terms and methods they describe. By drawing on rhetoric of science studies, readers of these articles can examine research articles carefully, considering alternative interpretations and the broader cultural debates in which such articles participate (Bazerman; Berkenkotter and Huckin; Myers; Schryer; Swales). The example we consider here is an article titled "Neural Mechanisms of Empathy in Adolescents with Autism Spectrum Disorder and Their Fathers," published by Ellen Greimel et al. in a 2010 issue

of *NeuroImage*. We chose this article because it deals with a topic of great cultural interest at the moment, one suited to the emphasis of this special issue on neurological difference: autism. Not only is autism a highly debated topic in popular spheres, but, as a communicative disorder, it is sometimes posited as a kind of touchstone against which rhetorical ability can be measured (see, for instance, Oakley 102).

Formerly seen as a rare disorder, autism diagnosis rates have risen dramatically over the last twenty years, with current prevalence estimates at 1 in 110, according to the Center for Disease Control. In the *Diagnostic and Statistical Manual* (DSM-IV) of the American Psychological Association, autistic disorder (sometimes called Autistic Spectrum Disorder, or ASD), is defined in part by a list of impairments in communication and social interaction, combined with repetitive and stereotyped behavior.⁶ This increase in diagnosis has led to many cultural developments: the rising influence of parent organizations arguing for biomedical treatment options; the increasing presence of autistic characters in television and film;⁷ and the growing self-advocacy movement among autistic individuals who seek a greater voice in shaping directions for research and advocacy (O'Neil; Solomon; Sinclair). Scientific articles about autism necessarily participate in this broader cultural milieu. New findings about autism tend to be widely reported in the media, especially when they suggest either anatomical or genetic differences that may explain the behavioral criteria that distinguish autism.

One of these broader cultural trends is the position of ASD as a male disorder. The first thing to notice from the title of Griemel's study is that the study focused on adolescents and their *fathers*. From the abstract, we learn that the study examined high-functioning boys with a diagnosis of ASD. While the writers do not remark on their choice of male subjects, from a rhetorical standpoint these facts situate the article within a broader cultural depiction of autism as a disorder affecting males. Studies suggest that boys are four times more likely than girls to receive a diagnosis of ASD, a fact that has led some researchers to posit that autism is a disorder of the "extreme male brain" (Baron-Cohen *The Essential Difference*; Baron-Cohen "The Extreme-Male-Brain"). In this theory, ASD simply represents an exaggeration of qualities taken to be typically male. In Baron-Cohen's theory, brains tend to be either "systematizing" or "empathizing."

⁶At the time of writing, The American Psychiatric Association (APA) was considering proposed changes to the criteria for autism for the next edition of the *Diagnostic and Statistical Manual*, DSM-5. Previously, there were separate diagnostic categories for Asperger's Syndrome and Pervasive Developmental Disorder (PDD), to variants of autism. According to the APA, the new category would help to simplify diagnosis, since deciding where to draw the lines between sub-categories was akin to trying to "cleave meatloaf at the joints." See American Psychiatric Association..

⁷Recent examples include *Mozart and the Whale* (2005), *Adam* (2009), and the HBO biopic *Temple Grandin* (2010).

Women tend to score higher on tests of empathizing, while men tend to score higher on tests of systematizing. Nonetheless, Baron-Cohen insists that it is *brains* that are male (systemizing) or female (empathizing), not necessarily the bodies in which those brains exist.⁸ At any rate, individuals with ASD, according to Baron-Cohen, get exceedingly high scores on systemizing tests. In fact, Greimel et al. used Baron-Cohen's survey of systematizing and empathizing tendencies, called the "Autistic Quotient," or AQ, to determine whether the fathers in the study possessed autistic qualities.

Rhetoric researchers might be interested in examining this broader debate about gender and autism and how it is inflected in a particular article. By focusing on male subjects, Griemel et al. subtly appeal to the dominant depiction of the disorder as fundamentally male—a depiction that also plays on the ever-popular suggestion that male and female brains are fundamentally different (Condit). This is not necessarily a shortcoming of Greimel et al.'s paper. After all, it is quite commonplace to constrain one's sample size by looking only at one sex. Recently, though, some researchers have suggested that girls and women with ASD are underdiagnosed, that the definition of the disorder itself overlooks how ASD may present in females differently (Koenig and Tsatsanis). Scientific articles like the one by Griemel et al. participate in this gendering of autism as a male disorder, a process that draws on cultural discourses about masculinity, technology, and geekiness.

By focusing on empathy, the authors of this study make a rhetorical, as well as a scientific, choice, framing their article as an intervention into that particular theory of autism's etiology. Autism presents interesting questions for neuroscientists who seek to identify differences in brain structure and function between people with and without autism. One of these proposed differences is a lack of empathy, often called mindblindness, in individuals with autism (Baron-Cohen *Mindblindness*; Happé). Accordingly, studies of empathy constitute a large proportion of autism research studies in psychology or neuroscience. Drawing on Baron-Cohen's work, Griemel et al. open by identifying "difficulties inferring their own and other persons' mental states" as among the core deficits of autism (1055). While the writers present this as a statement of fact, there are competing theories, such as the intense world hypothesis (Tager-Flusberg) or weak central coherence theory (Frith and Happé) which are not mentioned in this article. Further, the term empathy does not appear in the APA's diagnostic criteria for autism; the closest terminology in that text refers to difficulty with social reciprocity. Empathy may be an attractive concept to neuroscience researchers interested in autism because it can be operationalized in an fMRI study via quizzes or images, and

⁸Women can possess "male" brains, or men "female" brains, depending on how the individual scores on a test of systemizing versus empathizing, a fact that calls into question the use of the terms male and female to describe these brains in the first place.

because it has been studied in non-autistic individuals. In contrast, social reciprocity may seem fuzzier or more difficult to operationalize, and therefore more difficult to justify in a research article.⁹ Rhetorical scholars should pay careful attention to how and why scientists choose specific concepts to test, how they are defined, and whether they may (or may not) apply to rhetorical concepts.

Rhetoric scholars should also pay close attention to the terminology used to describe research findings. In their study, Greimel et al. draw on genetic explanations for autism, suggesting that "[s]imilarities in neurocognitive and behavioural profiles [between individuals with ASD and their family members] strongly suggest a common biological substrate underlying these disturbances. Thus, exploring the neural underpinnings of altered social cognition in persons with ASD and their first-degree relatives might be a valuable approach to identifying familial influences on autistic pathology" (1055–1056). Here, the writers first suggest a "common biological substrate" and then replace that term, in the second sentence, with "neural underpinnings," a move that concretizes their suggestion that there may be identifiable neurological similarities between the boys with ASD and their fathers. The writers suggest that their results indicate "that FG [fusiform gyrus] dysfunction in the context of empathy constitutes a fundamental neurobiological deviation in ASD" (1062). The transformation is subtle, but what are understood to be neural *correlates* of empathy become located in the fusiform gyrus (FG), a particular site in the brain, which then becomes (potentially) a concrete, physical predictor of ASD. The term *neural correlates* is particularly slippery in this way—while it suggests correlation, not causation, the noun phrase *neural correlates* makes the phenomenon seem more concrete. To a non-scientist, especially, neural correlates may easily be confused with "neural substrates" or something similarly tangible. It is easy to overlook the fact that the researchers are mapping BOLD activity, a proxy for neurological function, to behavior under particular experimental circumstances. Rhetoric scholars, then, should pay close attention to terms such as neural correlates, neural substrates, and the like, being sure to tease out what these terms mean and the potential suasory impact of such terms.

With regards to the methodology used, Asperger's syndrome serves an interesting rhetorical and methodological function. It is also notable that the authors studied adolescent boys diagnosed with Asperger's syndrome, usually considered a high-functioning variant of autism, but one that is currently listed as a separate disorder in the DSM-IV. The writers posit that Asperger's may serve as an

⁹For instance, the "intense world" hypothesis suggests that ASD stems from a hyperactive, hypersensitive brain, producing exaggerated (and confusing) reactions to sensory input (see Markram et al. 19). Autistic individuals often protest the "lack of empathy" or "mind-blindness" characterization. One autistic person writes: "sometimes doctors describe autistics as though they are emotionless automatons. This is far from the truth, especially as many autistics have parents or close relatives who have bipolar disorder. You can't get more emotional than bipolar disorder. I feel things very deeply. A lack of empathy isn't central to autism, it's just a feature of the social withdrawal." See Alien Robot Girl.

appropriate analogy to other forms of autism: “One way to overcome the barriers associated with such complexity [in autistic disorders] is to examine qualitatively similar but milder phenotypes in relatives of affected individuals” (1056). The rhetorical figure at hand is the *incrementum*, which Jeanne Fahnestock suggests orders subjects who presumably share some kind of attribute to differing degrees (*Rhetorical Figures in Science* 95). The notion that individuals with classic autism and with Asperger’s syndrome exist on a spectrum, or *incrementum*, implies that they differ in degree of impairment, but have the same underlying biological condition. It is this figure that grounds studies such as this one, which allow boys with Asperger’s to stand in for all individuals with autism.

The notion of *incrementum* can help to explain the language that writers use to describe autism and Asperger’s. While they portray Asperger’s as a “milder phenotype” of autism, they nevertheless described the test group as “affected individuals” (1062), while the control group was called “healthy adolescents” (1063) or “healthy controls” (1063). Individuals with ASD were characterized as having “*aberrant neural face and mirroring mechanisms*” (1055, emphasis ours) and “*socioemotional impairments*” (1063, emphasis ours). This terminology, common to scientific articles about autism, also constitutes a rhetorical choice among available terms. By choosing this language, the writers position their work clearly within a scientific conversation surrounding the deficits apparent in autism. A different choice of language might signal a different approach. For instance, individuals who argue for neurodiversity, or the notion that neurological differences are at least partially culturally produced, might use terms such as *difference*, *condition* (as opposed to disorder), and *acceptance* rather than *therapy* or *cure*. Meanwhile, parents who advocate biomedical treatments for autism tend to use terms connoting *disease* and *devastation*, on the one hand, and *cure* or *recovery*, on the other, to argue for their case. For rhetoric scholars, the point may not be to weigh in on this debate, but to pay attention to the kinds of language used to describe a neurological difference such as autism, and to the different meanings they carry in different contexts.

The implications of any scientific article, which usually appear in the discussion section, are key considerations. In scientific articles on autism, diagnosis and genetics tend to appear in discussion sections, serving as commonplaces to help writers address the so-what question. The upshot of Griemel et al.’s implications is that autism might be corrected through medical intervention, particularly early diagnosis and genetic identification. Griemel et al. suggest that “*Illuminating aberrancies such as reduced activation of the amygdala and the FG in persons presenting with mild autistic traits might prove beneficial for the identification of neurobiological endophenotypes of ASD and may provide future directions for molecular genetic studies*” (1063). These commonplaces are disputed in other circles, such as in the neurodiversity movement, where they are interpreted as portending the possibility of fetal screening and selective abortion of fetuses identified as “autistic.” Meanwhile, parents who write about autism often embrace

early diagnosis and screening techniques, since they may help them to argue for appropriate therapies and resources. For rhetoric scholars, then, it is key to consider how these *topoi* function as rhetorical choices, and how those *topoi* might be interpreted in other contexts.

One might be inclined to conclude from Griemel et al.'s study that the fusiform gyrus (FG) can verify the fundamentally human capacity for empathy, or the lack thereof in autistic individuals, and hence rhetoric. As we mentioned earlier, empathy underlies a number of rhetorical theories, including those of Quintilian and Burke. Indeed, Dennis Lynch argues that "The concept and practice of empathy insinuates itself into most modern rhetorical theories, under one guise or another" (6). It might be tempting, then, to use the case of autism as a kind of test case or touchstone against which "normal" human rhetorical capacities might be measured. Using empathy as a marker of rhetorical potential might seem to exclude individuals with autism from human rhetorical capacity on almost every level, a fact that can be ethically objectionable. A more responsible move, then, might be to question whether it is ethical for rhetoricians to assume a lack of empathy in other humans, or to consider whether rhetorical theories should be revised in order to better account for the full range of human rhetorical capacities, including those with neurological differences.

Any research article is situated both with relation to a scientific conversation and a broader cultural one. In the case of neurological differences, these contexts are increasingly convergent, in that non-scientists are gaining a voice in research decisions about autism, bipolar disorder, depression, and the like. However, readers must be quite familiar with such debates, both within scientific communities and outside of them, in order to understand the rhetorical choices, as well as elisions, within a given article.

Rhetorical Considerations: Neuroscience Findings in the Popular Media

Given the complexities of scientific texts, rhetoric scholars might be drawn to popular texts about neuroscience, since they provide accessible overviews of current findings. In general, though, popular science reports often repackage scientific findings by drawing on *topoi* such as application or wonder (Fahnestock "Accommodating"). In their study of popular news reports about neuroscience, in particular, Erik Racine, Bar-Ilan Ofek, and Judy Illes, categorize claims as falling into three types, which they call neuro-realism, neuro-essentialism, and neuro-policy. Readers should be aware of these three commonplaces, how they work on audiences, and how they might relate to the scientific reports themselves, rather than taking them at face value. Moreover, readers might also look for these tendencies in scientific articles, where they may appear in the discussion section as a way to signal the importance of a given research study.

As described by Racine, Ofek, and Illes, neuro-realism occurs when “coverage of fMRI investigations can make a phenomenon uncritically real, objective or effective in the eyes of the public” (160), or when reports invalidate or validate our ordinary understanding of the world. We would suggest that neuro-realism can occur in popularization of all kinds of neuroscience research, not just those that report on fMRI research. Rhetorically, neuro-realism operates through metaphors that work to spatially locate specific functions in the brain. One example of neuro-realism is this headline from *New Scientist*: “Emotional speech leaves ‘signature’ on the brain” (Thomson). In this study, scientists examined patterns of brain activation in 22 individuals who listened to a single sentence, read with different emotional inflections. In the article, Thomson suggests that the scientists observed “signatures,” a term that implies that the results in question somehow left a mark on the brain, rather than interpreting them as momentary patterns of activation. The usage reflects the underlying metaphor of the brain as text, inscribed by sensory experiences. A correlate of this metaphor tends to be the suggestion that scientists can therefore “read minds” in a popular sense, as though scientists could literally read a transcript of someone’s thoughts rather than *interpret* visual images or data. Such usage, along with references to regions of the brain such as a “emotion center,” “neural architecture,” or “god spot,” also involve spatial metaphors, which, like textual metaphors, seek to fix brain functions in particular spaces.

The second tendency, neuro-essentialism, refers to “how fMRI research can be depicted as equating subjectivity and personal identity to the brain” (160). The key rhetorical figure for neuro-essentialism might be a double synecdoche, wherein both the brain and the quality to be measured stand in for a complex of biological and cultural factors. An example of might be this claim from a MSNBC report: “Two new brain-imaging studies describing the origins of empathy and how placebos work provide insights into the nature of pain, the mind-body connection and what it means to be human” (Kane). The “brain” stands in for the complex network of neurons, blood flow, bodily actions, and cognitive processes that might actually make up something like pain or the “mind-body connection.” Once the brain takes over for this complex, it can be given tasks like “handling love and pain” or telling us “what it means to be human.” In this way, the brain represents the *essence* of human experiences (love, pain), or even of humanness itself. Such reports often anthropomorphize the brain, making it an active agent, as in the headline for the Kane article, “How your brain handles love and pain.”

Finally, neuro-policy refers to “attempts to use fMRI results to promote political and personal agendas” (Racine, Bar-Ilan, and Illes 161). Often, neuro-policy arguments rely on weak analogies that extend the initial research findings far beyond their original contexts. For example, a recent report in *Popular Science* suggested that a new study showing neural correlates of pain in 16 men undergoing oral surgery held implications for animal rights: “applications of this technology for fields beyond medicine, such as animal rights, may prove more transformative

than any medical use. Using the fMRI on animals could quantify the pain levels of veterinary and slaughter procedures, potentially changing the way we both heal and kill animals" (Fox). Here, the writer extends the research findings beyond their immediate context (research on humans undergoing oral surgery) to a very different context—animals being treated by a veterinarian or slaughtered for food. This is not to say that such an application might not be possible, or warranted, but these kinds of statements tend to minimize the time, effort, and technological innovation required for these applications. A weak analogy can also occur when writers extend animal studies to humans, since the biological and social factors influencing human cognition vary from, say, rats. Whether or not the comparison is apt depends on the situation.

Given these tendencies in popular and scientific articles, researchers in rhetoric should carefully question the interpretations writers give for neuroscience findings. More generally, both popular and scientific texts take advantage of the persuasiveness of visual images of the brain (McCabe and Castel; Johnson; Beaulieu "Images"; Weisberg et al.), sometimes leading audiences to grant greater credibility to scientific claims than they might otherwise. These images, nearly ubiquitous in popular reports, act as the warrant for the scientific claims, offering what Ann Beaulieu calls "a concrete unit of scientific knowledge" in an attractive, visual form ("Images" 54). Rhetoricians seeking to rely on popularized accounts of neuroscience need to carefully read such texts with a rhetorical lens, considering how authors frame their research, what arguments they make, and what other viewpoints might exist in the field.

Guidelines and Future Directions

Neuroscience research holds tantalizing possibilities for rhetorical scholarship; however, there exists a deep divide in how rhetoricians and neuroscientists communicate. Paying attention to the fundamental differences in discourse between these communities will help rhetoric scholars to work with neuroscience findings in a responsible manner. To conclude, we offer here some guidelines for scholars in rhetoric who plan to use neuroscience research in their work.

First, as we showed in the initial section, it is important to understand the methodological assumptions and debates driving neuroscience research. While neuroimaging technologies provide powerful tools, their interpretation is also guided by complex, ongoing arguments about specific methodological practices. In fact, untangling how methodological assumptions influence neuroscientific analyses sometimes reveals that these assumptions may predetermine results to some extent. By focusing on the topoi of *accuracy*, *precision*, and *bias*, we showed how neuroscientists negotiate the empirical parameters out of which claims about the brain can be made. Since these parameters are not yet settled, it is important for outside readers to be careful about applying scientific results to new contexts, such as rhetorical ones.

Second, rhetoric scholars should carefully compare their own terms and definitions with those used in neuroscience fields. As we showed in our second section, the neuroscience concepts of emotion, reason, and empathy might seem to match rhetorical concepts of pathos, logos, and identification; yet this assumption would be false in many cases. In order to draw conclusions from neuroscientific studies, rhetoric scholars will either have to make judgments about what qualifies as a close enough operationalization of a given concept or work directly with neuroscientists to operationalize our own concepts. Rhetoric scholars might work with neuroscientists to empirically test rhetorical effectiveness of, say, campaign speeches. However, both of us are skeptical of this approach, which could easily fall into the traps of neurorealism or neuroessentialism.

Third, scholars should draw on the insights of rhetoric of science scholarship when examining any particular scientific article. Rather than simply extracting the findings from an abstract, we should be careful to consider the framework the writers create for their data, asking what other scientific frameworks or explanations might be possible, and how those frameworks relate to broader debates. Such an approach requires at least some familiarity with the conceptual or methodological debates going on within a given field of study. For neuroscientists, evaluating a single article depends on the ability to fit that article within a body of converging evidence. For scholars doing interdisciplinary work, this poses a significant challenge. Ideally, collaborative work with neuroscience researchers could provide an avenue for rhetoric scholars to use neuroscience insights responsibly in their own work. In lieu of a direct collaboration, rhetoric scholars will need to do significant outside reading in order to situate a given research finding within its discourse community.

Finally, rhetoric scholars should be wary of repeating (or making their own) claims that fall into the trap of neurorealism, neuroessentialism, or neuropolicy. While we locate these pitfalls in popular accounts, they may also be tendencies in the cross-disciplinary endeavor we are calling *neurorhetorics*. For instance, we might be apt to argue that a given rhetorical concept (pathos, ethos, identification, or what have you) can be proven to exist due to neuroimaging studies—an instance of neurorealism. Or, we might lean toward neuroessentialism by claiming that brain scan studies attest to different types of brains—the “pathos-driven brain” or the “logos-driven brain”—based on how individuals respond to emotional versus logical kinds of arguments. The third pitfall, neuropolicy, may be especially likely to ensnare scholars interested in rhetorical production. Suggesting that brain studies offer proof of the effectiveness of a specific method of instruction will often fall into the trap of neuropolicy. Clearly, the classroom is a much more complex place than can be simulated inside an fMRI machine, so we should be wary of weak analogies that seek to offer scientific proof of the effectiveness of any given pedagogical method.

Given these caveats, we return to our initial claim that *neurorhetorics* research should involve both careful rhetorical analysis of neuroscience arguments as well

as consideration of how neuroscience can inform rhetorical theory and practice. Accordingly, we suggest the following directions for future research.

We may consider how scientific research about the brain is used to support arguments in all kinds of venues (political, legal, literary, medical, and so on). In this issue, for instance, Katie Guest Pryal, John P. Jackson, and Jenell Johnson each examine the rhetorical controversies that often surround attempts to define (or exclude) individuals on the basis of cognitive functioning or difference. Rhetoricians might also consider why neuroscientific explanations and images hold particular sway over audiences, an issue neuroscientists have themselves been debating. In one recent study, researchers David McCabe and Alan Castel found that people ranked descriptions of brain research as more credible if it included images of brain scans. In another study, researchers found that even including the words "brain scans indicate" increased readers' confidence in explanations of brain phenomena, leading researchers to question the "seductive allure" that neuroscience seems to hold (Weisberg et al.). Rhetoricians might help us to understand why neuroscience findings seem to hold this allure, and to what effect.

While scholars have shown that popular news accounts tend to overemphasize or decontextualize neuroscience research findings (McCabe and Castel; Weisberg et al.), we know of no studies that question whether neuroscience research articles themselves reflect popular science preoccupations. In other words, do publication and funding pressures encourage authors to frame their research in ways that will lead to attractive headlines? A related project might consider how rhetorical theory can account for the persuasiveness of neuroimaging and neuroscience findings noted by McCabe and Castel and Weisberg et al.

Applications of neuroscience research to legal contexts should also interest rhetorical scholars, since forensics have always been part of rhetoric's domain. Brain data are already being offered as evidence in trials, but we contend that such data must be interpreted by expert witnesses.¹⁰ For rhetoric scholars this means that expert ethos becomes a key issue—who is trusted to make these judgments in court (and in other venues)? How do legal and scientific arguments coincide in these cases? The legal venue is just one of many in which neurological difference is produced, identified, and realized in specific brains. As the articles in this issue demonstrate, the production of neurological difference never happens exclusively within scientific realms, but it nonetheless draws on neuroscience evidence for its power.

Finally, we hope more researchers in both rhetoric and neuroscience will undertake collaborative, interdisciplinary research. As we have shown, these two fields do have much to say to one another. While great differences in research methodologies, foundational concepts, discourse practices, and publication venues

¹⁰See Feigenson for a discussion of the admissibility and persuasiveness of fMRI data as courtroom evidence.

exist between these fields, we hope that the two-sided approach proposed in this article can help rhetoric scholars to use neuroscience insights in a responsible manner to yield productive insights into rhetoric while minimizing potential pitfalls of interdisciplinary work. We have highlighted a number of strategies here, such as carefully considering neuroscience research methods, comparing neuroscientific with rhetorical understandings of similar terms, or grounding any borrowings in a broader understanding of rhetorical and scientific debates surrounding neurological difference. Given the great interest and importance of these disciplines we encourage future research projects that have the potential to produce further productive interchanges between these fields.

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Appendix

Article	Definition (y/n)	How defined?	How operationalized?
Kompus, Kristiina, et al.	No	n/a	Subjects presented with neutral or emotional faces; emotional faces were negative (fear or anger)
Krämer, Ulrike, et al.	Yes	Encyclopedia Britannica definition of empathy (p. 110) + Decety et al.'s list of components (3 of them)	Chose one of Decety et al.'s components to operationalize using faceless cartoons of "emotionally charged" vs. "emotionally neutral" situations that they had created
Mak, Amanda K.Y., et al.	No	Defines "emotion regulation" as dealing with 'socially appropriate' behavior.	Used "emotional pictures" from the International Emotion Picture System plus extra pictures from popular media
Harris, Sam, et al.	No	Implicit – belief equated with truth, disbelief equated with falsity	Used fMRI to study the brains of 14 adults while they judged written statements to be "true" (belief), "false" (disbelief), or "undecidable" (uncertainty)
Ferstl, Evelyn C. and D. Yves von Cramon. Koch K., et al.	No	n/a	Twenty participants read two sentence stories half of which contained inconsistencies concerning emotional, temporal or spatial information
	No	n/a	"Induced negative emotion by means of negative olfactory stimulation (with rotten yeast)" (2745), which is "an effective standardized and validated method of mood induction" (2745).
Schaich Borg J., et al.	Yes	"For our purposes, 'emotions' are immediate valenced reactions that may or may not be conscious. We will focus on emotions in the form of negative affect. In contrast, 'reason' is neither valenced nor immediate insofar as reasoning need not incline us toward any specific feeling and combines prior information with new beliefs or conclusions and usually comes in the form of cognitive manipulations... that require working memory" (803).	Presented scenarios to subjects using both "dramatic (colorful)" and "muted (noncolorful)" language.

Azim, Eiman, et al.	No	(humor)	Shown cartoons that had previously been rated "funny" or "unfunny"
Sander, David, et al.	No	No, but emphasis here is on decoding/interpreting affective cues.	Voices – subjects listened to meaningless utterances read in angry vs. neutral prosody.
Canessa, Nichola, et al.	Yes	"Reasoning can be defined as a combination of cognitive processes that allows us to draw inferences from a given set of information and reach conclusions that are not explicitly available, providing new knowledge. Reasoning is the central nucleus of thinking and is essential in almost every aspect of mental activity, from text comprehension to problem solving and decision making" (930).	"In the present study, the effect of content on brain activation was investigated with functional magnetic resonance imaging (fMRI) while subjects were solving two versions of the Wason selection task, which previous behavioral studies have shown to elicit a significant content effect" (930).
Greene, Joshua D., et al.	Yes	"By "reasoning," we refer to relatively slow and deliberative processes involving abstraction and at least some introspectively accessible components" (389).	Subjects were asked to make various kinds of moral judgements (impersonal and personal) based on scenarios validated in an earlier study by Greene et al.
Reuter, M., et al.	No	n/a	"Subjects viewed pictures with sadomasochistic, erotic, disgusting, fear-inducing, and affectively neutral content. E.g. The disgusting pictures included unusual food, disgusting animals, poor hygiene, and body products such as excrement; fear-inducing pictures included scenes of animal threat, human threat, or disasters; erotic pictures contained either pictures of single naked subjects or pictures of couples in an intimate situation." (464)
Ochsner, Kevin N., et al. "Reflecting Upon Feelings"	No	n/a	"In this task, participants were presented with a series of blocks of photographic images and for each block were asked to judge either their own emotional response to each photo (pleasant, unpleasant or neutral), or to judge whether the image had been taken (indoors, outdoors, or not sure). The present study modified this paradigm through the inclusion of a third condition, which asked participants to judge the emotional response of the central character in each image (pleasant, unpleasant, or neutral)." (1748)

(Continued)

Appendix Continued

Article	Definition (y/n)	How defined?	How operationalized?
Ochsner, Kevin N., et al. "Rethinking Feelings"	Maybe? "The cognitive transformation of emotional experience has been termed "reappraisal." (1215)	"We employed two conditions: On "Attend trials," participants were asked to let themselves respond emotionally to each photo by being aware of their feelings without trying to alter them. On "Reappraise trials," participants were asked to interpret photos so that they no longer felt negative in response to them. . . . Each trial began with a 4-sec presentation of a negative or neutral photo, during which participants were instructed simply to view the stimulus on the screen" (1217).	
McRae, Kateri, et al.	Sort of	"Emotion regulation can be deliberate or habitual, conscious or unconscious, and can involve changes in the magnitude, duration, or quality of one or several components of an emotional response. Emotion regulation strategies can target one's own emotions or those of another individual, at a variety of time points in the emotion generation process (Gross, 2007). Because emotion regulation is an ongoing process, the overall trajectory of an emotional response can be characterized by the effects of regulation as much as the effects of 'pure' reactivity."	"At the start of each trial, an instruction word was presented in the middle of the screen ('decrease' or 'look'; 4 seconds), a picture was presented (negative if instruction was decrease (regulation instruction), negative or neutral if instruction was look (non-regulation instruction); 8 seconds) followed by a rating period (scale from 1-4; 4 seconds) and then the word 'relax' (4 seconds). . . . Following presentation of each picture, participants were prompted to answer the question 'How negative do you feel?' on a scale from 1 to 4 (where 1 was labeled 'weak' and 4 was labeled 'strong'). (147)
Trautmann, Sina Alexa, Thorsten Fehr, and Manfred Herrmann.	No	n/a	"A set of emotional videos and video screen captures showing different facial expressions (see Fig. 4) was applied for the fMRI study. The stimuli were depicted from a stimulus data base of 40 female and 40 male non-professional actors displaying each of eight different emotional facial expressions (happiness (smiling and laughing), surprise, enjoying, fear, anger, sadness, and

disgust) and neutral expressions Emotional expressions of actresses were triggered by a mood induction strategy (e.g., for disgust: "imagine, you come home after two weeks of vacation but you forgot to take out the biowaste container" or happy: "imagine you meet someone unexpectedly on the street who you really like and give him a smile because you are happy to see him"). For the purposes of the present study, only female dynamic and static emotional face stimuli (N = 40; see above for detailed explanation of gender differences) displaying positive (happiness), negative (disgust), and neutral expressions were used." (111)

"The task consisted of the successive presentation of animated visual images of hands and feet depicting painful and non-painful situations. Furthermore, these situations involved either an individual whose pain was caused by accident or an individual whose pain was inflicted on purpose by another person. A series of 144 stimuli were created and validated for this study. Validation of the material was conducted with a group of 222 participants (110, females) who were shown these dynamic stimuli and asked to estimate how painful these situations were and whether they believed that the pain was caused intentionally (Estabrook, 2007). Each animation consisted of three digital color pictures, which were edited to the same size (600 × 480 pixels). The durations of the first, second and third pictures were 1000 ms, 400 ms and 1000 ms respectively. These animated stimuli contained scenes of various types of painful and non-painful everyday situations" (723).

"The experimental tasks were adapted from a kind of intelligence test problems. The basal element of the task was a reverse triangle as shown in Figure 1. The three numbers located at three different positions may constitute a calculation rule, i.e., an equation like $Z = X + Y$. Figure 2 gave an example of the inductive reasoning task, which was assembled with three reverse triangles as mentioned above" (75).

The perception of pain in others can be used as a window to investigate the neurophysiological mechanisms that underpin the experience of empathy, i.e., the capacity to share and appreciate others emotional and affective states in relation to oneself (Decety, 2007; Goubert et al., 2009; Jackson et al., 2005). Empathy may be regarded as a proximate factor motivating prosocial behaviors and is crucial in the development of moral reasoning (Decety and Meyer, 2008). (722)

"Inductive reasoning is defined as the process of inferring a general rule (conclusion) by observation and analysis of specific instances (premises). Inductive reasoning is used when generating hypotheses, formulating theories and discovering relationships, and is essential for scientific discovery." (74)

Yes

Akitsuki, Yuko, and Jean Decety.

Yes

Lu, Shengfu, et al.